Total Energy Study:

Final Report on a Total Energy Approach to Meeting the State's Greenhouse Gas and Renewable Energy Goals

Vermont Public Service Department

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1 Introduction and summary

In 2005, the Vermont General Assembly set aggressive greenhouse gas reduction goals for the State: reducing emissions of greenhouse gases from 1990 levels by 50% by 2028 and, if practicable using reasonable efforts, 75% by 2050.[1] In 2011, the Vermont Comprehensive Energy Plan set out a broad vision for the state to acquire 90% of all energy from renewable sources by 2050 as a pathway to practically eliminate the state's dependence on oil.[2] These goals, the product of broad political and stakeholder deliberation, illustrate the importance Vermont places on addressing the climate challenge while recognizing the potential economic benefits and energy security associated with renewable energy resources. Renewable resources are more likely to be local, and with resources directed toward upfront capital expenditures rather than ongoing fuel costs, the impacts on Vermont's economy are expected to be beneficial.

The Public Service Department ("Department" or "PSD") offers this Total Energy Study ("TES") report identifying and evaluating promising policy and technology pathways that could allow Vermont to reach its renewable energy and greenhouse gas reduction goals. The report, by design, does not pick a "winner" or articulate a single path forward. It is not intended to be or replace the Comprehensive Energy Plan. Instead, by modeling the impacts associated with three routes to 2050 – a revenue-neutral Carbon Tax Shift, a Total Renewable Energy and Efficiency Standard (TREES), and TREES with a local energy requirement – it highlights key opportunities and risks to Vermont as the State moves toward meeting its goals. This report raises several key questions that should be addressed in the development of the next update of the Comprehensive Energy Plan, scheduled to be drafted with substantive public and stakeholder engagement throughout 2015.

The fundamental conclusion of this Total Energy Study is that **Vermont can achieve its greenhouse gas emission reduction goals and its renewable energy goals while maintaining or increasing Vermont's economic prosperity. However, to do so will require significant changes in energy policy, fuel supply, infrastructure, and technology.**

The TES was a phased process commencing in January 2013 involving decision-makers, expert stakeholders and the general public, structured to facilitate significant stakeholder and public engagement. Public and interagency input informed development of a wide set of scenarios that might meet the State's goals. The PSD then narrowed those scenarios based on a set of qualitative criteria that produced a manageable number of potential scenarios for further quantitative analysis.[3] The TES was structured around the development and evaluation of these discrete sets of policies and technology pathways. Policy sets are the tools deployed by the State (in concert with policies adopted at the National, regional, and local level) to shape deployment of potential technology pathways. Technology

[1] 10 V.S.A. § 578(a)
[2] Vermont 2011 Comprehensive Energy Plan. http://publicservice.vermont.gov/publications/energy_plan/2011_plan
[3] For a discussion of the criteria used, see Appendices B and C.

pathways describe ways that the state could meet its objectives in terms of hardware deployed (for example, how much electric power, and from which sources; how many cars powered by what fuels by what date; how many homes weatherized; etc.). Technology pathways strongly shape overall cost and economic impacts.

The scenarios selected for quantitative analysis were overarching in that they tested fundamental changes in the energy policy and technology structure reaching throughout Vermont's energy system and broader economy in the timeframe of 2012 through 2050. The Dunsky Energy Consulting ("Dunsky" or "DEC") team's analysis (see Section 2.1 and Appendix C) showed that Vermont's energy goals are technically achievable, using a number of different technology pathways. Across all of the scenarios examined, the aggregate present value costs to the energy system were found to be in the range of $38 to $90 per ton of CO_2e greenhouse gas (GHG) emission reduction. The impacts on the broader Vermont economy were found to be narrow in range, and relatively small in scale (see Section 2.2 and Appendix D). If the policies examined perform as intended and other jurisdictions pursue comparable action against climate change alongside Vermont, the annual average increase in Gross State Product ("GSP") is estimated to fall in the range of $69 million to $363 million (in constant 2014 dollars), with the high end of that range representing less than three quarters of a percent increase over baseline GSP levels.

The following sections first provide an overview of the policy modeling approach then highlight the greenhouse gas, renewable energy, and economic impacts of the modeled scenarios. Next, the key insights resulting from this analysis are described, including a short summary of the pillars of the possible transformation of Vermont's energy infrastructure. Finally, the report details questions raised by this process that the PSD plans to address during development of the next Comprehensive Energy Plan.

Supporting analysis for this Total Energy Study is embedded in five reports. These reports:

- Examine available policies (Appendix A, produced by the Regulatory Assistance Project);
- Describe a framework for and a focusing of those policies (Appendix B, submitted to the Legislature in December, 2013);
- Quantitatively examine three policy and technology scenarios for the energy sector (Appendix C, produced by Dunsky Energy Consultants);
- Estimate the macroeconomic implications of those three scenarios for the state as modeled with REMI software (Appendix D); and
- Summarize the input received from the public and stakeholders throughout the process (Appendix E).

2 Overview of policy scenario modeling

The Department selected three overarching policy approaches aimed at reaching Vermont's energy goals and compared them to a baseline business-as-usual scenario. Discussions throughout the stakeholder process informed the Department's selection of which policy scenarios to model. A full description of the process to select the scenarios can be found in Appendix B (the 2013 Legislative

Report on the TES) and Appendix C (the report from Dunsky Energy Consulting). The Department recognizes that it is challenging to model energy system and economic impacts decades into the future, and model results are shaped by the models' abilities and the input assumptions. Models can, however, be used to gain insights and draw conclusions from observed trends, including the scale and direction of changes due to policy intervention. When modeling policy scenarios, the Department analyzed model outputs for broad and robust conclusions rather than for precise numerical results.

While understanding the potential technology pathway will be critical to meeting Vermont's goals, the policy approaches were not linked to specific technologies. Instead, the Department made an active choice to be "technology agnostic" in order to evaluate the modeling results of the policy approaches without restriction. The Dunsky team performed emissions, energy resource, and energy system cost modeling using the Framework for Analysis of Climate-Energy-Technology Systems (FACETS) model[4] for the following scenarios.

Baseline:

- A business-as-usual ("BAU") scenario was calibrated to mimic Vermont's current energy policy to serve as a base case to which estimates of impacts from other policy scenarios could be compared. It was built on a database that includes relevant local, state, regional, and national energy system resources, including Canadian options, and modeled projections of how shares of different fuels would shift based on lowest total cost, assuming no technical constraints or market failures.[5] This BAU case should not be confused with a base fossil fuel case, as Vermont is already significantly implementing renewable energy policies and efficiency programs. The results show the makeup of Vermont's energy system if we continue along our current path with no significant policy changes. Absent policy intervention, the total amount of energy consumed annually in Vermont is projected to decrease slightly from 2012 to 2050, but not at a pace significant enough to meet Vermont's goals. The total share of renewable energy in Vermont's fuel mix does not increase significantly.

Policy Scenarios:

- The "Carbon Tax Shift" scenario tested the implementation of a revenue-neutral tax on greenhouse gases emitted from energy resources across all sectors offset by a corresponding tax

[4] FACETS is based on the TIMES (The Integrated MARKAL-EFOM System) model generator. A TIMES model represents the entire energy system of a country or region as a network, including all forms of energy extraction, transformation, distribution, end-uses, and trade. Each stage in the network has many different specific technologies available, each characterized by economic and technological parameters. The model also tracks greenhouse gas and criteria air pollutant emissions. The model calculates through the network to find the least-cost options for meeting all demands for useful energy services. More detail is available in Appendix C.

[5] While the total consumption levels in the BAU appear to be reasonable, the shares of various fuels in the BAU are somewhat uncertain since in the real world, considerations other than fuel cost projections factor into consumers' fuel choice, including availability (e.g. natural gas distribution), awareness, split incentives, and other market failures. As such, the BAU case in this study is valuable for comparison purposes but should not be used as inputs to other evaluation.

reduction or rebate in other areas of the economy. Various rates of a potential carbon tax were analyzed in order to determine the level necessary to reach Vermont's GHG emission goals.

- The "TREES[6] Basic" scenario tested policies requiring all Vermont energy distributors to source an escalating percentage of their supply from renewables or efficiency, with tradable certificates.
- The "TREES Local" scenario tested policies similar to TREES Basic, but also requires an increasing share of all energy to be sourced from in-state, Vermont renewable energy or efficiency resources.

During policy scenario modeling it became apparent that the price and availability of liquid biofuels was a critical variable in determining the technology pathway that resulted from each policy scenario. Thus, each policy scenario was modeled using a low biofuel price and separately using a high biofuel price (which also serves as a proxy for a lack of available liquid biofuels). More discussion on this key risk is included in Section 4.1 below.

Finally, modeling of policy approaches over 35 years into the future has inherent limitations. Key limitations identified by the Department include:

- The FACETS model's assumption that market actors are "rational" in that they will choose the most cost-effective option available, with little to no delay. There are a number of real world barriers that frustrate translation of this model assumption to reality.
- Data and modeling limitations required omission of a number of policies that are expected to reduce Vermont's energy demand. For example, transportation mode shifting and land use policies ("smart growth") are expected to reduce Vehicle Miles Traveled.
- While FACETS includes forecasted technological advances, innovation cannot be predicted. New technologies or breakthrough innovations, or a rapid change in fuel prices due to geopolitical events or new resource discoveries cannot be projected. For example, a breakthrough in energy storage technologies could dramatically change the economics of fuel switching opportunities. The results presented in the TES represent a least cost way of achieving Vermont's goals using a reasonable set of projections for future availability, cost, and performance of existing or currently anticipated technologies.
- The greenhouse gas impacts of fossil fuels described in the TES are from a "burner tip" perspective; they represent the amount of emissions emitted at the point of combustion or end use. They do not include the emissions associated with the entire lifecycle of fuel source emissions from production to end use. An exception to this is that solid and liquid biofuels were assumed to have GHG emissions equal to the fossil fuel emissions from combustion of fossil fuels used in their production, and none associated with combustion of the biofuel itself as

[6] The TREES acronym stands for Total Renewable Energy and Efficiency Standard. The TREES policies function similarly to a Renewable Portfolio Standard. However, TREES is broader in that it requires energy suppliers in all energy sectors – including electricity, natural gas, delivered fuels, and liquid transportation fuels – to source a growing proportion of energy from renewable resources and/or demand reductions via energy efficiency.

sustainable harvesting and production practices were assumed to result in an equivalent sequestration of carbon during this study period.

- Lack of data limited the analysis with regard to efficiency and fuel-switching opportunities in the industrial sector. This required modeling of the sector as simply reactive to fuel prices. The model did not examine technological or fuel shifts that may have been less expensive. In this respect, costs of meeting state policy goals are likely overestimated, as we know industries are already performing some fuel-switching in response to both price and policy signals.
- It is uncertain how the effects of climate change will impact Vermont and its economy during the study period.[7] The analysis did not include a forecast of how actions taken to adapt to the effects of climate change will impact Vermont's economy and energy sector.

Despite these limitations, the modeled policies provide indicative information regarding the relative impacts of differing policy approaches, provide insights to the key risks to Vermont in meeting its goals, and illuminate key questions to address in the upcoming Comprehensive Energy Plan update.

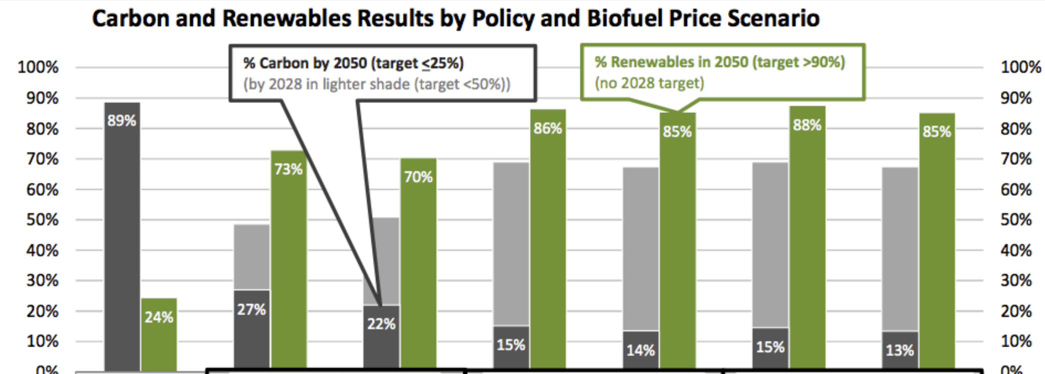
2.1 Energy system impacts

The modeled BAU scenario through 2050 shows that if Vermont continues along its current policy pathway, we will not meet our energy or GHG goals. Vermont cannot achieve the significant reductions in greenhouse gas emissions targeted in the statewide goals, nor the associated economic and environmental benefits, without implementing new policies and technologies at scale.

The analysis completed by Dunsky Energy Consulting finds that achieving the goal of a 75% reduction in greenhouse gas emissions by 2050 is achievable under all three Energy Policy scenarios. There is, however, a slight trade-off in the other goals, where a Carbon Tax Shift also achieves the mid-term GHG goals of 50% by 2028, but falls short of the renewable energy goal. Conversely, both TREES policies as modeled[8] effectively achieve the long-term GHG and renewable energy goals, but fall short of the mid-term GHG goal. Exhibit 1 shows the progress toward each goal under each policy scenario.

[7] The Vermont Climate Assessment (http://vtclimate.org) summarizes the current state of knowledge regarding climate change impacts in Vermont.

[8] TREES scenarios were modeled starting at current renewable energy levels and ramping linearly to meet the goal of 90% renewable by 2050. A TREES scenario could be structured to meet the 2028 goal as well, by utilizing a different ramp rate. However, this alternate TREES structure was not modeled.



	BAU	TaxSHIFT (LoBio$)	TaxSHIFT (HiBio$)	TREES Basic (LoBio$)	TREES Basic (HiBio)	TREES Local (LoBio$)	TREES Local (HiBio$)
2028 CO2 Emissions	87%	49%	51%	69%	67%	69%	67%
2050 Renewable content	24%	73%	70%	86%	85%	88%	85%
2050 CO2 Emissions	89%	27%	22%	15%	14%	15%	13%

Exhibit 1. Progress toward greenhouse gas and renewable energy goals in 2050 by policy set and assumption regarding biofuel prices.

The FACETS model produced calculations of the least cost energy portfolios under each policy scenario, including the BAU case. Exhibit 2 shows the model results for Vermont's total energy portfolio in 2015, 2028, and 2050 under each of the policy scenarios. In the BAU case, the total amount of energy consumed is projected to decrease slightly, while the quantity of renewable energy in the fuel mix does not change significantly. In contrast, total energy demand in each of the policy cases falls by between 25% and 38% by 2050, while electricity usage increases. On a primary energy basis, electricity use declines by 2028 in 5 of the 6 scenarios as fossil fuel combustion-based generation technologies are replaced by more efficient renewables. Increased electric service demand then drives the electric primary energy up by 2050. Aside from the continued use of some nuclear electricity in the Carbon Tax Shift cases, the mix of non-GHG-emitting electric generation technologies under each scenario is driven more by the FACETS model's assumptions on price and availability than by policy-related differences. FACETS also does not maintain the exact balance of supply and demand for electricity at each moment in time; in effect it assumes a larger regional grid with a diversity of electricity sources at any given time. As such, the model does not support conclusions regarding the specific mix of wind, solar, and hydroelectricity used in each scenario, and instead should only be relied upon to consider the total amount of renewable electricity relative to non-renewable resources. Appendix C contains extensive additional data regarding the results of energy system modeling.

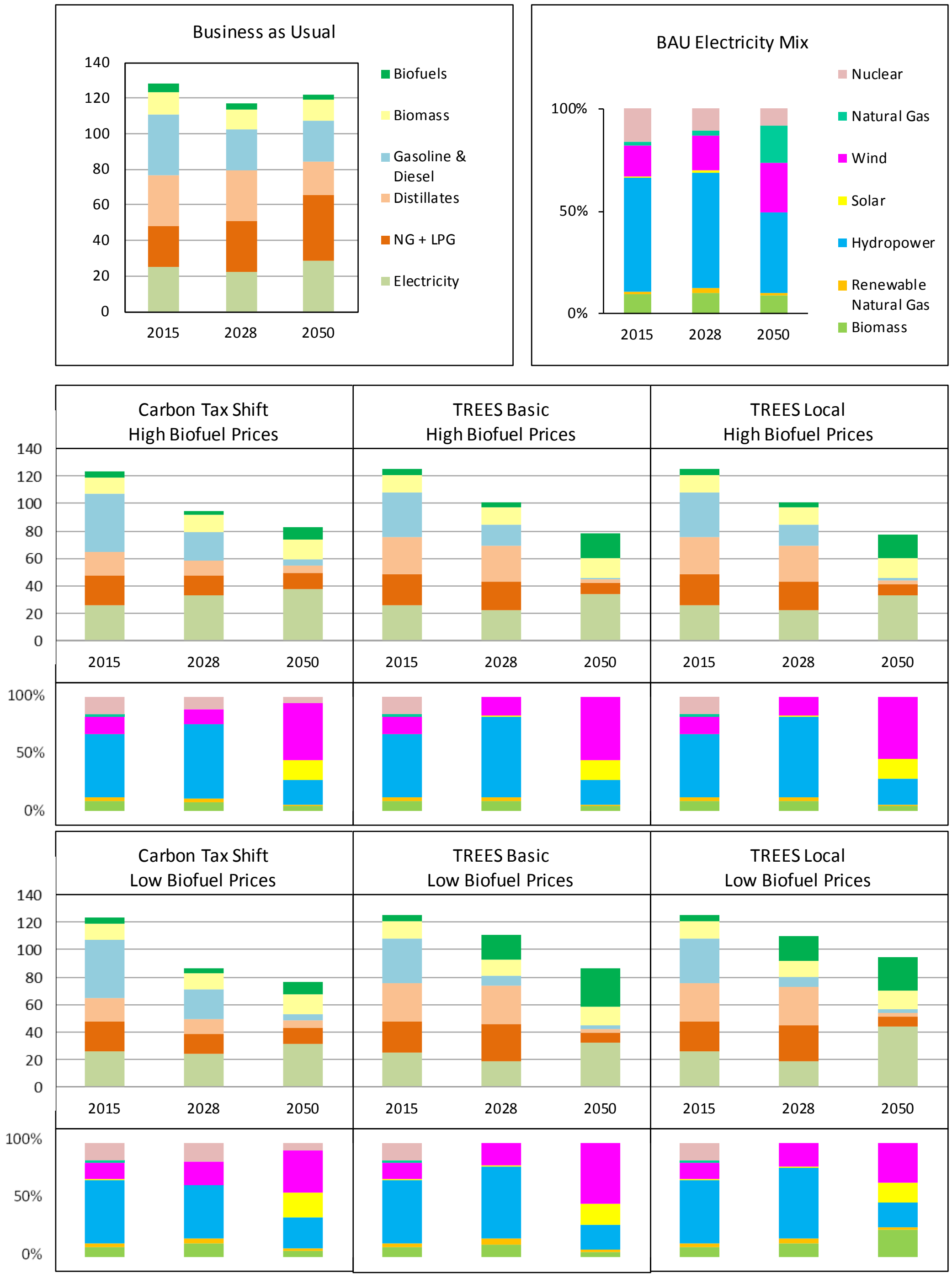


Exhibit 2. Total energy portfolios in 2015, 2028, and 2050 by scenario. For each scenario, the upper chart shows the TBTU of primary energy by fuel (including electricity), while the lower chart divides the electric portion by generation type.

Exhibit 3 presents the policy-driven costs to the energy system in terms of both the percent increase in total costs needed to meet Vermonters' energy service needs (including capital, operating, and fuel costs) as well as the average cost of reducing emissions per ton of total emission reductions over the period (in present value 2013 costs), relative to the BAU. Implementing the modeled policy options creates modest energy system costs. Exhibit 3 shows that, depending on the policy option as well as future biofuel prices, achieving the goals will add between 2.2% and 5.5% to the direct cost of meeting Vermonters' energy needs. While much of this range is associated with biofuel price sensitivity, the choice of policy approach also influences cost. The magnitudes identified here represent only direct energy-related costs, as determined by energy system modeling; they do not include any secondary economic effects addressed in Section 2.2 below, such as changes in consumer and business behavior in response to different fuel prices.

POLICY OPTION		**COSTS**			
		% change re: BAU		$/ton	
	BIOFUEL PRICES:	LOW	HIGH	LOW	HIGH
Tax Shift		2.6%	4.5%	$42	$67
TREES Basic		2.2%	5.4%	$38	$89
TREES Local		3.3%	5.5%	$56	$90

Exhibit 3. Policy-driven costs in the energy system compared with the BAU case.

DEC's FACETS energy system modeling also produced an informative account of Vermont's carbon emission abatement cost curve, shown in Exhibit 4. This figure shows the amount of carbon emission reductions achievable at different levels of cost, measured per ton of emission reductions. As the text in the Exhibit describes, in the low biofuel price case nearly half of the required emission reductions can be achieved at a cost, relative to BAU, of less than $50 per ton. A perfectly-functioning carbon tax set at a certain level would be expected to achieve GHG reductions up to the level at which the costs of changing the energy system are equal to the cost of paying the tax. A tax of $50/ton in the low biofuel price scenario leads to nearly a 50% GHG emission reduction. In contrast, the last 10% of the reductions required to hit the 75% reduction target would cost between $300 and $450 per ton, so the low biofuel price carbon tax shift scenario models a tax rising to $450/ton by 2050. The average cost of emission reductions is much lower than the cost of eliminating the final ton necessary to achieve a target.

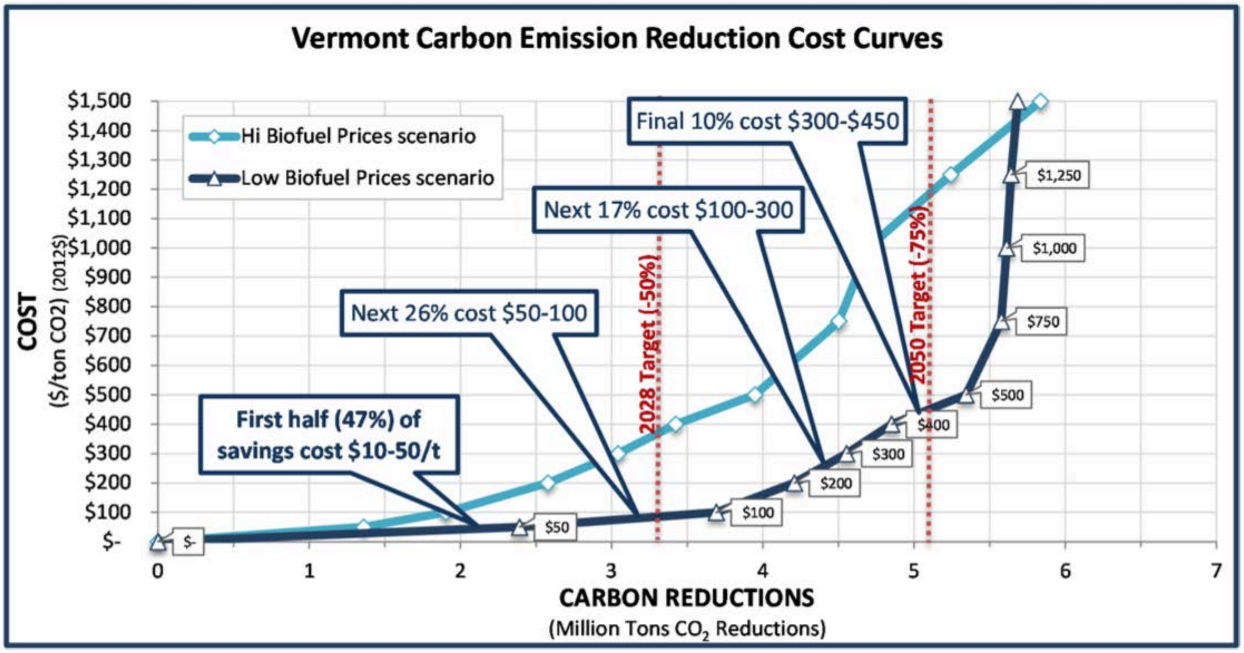


Exhibit 4. Vermont carbon emission costs per ton of CO_2 reduction in the high and low biofuel price scenarios.

2.2 Impacts on the Vermont economy

DEC's energy system modeling provided the Department with significant information regarding the changes in energy-related costs that could result under each policy scenario, including shifts in expenditures on types of fuel and different levels of capital and operating expenditures. However, these energy sector costs are not the end of the story with respect to economic impacts. The cost of energy pervades the entire economy, so changes in energy expenditures should also be expected to affect the broader economy. These expected effects include increased growth in the sectors which produce clean energy; increased productivity with increased energy efficiency; reduction in output by those sectors directly linked to fossil fuels; and changes to overall business competitiveness linked to changes in the cost of doing business in Vermont relative to other jurisdictions. In order to examine these effects in greater detail, the Department used PI+, a regional economic impact modeling software licensed by Regional Economic Models Incorporated, commonly referred to as "REMI." The Department constructed a variety of policy simulations each designed to represent possible outcomes of the FACETS model runs in both the high and low biofuel price scenarios. Appendix D summarizes the REMI methodology and describes the results of the REMI analysis in greater detail.

The REMI tool is, however, imperfect for this type of policy analysis. Therefore, PSD's modeled economic impacts can be treated as estimates of the likely scale and direction of possible outcomes, rather than as predictions. Comparative results from different REMI simulations can provide greater insight than any one model result, because they can illustrate how changes in policy or approach can affect results. As discussed below, for example, simulations run with and without a change in Vermont's net competitive position with respect to business costs for energy (reflecting whether other jurisdictions take comparable action to reduce climate change and adopt renewable energy) indicate the impact of this competitive pressure and inform policy discussions regarding the importance of collective action across jurisdictions.

Two particular shortcomings of the REMI tool are worth highlighting here. The first is that REMI is based on sectors as defined by the North American Industry Classification System (NAICS). These sectors do not sufficiently distinguish clean energy businesses from other similar businesses. Sector-specific and employment figures from REMI analysis therefore lack the resolution to fully identify the clean energy sector growth resulting from policy changes. To address this situation in the near term, the Vermont Clean Energy Development Fund has developed a Clean Energy Industry Report[9] based on business surveys. This report identified more than 15,000 clean energy workers in 2014, with expected growth of 12% in the next year. Note that this near-term growth precedes adoption of any changes in public policy of the sort contemplated in this report, and as expressed earlier is already incorporated in the BAU analysis.

REMI models are based on a smoothed approximation of the economy that lacks business cycles and short-term volatility. REMI is therefore unable to capture the impact of any changes in the resilience of the state's economy that might result from changes in energy supply and demand. For example, Vermont's current dependence on oil makes it sensitive to the dynamics of the global price of oil, which has shown a great deal of volatility in the last several decades. Under the policy scenarios examined here, that dependence is dramatically reduced. REMI cannot calculate a value to this independence and the associated economic resilience. Economic modeling using REMI is also unable to capture the potential rewards of being a first mover in energy policy. Such policy could attract and foster firms that become significant net exporters into other jurisdictions. If those jurisdictions follow Vermont's lead in adopting strong clean energy policies, such clean energy firms will find greater potential markets.

Despite REMI's limitations, the model is useful to glean general insights associated with the effects on Vermont's economy through evaluation of differences between scenarios that varied across policy sets and biofuel price cases, and also in how revenue streams associated with carbon tax revenue or renewable certificates were handled. This analysis supports four conclusions:

1. The net economic impacts of implementation of any of the policies examined here are likely to be positive if the policies are designed and implemented well.
2. If other jurisdictions also take strong action to reduce GHG emission and adopt renewable energy alongside Vermont, the net impact of these policies in Vermont is more positive.
3. The net economic impacts are expected to be small on the scale of the Vermont economy.
4. The clean energy sector is likely to thrive if these policies are implemented.

The remainder of this section examines each of these conclusions in detail, presenting the supporting evidence for each.

[9] http://publicservice.vermont.gov/sites/psd/files/Topics/Renewable_Energy/CEDF/Vermont%20Clean%20Energy%20Industry%20Report%20FINAL.pdf

2.2.1 Positive impacts of well-implemented policies

Well-implemented policies result in net positive economic impacts under all three policy sets, whether low-cost biofuels are available to meet policy targets or not. Exhibit 5 summarizes the REMI results for each of these six cases, compared with the BAU case for the total study period (2015-2050) as well as three sub-periods.

	Gross State Product				Employment
Scenario	2015-2025	2025-2035	2035-2050	2015-2050	2015-2050
Carbon Tax Shift: High Bio	+0.17%	+0.87%	+0.83%	+0.69%	+1.26%
Carbon Tax Shift: Low Bio	+0.08%	+0.15%	+0.32%	+0.23%	+0.44%
TREES Basic: High Bio	+0.03%	+0.70%	+0.53%	+0.45%	+0.90%
TREES Basic: Low Bio	+0.11%	+0.11%	+0.34%	+0.23%	+0.45%
TREES Local: High Bio	+0.09%	+0.58%	+0.58%	+0.47%	+0.85%
TREES Local: Low Bio	+0.11%	+0.13%	+0.40%	+0.27%	+0.51%

Exhibit 5. Difference from BAU in modeled average annual Gross State Product and average annual employment levels for each of six scenarios, assuming the best-performing implementation of each policy.

The findings for GSP in Exhibit 5 show that the modeled policies are likely to bring a relatively minor positive impact on the overall scale of economic activity in Vermont. The associated benefits of that change can be seen more clearly in the job creation that takes place in each of the policies. This rise in employment spans a range of around 2,260 to 6,400 more jobs each year on average over the whole period, depending on the specific policy and the prevailing price of biofuels (See Appendix D). As a percentage change from baseline levels, average employment increases are slightly greater than increases in GSP. Thus the moderate GSP growth in each TES policy scenario comes with a higher pace of job creation, suggesting a slight policy bias toward labor-intensive industry. Requiring increased energy locality, through the TREES Local policy, results in somewhat increased energy system costs while more money stays local, resulting in a small increase in overall GSP.

The Department was able to combine the FACETS and REMI analyses with historical data to produce Exhibit 6, which shows the increasing energy productivity of the Vermont economy over the last four decades, as well as the potential impact of the three policy sets (each with high and low biofuel prices) on the future trajectory, contrasted with the BAU path. The energy productivity under the modeled policy cases exceeds the energy productivity under the BAU case by between 27% and 60%.

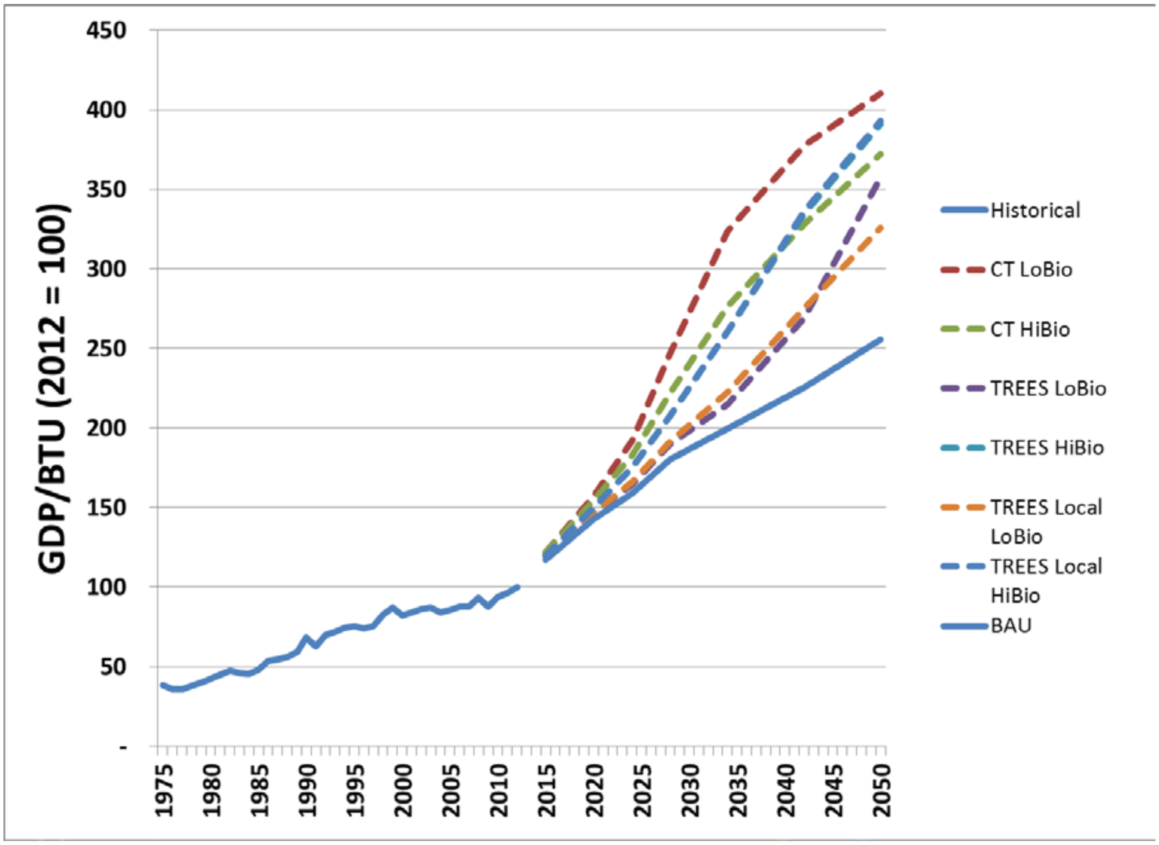


Exhibit 6. Energy productivity (Vermont GDP per BTU of primary energy), normalized to 2012=100. Historical data is from EIA and PSD; modeled data is from FACETS and REMI for each of the 6 policy cases and the BAU.

These results reflect well-implemented policies. REMI modeling enabled the Department to examine the potential impacts of other implementations, and show that net economic results can vary due to changes in implementation. For example, if carbon tax revenue is returned only to households, and not to businesses, net economic performance may suffer in a high biofuel price environment where the costs of renewable energy take a larger toll on Vermont business market share. This reflects a net transfer of money from businesses to households. Due to the high dependence of the Vermont consumer economy on other states and countries, households do not spend enough additional money in Vermont to make up for the business sector's net loss. For details regarding the range of implementations and assumptions tested, and further details regarding the REMI modeling methodology, please see Appendix D.

2.2.2 The importance of action in other jurisdictions

REMI modeling allowed the Department to compare policy sets' economic impacts with and without comparable action in other states. Action in other jurisdictions matters because of its effect on the competitiveness of Vermont firms. Our modeling examined two extremes—no action anywhere else or exactly comparable action—while the real world is likely to fall in between. The difference in modeled economic outcomes supports a conclusion that Vermont should be aware of the actions taken by others when designing our policies and that our state benefits when others take action. Exhibit 7 summarizes the net economic impact for well-implemented policy sets with ("together") and without ("alone") comparable action elsewhere. The economic improvement in the high biofuel price cases is larger in the "together" cases because these have both a more local energy mix—with associated economic activity—and no loss of competitive position.

	Together		Alone	
	Δ GSP	Δ Jobs	Δ GSP	Δ Jobs
Carbon Tax Shift: High Bio	+0.69%	+1.26%	+0.28%	+0.41%
Carbon Tax Shift: Low Bio	+0.23%	+0.44%	+0.26%	+0.36%
TREES Basic: High Bio	+0.45%	+0.90%	-0.14%	-0.32%
TREES Basic: Low Bio	+0.23%	+0.45%	+0.17%	+0.39%
TREES Local: High Bio	+0.47%	+0.85%	-0.24%	+0.06%
TREES Local: Low Bio	+0.27%	+0.38%	+0.13%	+0.38%

Exhibit 7. Net economic impacts (relative to the BAU case) on average annual GSP and employment levels for each policy scenario under a "together" case in which all other jurisdictions take comparable action on GHGs and renewable energy, and an "alone" case in which no other jurisdiction takes comparable action.

2.2.3 Net impacts are small on the scale of the economy

Despite the fundamental changes in the energy sector produced by the modeled policy changes, the overall economic scale of impacts is expected to be small, whether positive or negative, when compared with the size of the overall economy. A simplified example can help to illustrate why; see the sidebar. This example does not capture the complex interactions between economic sectors as electricity, building heat, industrial processes, and transportation all shift to new fuels and infrastructure. REMI modeling, however, confirms the overall scale of impact. The range of potential impacts across all scenarios tested—excluding nonsensical

A simplified example of economic impact

Vermonters currently spend around $1 billion per year on gasoline for light-duty transportation; a large portion of this money leaves the state to pay for the commodity fuel. Hypothetically, if all cars and light trucks were replaced by electric vehicles overnight, the resulting annual fuel expenditure might fall to about $315 million. With a highly local supply of renewable electricity, this spending would increase output by Vermont firms by around $250 million. The $1 billion in displaced gasoline purchases would have resulted in around a $170 million increase in output by Vermont firms. In addition to the electricity spending, the annualized capital cost of new electric vehicles could be about $520 million. Capital expenditures on electric vehicles flow largely out of state in the same way as purchases of gasoline, resulting in only a $45 million increase in Vermont output. This leaves $165 million (1000-520-315=165) available for discretionary spending by Vermonters. However, not all of Vermont spending goes to Vermont suppliers. A $165 million increase in discretionary spending raises Vermont output only by around $100 million. Thus the total increase in Vermont output associated with an overnight transition to electric vehicles would total around $225 million (250-170+45+100=225), or under a half of one percent of the roughly $54 billion of output from the Vermont economy in 2013.

implementations such as collecting carbon tax revenue and then just removing it from the economy—stretches only between a -0.04% and +0.03% change in the pace of annual GSP growth.

2.2.4 Impact on the clean energy sector

Despite the inability of NAICS categories to distinguish clean energy business activity from the rest of the economy, there are some industries where our REMI modeling does show that a noticeable effect would be expected from implementation of these policies. In particular, the utilities sector (which includes independent power producers) and forestry sector show significant increases in both jobs and economic activity in the policy cases when compared with BAU. Across policy scenarios, output and employment in the electricity-producing sector was found to increase by 20 to 30 percent on average when liquid biofuel prices are high and 5 to 8 percent on average when biofuel prices are low. (All scenarios assumed liquid biofuels to be imported.) The growth experienced by the solid biomass-producing sector is substantial enough when low-cost biofuels are not available to double baseline levels of sales and employment. When biofuel prices are low, biomass industry growth is slower, and ranges between 40 and 60 percent above baseline values. Collectively, average employment over the 2015-2050 period in these two sectors under in the various policy scenarios grows by as many as 2,500 jobs if biofuel prices are high and 820 jobs if biofuel prices are low. These results are consistent with the economy's increased dependence on electricity and solid biomass in each of the policy cases. In scenarios where liquid biofuels are heavily used, electricity and forestry benefit somewhat less, while retail (which includes activities selling liquid fuels) does somewhat better.

While individual businesses within industries would experience different degrees of positive and negative impacts in each scenario, as a whole most industries see little net impact. However, a small net impact for should not be confused with a lack of change within a sector, rather that positive and negative impacts roughly balance. In fact, significant changes within many industries should be expected to result from the policies examined here. The policy cases would likely result in a net growth of the industries associated with the clean energy economy, though the extent of this growth beyond that identified for electricity-producing and biomass-producing industries is uncertain. More fuel-intensive businesses, such as those within the transportation sector, would face challenges for which the modeled policy instruments alone may not always compensate.

3 Key insights

The fundamental conclusion of this Total Energy Study is that Vermont can achieve its greenhouse gas emission reduction goals and its renewable energy goals while maintaining or increasing Vermont's economic prosperity. However, to do so will require significant changes in energy policy, fuel supply, infrastructure, and technology. The achievement of these goals will result in a more local energy economy, primarily due to increases in both energy efficiency and the use of electricity generated in Vermont.

TES modeling indicates that the primary and initial technological mechanisms used to achieve the state's goals are generally the same across policy sets: increased energy efficiency; increased electrification of both transportation and heating; use of liquid biofuels for heating and transportation if available; an increased share of building heat provided by solid biomass; and a more local and renewable electricity supply. Each of these, with the exception of expanded use of liquid biofuels, results in an increasingly localized energy economy.

3.1 Interactions with other areas of state policy

The effects that a particular policy/technology pathway may have on other state policies depend on the details of policy implementation. The TES analysis confirms that well-implemented energy policy has the potential for mutually-reinforcing benefits with other policy areas. For example, the FACETS modeling indicates that woody biomass would heat an increasing fraction of Vermont's buildings under each policy scenario, but that the total amount of wood used is unlikely to increase significantly. Harvesting practices that support forest health and sustainability would be required in order to maintain this resource. This suggests compatibility between the energy policies studied here and other policy goals that prioritize air quality, forest health, and efficient use of our renewable resources. Modern wood heating systems installed in weatherized buildings can heat more buildings, more efficiently, while also resulting in better air quality due to improved combustion technology.

Similarly, policy goals related to land use and transportation choices, such as smart growth and transportation demand management ("TDM"), are highly compatible with the state's energy and GHG goals. However the qualitative nature of such broad changes places them beyond the ability of FACETS to accurately capture. Nonetheless, it can be conservatively assumed that smart growth and TDM policies have the potential to reduce GHGs from the transportation sector by 5-10% over the study period.[10] If these policies were implemented in parallel with the examined energy policies, they would have the result of lowering the net cost of the energy sector transition by mitigating the need to utilize the most expensive alternative measures.

The Comprehensive Economic Development Strategy recently completed by the Department of Economic Development[11] has identified renewable energy and energy efficiency as key areas of economic potential for Vermont. The recent Vermont Clean Energy Industry Report[12] identified that 4.3% of the state's workforce is in jobs related to renewable energy or energy efficiency, of which more than half of the employees spend all of their time on clean energy-related work. While the macroeconomic modeling of the FACETS results does not allow precise estimation of the impact of the energy transition on these or other industries, modeling does indicate that the state's energy transition would result in an increasingly local energy sector, with associated increases in local energy-related employment.

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[10] Vermont Agency of Transportation modeling of diverse transportation energy futures using the pilot "Energy and Emissions Reduction Policy Analysis Tool" indicates results in this range.

[11] http://accd.vermont.gov/business/strategic_planning

[12] http://publicservice.vermont.gov/sites/psd/files/Topics/Renewable_Energy/CEDF/Vermont%20Clean%20Energy%20Industry%20Report%20FINAL.pdf

3.2 Technological pillars of the transformation

While each policy scenario and biofuel price assumption generates different modeled energy mixes, all cases revolve around three technological "pillars" upon which Vermont's energy transformation will be built: efficiency, fuel- and mode-switching, and renewable supply. Each of these pillars plays a critical role in supporting the large-scale carbon reductions and renewable energy increases necessary to meet Vermont's goals.

Reduction in total energy demand has been reaffirmed as essential to meeting the state's energy goals while maintaining compatibility with other state policy objectives. Energy demand can be managed through efficiency and conservation; demand shifting and load management; and fuel and mode switching. The discussion of fuel and mode switching, in particular, represents a new direction for analysis since the publication of the 2011 CEP.

3.2.1 Efficiency

Each policy scenario results in improved energy efficiency beyond the efficiency encouraged by already strong Vermont policy (which is itself reflected in the BAU case). Modeled policy options lead to greater efficiency via two primary means. The first is reduction in demand caused by higher energy prices that encourage conservation over time. The second is that increased fuel prices can encourage acquisition or installation of higher efficiency equipment that has lower life-cycle costs.

3.2.2 Fuel- and mode-switching

Modeling of all three policy options indicated that partial or complete fuel switching for both heating and transportation uses plays a critical role in meeting Vermont's energy goals. Depending on fuel price and availability, consumers are expected to shift from fossil fuels to solid or liquid biofuels or to electricity for heat and transport. If liquid biofuels are very expensive or unavailable, the shift to electricity happens much more quickly.

New electric technologies, such as cold climate heat pumps and electric vehicles, are significantly more efficient than the combustion-based incumbent technologies, so this fuel switch is also a type of efficiency improvement. Switching to liquid biofuel, such as distillate blended with biodiesel for heating oil, ethanol for light duty vehicles, or biodiesel for medium and heavy-duty transportation, requires less significant infrastructure change than would the adoption of electricity for any of those purposes. Heating and transportation demand for biofuels would be highly sensitive to the price of those fuels, which would largely have to be imported into Vermont.

While the quantitative modeling undertaken for this TES could not directly address mode switching in transportation (such as increased use of transit or carpools, or freight traveling by rail), such changes also have the potential to displace a portion of energy use while delivering the same energy service (mobility).

3.2.3 Renewable supply

The five renewable primary energy supply resources available to Vermont are solar, wind, hydropower, methane capture, and solid and liquid biomass. Each has strengths and weaknesses, described in detail in the 2011 CEP. Assessment of the use of each of these resources depends on their efficiency of utilization (especially for combustible resources) and the scale and location of energy generation infrastructure.

The TREES scenarios have a stronger influence on the growth of renewable power generation (both in state and out-of-state) than does the Carbon Tax Shift in the low biofuel price case, particularly in the latter half of the study period. In the near to mid-term, growth in renewable energy supply at scale can be secured at lower cost to the energy system through large scale/centralized resources, whether in or out of Vermont. In the longer term, in-state renewable resources of all scales play a more significant role as costs and risks are expected to decrease over time.

3.3 Complimentary policies

The three policy scenarios examined in detail for this Total Energy Study were chosen as illustrative overarching pathways to achieve Vermont's energy goals. Policy implementation outside the idealized world of modeling could require additional policies or programs designed to complement these overarching market-based structures. The Department has identified three general types of these complimentary policies: information and access, strategic investment, and codes and standards.[13]

Information and access policies address real-world shortcomings of a price-based policy instrument such as a Carbon Tax Shift or TREES. These policies enhance markets by providing information, technical assistance, or access to capital, as well as addressing market failures such as the misaligned incentives present between landlords and tenants. They are aimed at ensuring efficient markets where consumers can identify and act upon least cost options.

The technological directions identified in the FACETS modeling could result from adoption of the policies modeled, however strategic investment may be required to spur and shape the early adoption of new technologies and their markets. Research and development may produce examples to build upon to and energy supply or demand reduction options. Policies can build markets for nascent technologies, such as Vermont programs supporting development of farm methane digesters, small-scale solar PV deployment, and bulk wood pellet infrastructure through the Clean Energy Development Fund, or multi-state efforts to advance electric vehicles through the Zero Emission Vehicle Action Plan.[14] Strategic investment that is directed at the highest-cost necessary technologies for achieving Vermont's goals (those used toward the upper right of Exhibit 4) can reduce those costs, or achieve those emission reductions through mechanisms other than price alone. This allows price-based policies to drive optimization without unreasonable direct price impacts.

Codes and standards, such as building energy codes, appliance efficiency standards, vehicle fuel economy rules, and land use plans, serve to avoid lost efficiency opportunities in long-lived products and infrastructure using established technology. Such rules commonly require actions that are demonstrated

[13] This structural formulation is inspired by Grubb, Hourcade, and Neuhoff, *Planetary Economics: Energy, Climate Change, and the Three Domains of Sustainable Development* (Routledge, 2014).
[14] http://www.nescaum.org/documents/multi-state-zev-action-plan.pdf

to have a positive lifecycle economic benefit and lock in economic savings for consumers. Enforcement of these policies ensures that savings occur.

4 Key questions

The following short sections identify a number of questions and issues that have come to the surface as a result of the TES process. The Department expects to engage with each of these points during the upcoming 2015 Comprehensive Energy Planning update process, through both further analysis and stakeholder and public comment.

4.1 Liquid biofuels

The price, availability, and climate implications of liquid biofuels are a primary source of uncertainty in the TES energy sector modeling. The energy modeling conducted for the TES assumed that next-generation liquid biofuels could result in significantly lower GHG emissions than their fossil equivalents (including on a full life-cycle basis). Liquid biofuels considered included corn ethanol, cellulosic ethanol, biodiesel, and bioheat, and did not include biogases (such as from anaerobic digesters or landfills). If liquid biofuels 1) can be used as “drop-in” replacements, particularly in heavy-duty transportation and heating uses (such as replacing diesel fuel or distillate heating oil), 2) are available at Vermont scale and reasonable prices, and 3) are considered to be renewable low-carbon resources, then the least expensive path to meet Vermont’s renewable energy and GHG goals would use them heavily. If, however, these various conditions are not met (biofuels are not available at scale, are very expensive, or are not low-carbon), then Vermont’s least cost path is more expensive, and liquid biofuels play less of a role even though energy and GHG goals are still achievable. Vermont’s risk, however, is that these conditions are largely beyond our control because national policies, markets, and technological development will determine them. This leads to questions of how to mitigate this risk. Should Vermont avoid these technologies as too risky, opting to face a potentially more expensive path? Use them as a bridge to other fuels? Invest heavily in them in hopes of encouraging scale economies, perhaps in concert with regional collaborators?

One option could be to identify some sectors where liquid biofuels are appropriate, and where policies could lean on them for success, but avoid them in other cases. For example, Vermont could pursue different options for industrial process heating applications and heavy duty and on-farm transportation than we pursue for generic residential and commercial building heat. Additional considerations include the economic implications of liquid biofuels, which would generally replace an imported fossil fuel with an imported biofuel.

4.2 Natural gas

One of the larger uncertainties highlighted by the FACETS modeling is the future of natural gas as a significant portion of Vermont’s total energy supply. While in all policy cases the use of natural gas is lower than in the BAU case (where GHG and renewable energy goals are not met), the low-biofuel price Carbon Tax Shift scenario retains significant natural gas consumption through 2050. The low-biofuel price TREES policy reduces natural gas consumption as the last fossil fuel to switch to renewable energy, in the model year 2050. This correlates to the marginal cost in the carbon emission reduction cost curve for that scenario, seen in Exhibit 2, which shows that the final 10% of carbon reductions costs $300-$450 per ton of CO_2e emission reduction. The high-biofuel price scenarios reduce the portion of natural gas from Vermont's energy mix somewhat sooner. All policy cases retain natural gas use equivalent to current levels at least through 2028. These FACETS model outcomes are a result natural gas's smaller burner tip combustion emissions of carbon dioxide and lower cost relative to petroleum-based fuels. This suggests that natural gas could have an important role as a fuel that helps to reduce the state's emissions while mitigating upward pressures (if any) on energy costs.

These results highlight several choices that were made in modeling the state's energy future. Natural gas was modeled as relatively unconstrained by infrastructure over the extended model period, recognizing that economic or policy forces could result in significant expansion of pipeline infrastructure and/or expansion of compressed or liquefied natural gas. The model did not explicitly consider the cost of natural gas infrastructure, but natural gas is expected to remain less expensive than other fossil fuels after accounting for the cost of infrastructure, so such inclusion would have been unlikely to change the general path resulting under each scenario. Finally, a renewable component of natural gas supply was not modeled due to data limitations and uncertainty with regard to its potential magnitude.

4.3 Timing and pace

The FACETS energy system modeling projects significant technological change over time, but it lacks resolution regarding the early stages of market transformation needed to create the potential for those technologies. As a model of rational economic actors, when a new option becomes less expensive, on a life-cycle basis, the model enacts a large-scale switch in a very short period. In fact, new technologies are likely to require early adopters and those with specialized needs to lead the way. There is a transition time, therefore, between a technology's introduction and the point when it becomes ubiquitous among products for sale. Statewide vehicle fleets and building stocks have long lifetimes—10 or more years for vehicles; decades to centuries for buildings—so even if all new cars and buildings embody a new technology, it will take time for the stock to reflect the shift.

There may also be significant synergies (or conflicts) that could arise when fuels are used across sectors. For example, if biodiesel fuel supply is constrained, it may make sense to focus on its use in some sectors prior to others. Electricity requires constant matching between supply and demand, so there may be merit in incorporating technologies with controllable loads at a pace comparable to the introduction of intermittent generation from renewable sources. Matching seasonal generation to appropriate loads may also be desirable.

4.4 Prioritization of goals

When comparing the Carbon Tax Shift to the TREES and TREES Local policy sets, one of the primary points of difference is whether the policy is built upon GHG emissions reductions or renewable energy promotion. Each policy advances both GHG emissions and renewable energy goals. However, the Carbon Tax Shift alone does not meet the goal of 90% renewable energy by 2050, while the TREES policies exceed the 2050 GHG reduction goal, but would need to be accelerated (at a likely additional cost) beyond what was modeled in order to achieve the 2028 GHG reduction goal. This raises the question of the prioritization of goals. If the statutory GHG goals are primary, and renewable energy is pursued simply as a means to achieve GHG emission reductions, then it may be preferable to use a GHG-based policy instrument such as a Carbon Tax Shift. This would also avoid what would then be excess, high-cost GHG emission reductions in the later parts of the period as occur with the TREES policies set to reach 90% renewable by 2050. However, if increased use of renewable energy (as a fraction of the total) is pursued for its own purposes, such as increased locality of energy supply, energy security, and the avoidance of other externalities (such as those related to nuclear power or natural gas extraction), then it may be preferable to use a TREES-like policy set.

4.5 Policy flexibility and control

Related to the question of prioritization addressed above are the questions of certainty and flexibility. The TREES policy sets offer a certain quantity of renewable energy and energy efficiency, and more assurance of emission reductions, but without price certainty (either overall or per ton of emission reductions). In contrast, the Carbon Tax Shift policy offers guidance regarding the value of emissions reductions, which may promote greater investment certainty and lower cost of capital, but provides no certainty regarding the amount of emission reductions achieved.

For example, a TREES policy would achieve renewable energy and GHG emission reduction goals regardless of the price and availability of liquid biofuels. It would cost more in the case where such fuels are not utilized, but the policy would not need to be amended. In the Carbon Tax Shift case, on the other hand, if the tax were set to rise on a path to $450/ton in 2050 assuming access to plentiful and low-carbon liquid biofuels, but those fuels turned out not to be available, the tax trajectory would need to be amended significantly in order to meet the state's GHG emissions goals.

The Carbon Tax Shift policy offers greater policy implementation flexibility to the state government than do the TREES policies. TREES policies have flexibility in policy design (such as determining the parameters of comparability between different kinds of TREES compliance), but are based on the creation of a new and relatively independent market and lack the flexibility to direct significant sums of revenue.

A carbon tax would raise significant amounts of revenue, with the intention that those dollars be returned to Vermonters. The flexibility of a carbon tax lies in how to return that money and maintain revenue neutrality. The potential sums are comparable to or greater than the amounts raised by some of the state's core taxes, including the sales, income, fuel, and property taxes. Some or all of these taxes could be cut significantly in order to balance the carbon tax revenue. Alternatively, the state could issue dividend payments on a regular basis. Commercial and industrial customers are a particular challenge for this aspect of policy design, as they (in aggregate) currently pay less in state taxes than they might pay under a carbon tax scenario; merely offsetting tax reductions would then not be sufficient for revenue neutrality. A dividend option is therefore a possibility, but how would the state decide on the size of dividend for each firm? This policy offers great flexibility, which is associated with the need to make a number of decisions. The effect of regional choices increases the complexity of these decisions.

4.6 Regional and national markets and policy consistency

The FACETS and REMI modeling conducted for this study focused on policy action that impacts Vermont energy supply and demand. REMI modeling supports a conclusion that similar policy action in other jurisdictions is in Vermont's economic interest. Policy and technology choices made in Vermont should be compatible with the choices made elsewhere, or at least recognize and account for them. Vermont has experienced the impacts of being regionally out of sync with respect to renewable portfolio standard policies.

There are three main aspects in which Vermont's policy and technology choices depend on uncertain outcomes of regional or national processes. The first is the potential impact on Vermont's economy of the relative cost of doing business here when compared with other jurisdictions. Vermont policymakers typically choose a path of leadership, to capture early-mover advantage in new markets, while simultaneously working to inspire other jurisdictions to action. This creates markets for Vermont's clean energy firms while also creating an uncertain economic impact if other states do not follow. The second is the area of liquid biofuels, where the national choice made by the heavy-duty vehicle sector between compressed natural gas and biofuels will have an impact on how Vermont adapts.

Third, and more generally, is the question of policy compatibility in the face of regional markets. Where Vermont firms export or import goods, including energy, the policies in other states can have a direct impact on Vermont firms. This exposes Vermonters to a policy risk from changes in other jurisdictions. Similarly, regional and national markets and policies significantly affect the availability and price of renewable or low carbon fuel technologies. For example, if all of New England and New York support similar policies to promote electric vehicles and infrastructure, this may significantly reduce manufacturer costs (passed on to consumers) associated with meeting this broad regional demand. This demand could, in turn, move the national market, further reducing costs. On the other hand, if Vermont acts alone to promote electric vehicles, then the cost to manufacturers (passed on to consumers) may be much higher. To that end, reasonably compatible policy structures reduce risk for all regional states, and have the potential to reduce costs as well.

Vermont cannot make the energy transition modeled in this study on its own, just as it cannot sustain the business as usual path on its own. At the same time, Vermont can also be a policy and technology leader. Based on other experiences, the state's small scale allows faster transitions and more coordinated actions across sectors than is generally possible in other states. Demonstrating policy leadership can set examples for other states or nations. Leadership in clean energy innovation enhances the Vermont brand, with the potential to bring additional firms to Vermont and assist those here and growing.

4.7 Potential in the industrial sector

FACETS modeled Vermont's manufacturing and industrial sector simply as reactive to fuel prices, due to a lack of Vermont-specific industrial energy use data. Thus, technological or fuel shifts that might have been less expensive than the fuels chosen for the sector in the model were not considered. As a result, in this respect FACETS likely overestimated the costs of meeting state policy goals.

These issues identify clear future data and analytic needs for policy design. For example, a more robust picture of the efficiency and fuel-switching opportunities in this sector is needed. While the sector is not modeled completely in this analysis, it will be imperative that state policies reflect the sector's important role in seizing opportunities associated with energy system transitions, increasing Vermont's energy productivity and reducing emissions.

4.8 Access to capital

One of the primary characteristics of the technologies deployed to achieve Vermont's goals is a shift toward energy technologies with greater up-front cost and lower (or no) operating cost (energy efficiency is the clearest example, but also solar, wind, and hydroelectric generators, biomass heating systems, and electric vehicles). This raises the importance of access to capital and financing. To avoid creating barriers to technology deployment, such capital must be straightforward to access, available at Vermont scale, and at rates of interest comparable to risk. While this analysis did identify the capital needed to invest in these technologies over the 36 years ahead to 2050, the TES did not examine the financial structures necessary to access that capital. This question was examined at a pair of Clean Energy Finance Summits in 2012 and 2013 co-organized by the Department, and continues to be an area for the Department to explore in collaboration with other state finance entities and stakeholders.

4.9 Carbon accounting

10 V.S.A. §578 articulates the goal of the state to reduce greenhouse gas emissions from "within the geographical boundaries of the state and those emissions outside the boundaries of the state" caused by Vermont's energy use. As noted above, the greenhouse gas impacts described in the TES are from a "burner tip" perspective; they represent the amount of fossil fuel emissions emitted at the point of end use, or in the case of electricity, biomass, or biofuels at the point of production. This treatment is comparable to that currently used by the State to calculate GHG emissions. However, GHG emissions resulting from Vermont energy use include the impacts associated with that energy throughout all stages of its life-cycle, from fuel extraction, processing and production—through transportation, delivery and end use combustion. It is unclear how modeling results would change if carbon were measured in this manner, or if the assumptions made for this analysis regarding biomass and biofuel net carbon impacts were higher or lower. For example, in the Carbon Tax-shift policies, would nuclear energy remain part of the electricity portfolio if lifecycle emissions were included? Carbon-emission based policies are likely to be more sensitive to the results of emissions calculations than are renewable-based policies. Consensus values for life-cycle emissions for all types of fuels are not currently available. While incomplete, "burner tip" analyses offer clear comparisons to historical data, and are generally more straightforward calculations. Alternative options would require addressing the question of whether the state should prioritize emissions reductions from energy used solely within the state, or also emissions reductions elsewhere that could have an impact on Vermont's lifecycle emissions. This question also highlights the need for clearly articulating lifecycle analysis methodology and data.

5 Next steps

This report concludes the Department's formal efforts of the Total Energy Study, required by Act 170 of 2013 and Act 89 of 2013. The results identified in this report and its appendices contribute to the substantial body of analysis that the Department has at its disposal as it prepares to produce the 2015 Comprehensive Energy Plan update. The Department anticipates a multi-faceted effort to produce that Plan, including both additional quantitative and qualitative analysis, conducted by in-house and outside experts under contract as well as by interested members of the public and outside organizations. During the late fall and winter of 2014-2015, the Department plans to engage with members of the public and the Legislature regarding the results of this Total Energy Study. The formal public process for the 2015 CEP will take place beginning in early 2015 and will include multiple rounds of public engagement via written comments, public meetings, and presentations to and solicitations of input from stakeholder groups, extending throughout 2015. The Department welcomes engagement on any and all aspects of the Comprehensive Energy Plan.

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The Total Energy Study would not have been possible without the active engagement and contributions of more than one hundred Vermonters who volunteered their time and effort to meet with Department staff and submit written comments. The Department is also indebted to the assistance of partners from many other Agencies and Departments, coordinated through the Climate Cabinet. The Department thanks its current and former staff who ran the study process and wrote this report and several of its appendices: TJ Poor, Ed Delhagen, John Woodward, Karin McNeill, Kelly Launder, and Asa Hopkins; and the Regulatory Assistance Project and Dunsky Energy Consulting for providing their expertise and assistance.

Appendices

A. "Policy Options for Achieving Vermont's Renewable Energy and Carbon Targets." Prepared by the Regulatory Assistance Project for the Vermont Public Service Department. 2013.
B. "Total Energy Study: Progress Toward a Total Energy Approach to Meeting the State's Greenhouse Gas and Renewable Energy Goals." Public Service Department. Report to Vermont Legislature, Dec. 15, 2013.
C. "Energy Policy Options for Vermont: Technologies and Policies to Achieve Vermont's Greenhouse Gas and Renewable Energy Goals." Prepared by Dunsky Energy Consulting for the Vermont Public Service Department. 2014.
D. "Economic Modeling Analysis of Total Energy Policies." Public Service Department, Dec. 5, 2014.
E. "Total Energy Study: Public and Stakeholder Engagement Appendix." Public Service Department. 2014.

RAP Energy solutions for a changing world

Policy Options for Achieving Vermont's Renewable Energy and Carbon Targets

Prepared for the Vermont Department of Public Service
June 2013

The Regulatory Assistance Project
Beijing, China • Berlin, Germany • Brussels, Belgium • Montpelier, Vermont USA • New Delhi, India
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I. Introduction

The purpose of this report is to provide an overview of the most promising technologies and policies available to Vermont as it crafts a plan for achieving the state goals referred to in Act 170 of 2012: 90 percent of the energy consumed across all sectors of the economy in the state will be renewable energy by 2050, and the state will reduce its greenhouse gas emissions by 75 percent from 1990 levels by 2050. The report is intended for use by the Department of Public Service to facilitate a stakeholder process in which discussions will be held about these goals and the means to reach them.

a. Vermont's Goals

The global scale of the climate change challenge, together with health, environmental, and other concerns associated with heavy dependence on fossil fuels, requires significant actions to resolve. Accordingly, Vermont established in the 2011 Comprehensive Energy Plan the goal of sourcing 90 percent of its energy from renewable resources by 2050 as a way to meet the statutory goal, established in Act 168 of 2006, of achieving a 50 percent reduction in carbon levels from a 1990 baseline by 2028 and a 75 percent reduction by 2050. Vermont's goals appear to be consistent with the scale of the global challenge. Vermont now needs to complement its statutory ambition with equally strong, effective policies to achieve these goals. To respond adequately, the policy interventions will need to be early, significant, and sufficient to ensure that the course corrections Vermont makes are consistent with the scale and scope of the challenges ahead.

Vermont's statutory initiative comes at a critical time, as the climate challenge is well established. In 2007, the United Nations' Intergovernmental Panel on Climate Change (IPCC) concluded, "[w]arming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level."[1] These changes over the past 50 years are very likely due to anthropogenic greenhouse gas increases and are likely have had a discernible influence at the global scale on many physical and biological systems.[2] The IPCC conclusions have been reinforced by widespread consensus among the scientific community:

> (i) 97–98 percent of the climate researchers most actively publishing in the field support the tenets of ACC [anthropogenic climate change] outlined by the Intergovernmental Panel on Climate Change, and (ii) the relative climate expertise and scientific prominence of the researchers

[1] Intergovernmental Panel on Climate Change (2007).

[2] *Id*.

unconvinced of ACC are substantially below that of the convinced researchers.[3]

However, despite the apparent international scientific consensus on the challenge, current baseline projections by the United States Department of Energy (DOE) and the United States Energy Information Administration (EIA), as shown in Figure 1, continue to put the United States on a path of continued reliance on carbon-emitting fuels exceeding climate targets through the foreseeable future.

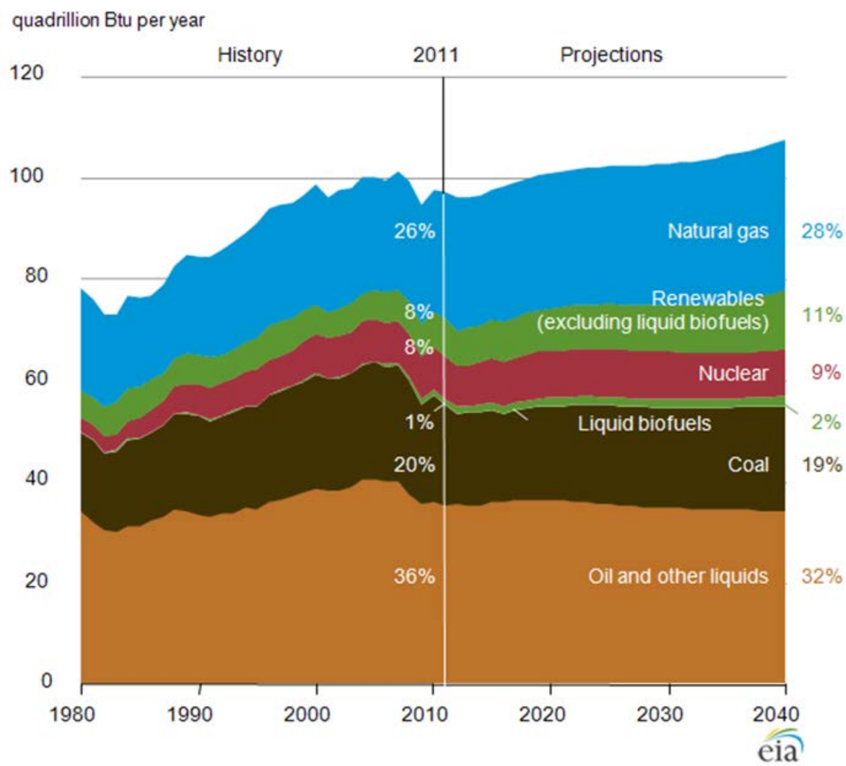

Figure 1: US Primary Energy Consumption by Fuel, 1980-2040

A number of factors will make this dramatic change even more challenging. For example, the slow turnover of the building and transportation vehicle fleet and the cumulative and persistent nature of carbon in the atmosphere underscore the need for decisive action now. Most transportation emissions come from passenger vehicles, with transportation accounting for approximately 28 percent of greenhouse gases nationally and about 47 percent for Vermont.[4,5] The average life of a car on the road today is 10.8 years.[6] According to the most recent

[3] Anderegga, *et al.* (2010).
[4] U.S. Environmental Protection Agency (2013d).
[5] Department of Environmental Conservation Air Pollution Control Division (2010).
[6] Gorzelany (2013).

inventory, fuel use in buildings accounts for about one third of greenhouse gas emissions in Vermont, and the average life of the building stock is quite significant. [7] While it is clear that these sectors require significant changes because of the scale of their impact on the environment, it is equally clear that the required transformation of such long lived and expensive items will be a challenge to achieve. To meet the state's energy and climate goals, the existing building stock will probably require new heating technologies and energy sources, and Vermont may need a significant electrification of the light duty vehicle fleet, coupled with a virtually complete shift from fossil fuel to biofuels for the remaining light vehicles using internal combustion engines (ICE). Biofuels or natural gas may become viable fuel options in the future for ICE-powered heavy duty vehicles.

The magnitude of the problem gives an indication of the scale and timing of the needed changes. It is important to recognize that the nature of Vermont's contribution to climate change is cumulative. Carbon dioxide molecules persist in the atmosphere for 50 to 200 years.[8] Thus, significant, concerted change is required earlier rather than later. Earlier changes are much more impactful than later changes because they prevent further cumulative damage to the environment. Significant steps early also help to reduce the impacts from the lock-in of highly polluting and inefficient capital items that later must be scrapped or retrofitted to maintain a path of achieving the 2050 objectives. Additionally, regional, widespread change is preferred over individual or local change because of the greater scale of impact that can be derived from regional efforts.

Once the scale and urgency of the challenge is understood, the type of policy interventions that make sense to pursue come into greater focus. Not all of the policy pathways to cleaner energy are equally grounded in the public interest. The costs and cost-effectiveness of these strategies will vary. Some of the pathways simply do not address the scale of the challenge, no matter how favorable the economic case. Other strategies leave Vermont more exposed to different types and magnitudes of financial risk. Some pathways are not well suited to pursuing at a municipal or state level due to scale diseconomies. In such instances, Vermont may need to play either the cooperating partner or advocate in the move to affect needed change at the regional, national, or even international level. Further, change cannot happen overnight. Government is advised to resist quick improvement schedules that meet public approval but may not allow the economy to adjust in an orderly way.

[7] Department of Environmental Conservation Air Pollution Control Division (2013).
[8] U.S. Environmental Protection Agency (2013b).

While the challenge is significant, there are some positive notes to sound. The cost of clean energy technologies is decreasing.[9] The electrification of passenger vehicles (the primary source of carbon in transportation) appears both a viable option and, perhaps, an increasingly inevitable pathway accepted by most analysts and pursued by the industry. Further, electric vehicles may prove to be less costly to operate than the current stock of internal-combustion vehicles. Investment in energy efficiency, an essential ingredient in the policy mix, grew dramatically over the last five years. In 2010 alone, Americans spent between $479 and $670 billion on energy efficiency goods and services.[10] Targets for energy efficiency investments are also growing rapidly globally. Electricity load growth stabilized in many regions of the U.S., including in Vermont, which has experienced negative load growth in recent years. There is also a growing appreciation that clean energy solutions are not just the right thing from the environmental standpoint, but also make sense from the standpoint of economic development and national security.[11] Furthermore, many states have taken up the environmental challenge and are moving forward at an impressive pace. 30 states established targets for renewable energy, and California and other states established carbon targets and participate in cap-and-trade programs. Electricity sector planning initiatives for high levels of renewables are taking place across the nation. All of these activities should give Vermont confidence that the climate challenge can be and is being met.

b. Impediments to Change

Before considering what policy options to employ in meeting Vermont's goals, one must first recognize that certain factors contribute to our continued dependence on carbon-emitting fossil fuels. Chief among them are:

- **Public understanding**: Even while the vast majority of the worldwide scientific community reinforces the conclusion that climate change is a manmade phenomenon largely driven by the use of fossil fuel, there are persistent voices in the United States casting doubt on that claim. In a democratic society like the United States, improving public understanding through quality sources of information and education will be a required step in any effort to take the right path on climate change.
- **Market, regulatory, and behavioral failures:** A host of market, regulatory, and behavioral failures are associated with the failure of markets to internalize certain "external" costs associated with the extraction, production, generation, and sale of the energy commodity. This dynamic masks the true cost of fossil fuels to our society and

[9] ClimateProgress.com (2013).
[10] Laitner (2013).
[11] CNA Analysis and Solutions (2009).

globe. These costs are ultimately borne separately by the public in the cost of health care, environmental quality, and national defense, to name only a few.[12]

- **Voter paradox:** As members of the global community, we are, in effect, faced with a dilemma analogous to that of the citizen voter or community volunteer. A rational voter acting only in her immediate self-interest might conclude that her vote is unlikely to produce benefits that will make the effort to self-educate and exercise the participation worthwhile. But, in the aggregate, such decisions (or abdications of responsibility) can lead to a general breakdown of the community. In a similar vein, the global community requires effective contributions from each member nation to overcome the shared threat of which they are all, in varying degrees, the cause. But this circumstance also creates a welcome and ironic opportunity. Early in the fight against global warming, the actions of a single nation or of even a single state, already beneficial to itself, can have wider and altogether disproportionate effects. This is the threat of a good example, and one need look no further than Vermont's leadership role in the development of the Regional Greenhouse Gas Initiative (RGGI) to see ample proof of its power.
- **Regulatory oversight:** The gas and electricity sectors have long existed as regulated natural monopolies. Sometimes regulators fail to create the frameworks necessary to encourage market participants to perform in ways consistent with the broader public interest. They may, for example, fail to adopt rate designs, planning frameworks, critical standards, or regulatory incentives that fairly align the public interest with consumer interests when making purchases or operator interests when planning for future system needs. This dynamic leads to over-investment in fossil fuel generation.
- **Entrenched interests:** The nature of any system is that the pre-existing economic interests also have a strong interest in resisting change that may adversely affect the status quo.

Once one recognizes these failures, policy options can be considered with these failures in mind. Well-conceived policy interventions and effective leadership, supported by a strong public commitment, are essential to ensuring markets are properly incented to overcome the failures noted above and deliver outcomes in line with the larger public good.

[12] Beyond the significant concerns for health and the environment that go under accounted, there are a host of other market failures commonly cited in the literature. The interested reader should refer to Helbling (2012).

II. Technology and Resource Pathways to Meeting Vermont's Goals

In order to achieve the objectives for renewable energy and carbon reduction, it helps to understand the technology pathways available for success. Technology options and pathways can change over time, and there is considerable inertia behind each pathway. Some pathways are more expensive or create greater risk of falling short of targets. Other pathways may be achievable even given the state of existing technologies. The following section discusses qualitatively the technology and resource pathways available to achieve the stated goals. It largely focuses on existing technology and promising developments.

a. Energy Efficiency and Load Management

1. Energy Efficiency

Studies for the state of Vermont to estimate the potential savings from cost effective energy efficiency consistently show the availability of a large reservoir of energy savings. Ratepayer funding from regulated energy sources (electricity and natural gas) has enabled aggressive capture of these savings. However, obtaining savings from the non-regulated sector has proven much more difficult. Significant, achievable savings are still available from the electric sector and the unregulated fuel sector, even assuming only current technology.[13,14,15] Improvements in technology can and will increase the energy efficiency of all sectors and create new opportunities for programs to augment savings opportunities. Capturing this energy efficiency resource will make it easier to achieve the state's goals. For example, to the extent that total energy use is reduced, a smaller absolute amount of renewables will be needed to meet the 90 percent target.

Many opportunities for improvement will come from forces moving at the national level. As is discussed more fully below, electric vehicles are making great strides toward achieving the full utility of gasoline powered vehicles and lightweight components also have the potential to increase the efficiency of gasoline fueled vehicles. Efficiency in the buildings sector is tremendously cost effective, and advances in windows, space conditioning equipment, heat pumps, and LED lighting will open up new opportunities for savings. Smartphone applications allow users to control appliances and lights remotely. Innovation in industry is making the

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[13] Vermont Department of Public Service (2007). A 12 percent reduction in total fuel consumption annually (on a combined MMBTU basis) in the residential, commercial, and industrial sectors is possible.

[14] Cadmus Group (2011). Energy efficiency could achieve a reduction of 25.4 percent of forecasted kWh sales in 2031, and 19.9 percent of 2031 forecasted summer peak demand.

[15] *Id*.

bottom line more competitive, with energy and process efficiency becoming a leading choice for plant managers to shave production costs.

Much can also be done on a regional or state level, working in conjunction with those forces driving efficiency nationally. One role of the state is to recognize trends emerging on a national level and create conditions that foster the adoption of new technologies or business practices in Vermont. The state already has an excellent efficiency resource in Efficiency Vermont, as well as Burlington Electric Department and Vermont Gas Systems. In addition to the efficiency services they provide homeowners and businesses in the state, Efficiency Vermont has built relationships with contractors and retail outlets that will prove invaluable in bringing new technologies to the unregulated fuels market. Leveraging Efficiency Vermont will be critical to the success of additional efficiency efforts in Vermont. Other policies and actions by the state can make it more likely that residents will adopt efficient technologies and habits in the future.

The strong local voice of many concerned citizens and their ability to organize around a crucial issue like energy efficiency, are resources Vermont cannot overlook. Harnessing this power can give Vermont a strong ally in its efforts to meet the state's energy and climate goals.

2. Load Management and Storage Capabilities

Increasing the penetration of renewable energy sources in the electric resource portfolio will necessitate the introduction of balancing resources that can function to match the intermittent nature of renewable supply resources with the load. Some renewable energy is variable because it relies on the wind blowing or sun shining to generate energy; this means energy production can go up and down outside of the control of system operators. This differs from traditional generation, which can be dispatched at will to meet the existing demand for electricity. Balancing resources are those resources the system operator uses to make up the difference between existing demand for electricity and the currently available amount of renewable energy. These balancing resources can come from a variety of sources, including quick response generation or storage capabilities (batteries or vehicle to grid applications hold promise for the future). However, there is considerable inexpensive flexibility and storage capability on the customer load side – from controllable loads, especially those with thermal storage capacity, and demand response initiatives. The old paradigm that generation must be prepared and able to meet whatever load appears on the system is changing with the advent of advanced metering systems, smart grid, and remote load control devices.

Tremendous potential exists to control electric water heaters. In New England, about one third of the water heaters are electric, and controlling these through smart meters or other technology represents an inexpensive, low-tech, already deployed resource that could be harnessed to support renewable integration.[16] ISO-New England already has seen significant growth in its demand response programs, and advances in technology will allow more and smaller loads to participate economically in this market through aggregators and other service innovators.

On the load side, the price of batteries for electric vehicles is decreasing while performance is improving. As penetration of electric vehicles and charging stations increases, vehicles could become an important balancing resource. Vermont and New England could also look to Hydro Quebec with its controllable hydro system as a large scale balancing resource.

b. Fuel Choice

1. Electrification

Several large studies have concluded that achieving carbon reduction objectives on the order of Vermont's goals cannot be accomplished through efficiency improvements alone.[17] Renewable systems must play a major role, and the significant electrification of both the transportation sector and the buildings sector will be necessary to meet Vermont's greenhouse gas reduction goal. Electrification of buildings impacts assets with long lives, so developing responsible policies in the near and long terms to promote electrification of end uses in buildings will contribute to meeting the state's goals, provided they are supplied with sufficient renewable and non-carbon emitting electric generation.

Technology is developing to enable this, and policy can push it faster. Electric heat, long on the list of undesirable technologies, is now poised to cost effectively harness renewable energy in the form of efficient air source heat pumps that can operate adequately in the Vermont climate.

i. End Use: Electric Vehicles

The transportation sector comprises a significant percentage of Vermont's fossil fuel energy use and produces substantial emissions. Advanced vehicle technologies, such as plug-in hybrid electric, full battery electric, and fuel cell electric vehicles, can contribute to the electrification of the transportation sector, replacing gasoline powered cars. When combined with electric generation resources powered by renewables, the use of electric vehicles offers the potential for important reductions in Vermont's fossil fuel use and related greenhouse gas emissions.

[16] Energy Information Agency (2009).
[17] See European Climate Foundation (2010), Johnston & Wilson (2012), and Maryland Electric Vehicle Infrastructure Council (2012).

In addition, an electric vehicle fleet, coupled with existing smart grid technology can provide utility grid load and supply management benefits. A 2012 Fraunhofer Institute study showed that in California, and in a beneficial but lesser extent in Germany, plug-in electric vehicles can even out the intermittent nature of renewable generation and contribute to the integration of renewables to the grid.[18]

Adoption of electric vehicles experienced a slow start for several reasons, not least of which is the current retail cost of the vehicles. In addition, there is very little infrastructure in place for charging vehicles in public, increasing the so-called "range anxiety" of would-be electric vehicle owners who fear the vehicles will limit their mobility beyond a localized area close to home. Electric vehicles are not likely to become mainstream unless there is a solid array of charging options.[19]

Despite the slow start, every major manufacturer now offers at least one electric vehicle model, and it is evident the automobile industry is trying to create a mass market for electric vehicles. Projections of electric vehicles as a percent of new vehicle sales by 2030 vary widely from 10 percent to 50 percent. Even on the lower end of this scale, significant numbers of new electric vehicles could be added to the fleet over the next two decades.

Successfully increasing electric vehicle penetration will require many actions, but supportive measures implemented in the near term may reduce or remove barriers to commercialization. Highly valued among these actions is solid investment to establish numerous, widespread, and publicly available charging stations. In addition, Vermont communities can provide local zoning and planning regulations that not only allow but actively encourage the necessary infrastructure in support of widespread use of electric vehicles.

The cost of batteries for electric vehicles is decreasing while performance is improving, and electric vehicles are advancing rapidly toward providing equal utility to a gasoline powered vehicle. The DOE "EV Everywhere Grand Challenge" aims to produce a plug-in electric vehicle within 10 years that is "as affordable for the average American family as today's gasoline-powered vehicles"[20]

Present technology (i.e. the Nissan LEAF battery-electric vehicle) uses about 0.34 kwh per mile. At an average electric rate of 14 cents per kwh this results in a cost of $1.40 for 30 miles of

[18] Dallinger, *et al.* (2012).
[19] Maryland Electric Vehicle Infrastructure Council (2012).
[20] U.S. Department of Energy (2013b).

driving (10 kwh for 30 miles).[21] A reasonably fuel efficient gasoline powered car getting 30 miles per gallon would cost $3.60, more than 2.5 times as much, to drive the same 30 miles.[22] Assuming an average of 11,000 miles driven per year, the all-electric vehicle could save as much as $800 annually on fuel costs. Critically important to this discussion and the future electric vehicle market success is the development of electric rate designs such as time of use (TOU) and dynamic pricing that may lower the purchase price of electricity for vehicle charging, helping to make the vehicles cost competitive and encourage their use. In addition, implementing practices that allow electric vehicles to participate as a consumer rate class in wholesale electricity markets will enhance value and encourage greater deployment.

Electric vehicle interconnection and related grid reliability may be an issue at the local electric distribution system level. Vermont's *Comprehensive Energy Plan* encourages distributed utility planning as a method to improve and strengthen the grid delivery system. This approach is consistent with the ability to address any complications created at the local distribution level as electric vehicles are added in increasing numbers in Vermont.

ii. End Use: Heat Pumps[23]

Heat pumps are electrically powered appliances that employ refrigeration cycles (similar to those used in air conditioners or refrigerators) relying on temperature differentials to provide either heating or cooling to the inside of the building. Two popular designs are air to air heat pumps, which extract energy from the outside air, and ground source heat pumps, which employ buried pipes and rely on the soil's relatively constant temperature to provide energy.

Widespread adoption of heat pumps has the potential to displace large volumes of fuel oil, natural gas, and other fuels presently used for heating homes and buildings in Vermont. This technology offers considerable promise to achieve Vermont's renewable energy and greenhouse gas emission goals. Heat pumps rely on electricity, so when their use is combined with a renewable electric supply they can provide 100 percent renewable energy for heating.

iii. End Use: Air Source Heat Pumps

Air source heat pumps are cold climate capable for significant displacement of fossil fuel but generally are not recommended in Vermont for the full replacement of an existing heating system. Rather, they may be targeted at displacing the use of fossil fuels to save money and reduce carbon emissions. Also known as cold-climate heat pumps or air to air heat pumps, this

[21] Union of Concerned Scientists (2012).
[22] Approximate cost of regular (87 octane) gasoline in Vermont, May 2013.
[23] See http://www.efficiencyvermont.com/for_my_home/ways-to-save-and-rebates/energy_improvements_for_your_home/Cold-climate-heat-pump/overview.aspx.

technology has been used in Europe and Japan for several decades for space heating and cooling, dehumidifying, and domestic water heating.

The efficiency and performance of modern air source heat pumps is significantly greater than those available 30 years ago as a result of technical advances, including variable speed blowers and compressors and improved coil and motor designs. A key to successful performance in Vermont's northern climate is variable frequency drive compressors that allow more highly efficient operation at a variety of load levels and temperatures. In addition, consistent with international accords, older, environmentally damaging refrigerants are being phased out.[24]

Efficiency Vermont is developing a rebate program for Cold-Climate Heat Pumps,[25] and Green Mountain Power offers a limited rental program for legacy Central Vermont Public Service customers.[26]

iv. End Use: Ground Source Heat Pumps

Ground source heat pumps, sometimes referred to as geo-exchange, earth-coupled, geothermal, or water-source heat pumps, have been used since the late 1940s.[27] They rely upon the relatively constant temperature of the soil a few feet below the ground to provide building heating and cooling. Ground source heat pumps offer flexibility of installation and can be adapted to a variety of buildings, lot sizes, and locations, including single- or multi-family dwellings and commercial retrofit or new construction.

Significant barriers to widespread support and deployment of ground source heat pumps in Vermont include the relatively high cost of initial installation, as well as a lack of agreed-upon installation standards and best practices to ensure that the most efficient models of ground source heat pumps are installed.[28]

2. Electricity Supply

i. Solar Electric

Sunlight generally is considered the most abundant renewable energy resource. The *Comprehensive Energy Plan* states, "For illustrative purposes only…Vermont's solar resource could generate 100 percent of the state's annual electricity consumption….[using]~0.25 percent of the states total land area." Electric generation from solar photovoltaic (PV) recently became a significant and growing source of electric generation in Vermont. Continuing advancements in

[24] U.S. Environmental Protection Agency (2012b).
[25] Efficiency Vermont (2013).
[26] Green Mountain Power (2013).
[27] U.S. Department of Energy (2012).
[28] Vermont Department of Public Service (2011).

efficiency and significantly reduced costs in solar cell technology make it a probable major resource for Vermont's renewable energy future. The cost of PV cells has dropped dramatically (40 percent in last 6 years) as manufacturing achieves economies of scale, and prices are expected to continue to drop further in the future.[29]

Solar PV installations offer many advantages, including quiet operation, low maintenance, and a high coincidence of producing power when it is needed most during hot summer afternoons. PV systems can be installed on rooftops or the ground and can be fixed-rack, fixed-pole, or tracker mounted. In Vermont, residential PV systems are 10 KW or less, while commercial or community PV is 500 KW or less. Generally, PV systems more than 500 KW are considered utility scale, with numerous generating systems in operation or under development in Vermont that are multi-megawatt in size. Significant in-state expansion of solar PV electric generation is expected in the coming years, with PV playing an increasingly important role in Vermont's energy future. The *Renewable Energy Atlas of Vermont* reports more than 1,400 solar PV systems are installed, totaling more than 30 MW of capacity as of May 2013, an increase of approximately 60 percent from the previous year.[30]

ii. Solar Heating

Solar water heating systems can provide hot water for use in homes or businesses and is an excellent way to help heat a swimming pool. Use of solar can reduce significantly fossil fuel usage and related expenditures by 60% to 70% for domestic hot water.[31] Most solar water heaters are active systems with a pumping mechanism that moves water through the panels where it is heated and then into a traditional electric or gas water heater. While they substantially reduce the fuel use, solar water heating in Vermont does not usually completely displace the need for a conventional heater for either domestic hot water or pool heating.

Experienced firms have been successfully selling or installing solar equipment for many years in Vermont. The technology continually improves but has matured to a point where it is both effective and practical in the Vermont climate. Solar water heating systems depend upon manufacturing scale that is suitable for Vermont and may offer potential for additional economic development in the state for production or assembly of components.[32] Vermont currently hosts 331 solar hot water installations.[33]

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[29] Vermont Department of Public Service (2011).
[30] Renewable Energy Atlas of Vermont (2013).
[31] Vermont Department of Public Service (2011).
[32] *Id.*
[33] Renewable Energy Atlas of Vermont (2013).

Vermont's northern climate limits the available solar energy for building heat; however, passive building designs can capture the sun's heat even in winter. Currently, solar heating for buildings seems to offer small potential but warrants some consideration, especially for new construction if buildings can be properly sited with south-facing orientation and designed with a storage medium built in with the initial construction. As with active water heating, in most cases the solar energy gain supplements but does not displace the need for other heating systems.

iii. Wind Power

New wind generation is the least expensive form of new renewable electric generation to build in Vermont.[34] Wind power has been the fastest growing electric generation resource over the past several years in the world, in the U.S., and in Vermont. 100 Countries are using wind power, with worldwide wind power generating capacity at more than 280,000 MW. In 2012, almost 45,000 MW of new wind power capacity was added internationally, a 19 percent increase, which is the lowest percent increase in more than 10 years. These wind turbines provide 580 million MWH per year or 3 percent of the world's electric production.[35]

Approximately 120 MW of large scale wind projects and about 12 MW of small scale wind projects operate in Vermont. The state has several options for increasing the wind power used in Vermont, including in-state utility scale wind projects; small-scale wind turbines that may be net metered installations serving homes, businesses, and communities; and purchases from developments in surrounding states.[36] Surrounding states and the Province of Quebec, as well as the state of Maine, have substantial on-shore and off-shore wind resources with expectations that significant wind power development may be realized in the coming decades.

Recent studies by the U.S. Department of Energy and National Renewable Energy Laboratory (2003 and 2010) conclude that the technical potential for wind development in Vermont is around 6,000 MW of electric generation when all possible locations with suitable wind regimes are taken into account. Practical and reasonable levels of development, once all competing considerations are accounted for, are far less. However wind is one of the most abundant renewable energy resources available to Vermonters.[37]

The New England Wind Integration Study, published in December 2010, reported that wind could reliably meet up to 24 percent (12,000 MW) of the region's electricity needs in 2020

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[34] Vermont Department of Public Service (2011).
[35] World Wind Energy Association (2013).
[36] Vermont Department of Public Service (2011).
[37] *Id*. Sites are eliminated as various factors are considered, including environmental matters, visual issues, ownership patterns, access to transmission, and other factors.

under certain assumptions.[38] Wind generation also can displace fossil fuel generation, primarily from natural gas-fired plants, which currently provide about 50 percent of New England's power. The natural gas-fired fleet is very flexible, can ramp up and down quickly, and can be operated in a manner compatible with large amounts of wind and other intermittent renewable capacity on the New England grid. ISO-New England does not anticipate the backup capacity requirement of wind or other variable resources will be a major cost or impediment to an efficiently integrated system in New England.

Few topics have split the environmental community as much as development and use of large scale wind power. The *Comprehensive Energy Plan* states,

> The windiest areas in Vermont are most often on the higher-elevation ridgelines that can host sensitive habitats for plants and wildlife and are the source of the state's most pristine headwaters. In previously road less areas, permanent road access is built to service the wind facility. These environmental disturbances can impact wildlife and people in the vicinity of a wind facility.[39]

Ridgeline development also raises aesthetic concerns from the visual impacts of both the turbines and required nighttime lighting. These are valid issues that must be addressed regarding wind power development in-state. Siting and permitting are critically important to successful employment of wind. In recent years, there has been a significant effort by a minority of residents to oppose under all circumstances wind power development on ridgelines in locales where utility scale wind power projects have been proposed. It is important for the state to address issues raised by stakeholders in a comprehensive way so proper consideration of competing interests is provided in all cases. For wind siting and all other Section 248 siting proceedings, the Department of Public Service and the Public Service Board should consider developing a mediation program to be used to resolve disputes among parties.[40]

The existing permitting process set forth in Title 30 VSA, Section 248 and administered by the Public Service Board is intended to address all pertinent issues. The recent report by the Governors Siting Committee reaffirmed that this existing Certificate of Public Good (CPG) requirement is comprehensive and properly placed in the responsibility of the Public Service Board.[41] However, the report recommends a number of steps to improve the CPG process,

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[38] ISO-New England (2010).
[39] Vermont Department of Public Service (2011).
[40] *Id.*
[41] Vermont Energy Generation Siting Policy Commission (2013).

including drawing in local and regional planning interests in a more substantial manner. Vermonters care about the natural environment, wildlife, recreation resources, and view shed offered throughout the state; however, they also support the increased use of renewable resources, including two-thirds of the residents supporting utility scale wind turbine development on Vermont ridgelines.[42] Vermont should continue to facilitate development of in-state wind projects in order to achieve the state's renewable energy goals.[43]

iv. In-State Hydroelectric

The *Comprehensive Energy Plan* reports that 68 FERC-licensed hydropower facilities in Vermont with capacity of more than 150 MW, generated about 8 percent of the electricity consumed in Vermont in 2009. Current state policy supports the development of environmentally sound in-state hydroelectric projects.

Opinions differ widely on the amount of additional "environmentally sound" hydropower that is available in Vermont; however, most people agree that the best hydropower sites already have been developed. There are very few undeveloped sites with existing dams that could support capacity greater than 1 MW and a relatively low number in the 500 kW to 1 MW range. There are many potential smaller community and residential sites sized at less than 200 kW. The Agency of Natural Resources recently approved sites with generation capability as low as 15 kW and 50 kW. Any large, new hydroelectric facilities in Vermont (greater than 10 MW) would probably require construction of new dams, which raises a number of biological and ecological issues, as well as competing uses of the river and related land resources. The Agency of Natural Resources is updating an assessment of the undeveloped in-state hydro capacity.

The *Comprehensive Energy Plan* suggests that an effective way to increase hydroelectric capacity is to improve efficiency and output at existing hydroelectric facilities through three types of activities: installing more efficient turbines, installing small turbines at the dams that utilize bypass flows, and installing new turbines that can operate efficiently over a wider range of flows. In addition, existing municipal water supply and wastewater treatment pipelines could capture the energy in these systems by installing hydro turbines to the pipelines without otherwise altering the regular operation of the system. Such in-pipe hydroelectric systems have minimal environmental impact and have been successfully installed in Vermont.

v. Imported Large-Scale Renewable Resources

Vermont has a long history of relying on an energy mix from clean renewable energy resources from our neighbors in Quebec. Large hydro and wind resource projects have been developed

[42] Castleton Polling Institute (2013).
[43] Vermont Department of Public Service (2011).

and continue to be developed in Quebec and in Labrador. Large wind projects are being developed in Maine, New Hampshire, and New York. Provided that there are adequate transmission corridors to Vermont, these projects offer potential opportunities to access utility-scale, clean sources of power.

vi. Biomass and Biofuels

Biomass and biofuels presently (and historically) provide an important portion of Vermont's energy supply. Currently, biomass meets about 6 percent of the electric load and 14 percent of heating needs in Vermont. Recent assessments indicate the use of wood and other biofuels could be expanded consistent with sustainable, monitored forest management practices.[44]

vii. Biodiesel and Bioheat

Production of liquid biofuels from plants and agricultural wastes is an opportunity for agriculture in Vermont, especially for biodiesel used in farming equipment. It also offers promise as a transportation fuel for local, short haul purposes, and as a heating fuel for buildings. Vermont farms may realize benefits, including fuel cost reductions and an additional product to market while helping to reduce reliance on traditional fossil fuels. In addition, possibilities for use of biodiesel or mixed fuels from local sources or produced elsewhere, such as B20 (a fuel consisting of 20 percent biodiesel and 80 percent petro-diesel) in trucks and heavy duty vehicles warrants further exploration in Vermont. On-farm research and development is increasing the potential for achieving substantial savings with biodiesel derived from agricultural crops. Promising research into the use of algae as a source of biodiesel suggests potential benefits in the coming decades. The same biofuel can be used for building heating systems (bioheat) and offers another market and an avenue to offset fuel oil and other fossil fuels used for heating.

viii. Woody Biomass

While woody biomass is renewable when harvested appropriately, it is not inexhaustible. The 2012 *Biomass Energy Development Working Group Final Report* indicates good management practices likely will both improve Vermont's forests and provide for on-going, increased yields of biomass for energy.[45]

The *Biomass Energy Development Working Group Final Report* recommends the increased use of wood-fired district heating and also recommends the state develop incentives to encourage the efficient use of wood for home heating. The working group also endorses converting schools, government offices, hospitals, industrial parks, and college campus facilities from oil to

[44] Governor's Commission on Climate Change (2007), Vermont Department of Public Service (2011), Biomass Energy Development Working Group (2012).
[45] Biomass Energy Development Working Group (2012).

wood fuel. Combined Heat and Power (CHP) is a suggested approach for both new electrical generation and for district heating when fueled by woody biomass. See the CHP section below for a further discussion of this subject.

ix. Non-Woody Biomass

In addition to woody biomass, grass-based biomass may take hold in Vermont for institutional heating or CHP applications. We should not neglect the chance to use otherwise fallow fields for energy production from sustainable, renewable grass crops that also provide water quality protection and a source of income and jobs in Vermont's agricultural sector.

x. Advanced Biofuels

Advanced biofuels are liquid fuels such as ethanol and butanol that can be derived from organic material, including crop and animal wastes, renewable biomass, or food waste. Ideally, biomass crops used for advanced biofuels are perennial plants grown on marginal or otherwise agriculturally unproductive lands and require little or no fertilizer or irrigation. DOE is supporting research and development of new technologies to convert biomass into advanced biofuels, especially transportation fuels for cars, trucks, and planes.[46] This technology is promising but likely will not mature in the short term. It may offer benefits in Vermont over the coming decades.

Because cellulosic ethanol research and development has not made much progress in the region, the Department of Public Service does not assume that wood will be used to produce ethanol.[47] The *Biomass Energy Development Working Group Final Report* went further to suggest biomass for the production of transportation fuels is **not** a wise use of the wood resource, stating that such an approach could take biomass energy away from other beneficial purposes, would do little to affect energy security, and likely would have a negligible effect on gasoline prices.[48] In addition, making liquid fuels from woody feedstock generally requires operation at considerable scale, meaning this is an all-in or all-out proposition for production within Vermont.

xi. Biogas: Farm and Landfill Methane

Small-scale farm methane digester development and use has gained a respectable foothold among Vermont's dairy farms. In addition to providing renewable base load power to the grid, this technology offers other benefits, including efficient farm waste management, odor control, and additional revenue streams to farms. Most existing farm digesters are at larger farm operations, and the technology presently does not lend itself to smaller farms with less than

[46] U.S. Department of Energy (2013c).
[47] Vermont Department of Public Service (2011).
[48] Biomass Energy Development Working Group (2012).

200 cows. Additional support for research and development of small-scale digesters is needed to advance the use to smaller operations.[49]

The good news is that alternative digester designs (e.g., "mixed-substrate" anaerobic digesters) can, in addition to manure, use certain crops, other farm waste, and food-processing wastes. Smaller farms may be able to take advantage of this approach and employ the technologies. While there are challenges, this technology may be able to generate up to 30 megawatts of renewable base load power by 2025.[50]

xii. Landfill Methane

As refuse decomposes in landfills, methane gas is released, eventually rising to the atmosphere. Large landfills control this flammable gas by collecting it via pipelines buried in the landfill and either flaring it or allowing it to be used for energy. Vermont has a small number of landfill biogas generation facilities. There is a limited capacity for new landfill biogas generation in the state, mostly from the expansion of existing systems or the installation of generators on smaller landfills.

xiii. Fuel-Cells

Fuel cell technology, first developed around 1840, converts fuel such as hydrogen to electricity, thermal energy, and water vapor through a chemical process that does not involve combustion. This process is much cleaner than burning fuel, produces almost no harmful emissions, and, as the by products are electricity and heat, the technology is suitable for combined heat and power applications. NASA used fuel cells for power and heat in space craft beginning around 1965.

DOE advises that fuel cells have revolutionary potential to provide clean, efficient replacement of internal combustion engines for transportation and use of fossil fuel for heating. DOE is sponsoring research and development work aimed at evolving fuel cells for commercial use for transportation and buildings. The automobile industry is moving toward a 2015 commercial launch of fuel cell powered vehicles with seven major international automakers participating in this endeavor. Internationally, interested parties are developing regulations, codes, and standards to accommodate what is expected to be a burgeoning market for this technology. Fuel cells provide potential for several applications in addition to transportation. Stationary uses include small scale combined heat and power sources for homes and small commercial buildings; systems for back-up power, uninterrupted power supply, or remote power

[49] Vermont Department of Public Service (2011).
[50] *Id*.

applications; and larger systems for industrial or large commercial operations, including district heating applications.

The global market for fuel cells and the necessary fuel infrastructure to operate them have not fully developed at this time. DOE advises that,

> To be economically competitive with the present fossil fuel economy, the cost of fuel cells must be lowered by a factor of ten or more and the cost of producing hydrogen must be lowered by a factor of four. In addition, the performance and reliability of hydrogen and fuel cell technologies must be improved dramatically.[51]

However, many people still perceive fuel cells as a maturing technology that can and will play a substantial role in coming decades. Planners and policy makers foresee the benefit of clean, quiet, efficient energy conversion systems that are modular and scalable to a wide variety of size needs. Technological breakthroughs are not necessary, but steady improvements in costs, availability, and fuel supply infrastructure will be needed to allow widespread use of fuel cells to provide energy for transportation, building heating, and electrical generation.

xiv. Combined Heat and Power

Combined heat and power (CHP) technologies produce both electricity and heat energy (usually steam) from a single fuel input, recovering and reusing heat that would otherwise be wasted. Also commonly known as cogeneration, CHP technology provides greater efficiency than realized from producing either product alone. Plants are usually located at or very near the location where the energy is used, which is often an industrial plant or a district heating facility in large commercial or public buildings. Natural gas (or other fossil fuels) is often the primary fuel source for CHP; however, a variety of biomass and biofuels can also be used. Use of fossil fuels for CHP is often encouraged as the substantially improved efficiency creates benefits and reductions in greenhouse gas emissions compared to dual energy systems performing the same work. Vermont rules allow fossil fueled CHP systems of up to 20 kW to qualify for net metering status under 30 VSA Section 219 and to receive the relatively high payment per kwh afforded to net metering resources.

CHP historically has not played a large part in Vermont's energy mix; however, it has been much more successful in Europe, possibly because of higher energy prices experienced there. The use of small scale CHP expanded in Europe in recent years and is employing technology in the 100 kW to several MW range, increasingly in packaged systems that are easily installed and

[51] U.S. Department of Energy (2013c).

operated. CHP is common in industry, but smaller scale applications (e.g., commercial buildings, hotels, office buildings, schools, and medical establishments) are increasingly common, with scaled packaged units available to meet varying needs for power and energy. Modern CHP technology allows small scale use of renewable resources such as organic waste, including a variety of animal and plant wastes, generating biogas to fuel the CHP units. A CHP plant can also operate on natural gas, landfill gas, liquid gas, propane, diesel, and biodiesel.

Recent experience in Europe is transferrable to the United States and Vermont and small scale CHP, fueled by either fossil or renewable fuels, will likely play an expanded role in the state's energy future.

Vermont has clear goals for increasing use of CHP, with the legislature determining that 60 MW of electric generation from qualified CHP plants by 2028 should be achieved. Possible approaches to meet this goal include efforts to develop CHP systems for schools, college campuses, community buildings, and other public buildings. Vermont has at least one local brewery that employs an anaerobic digester to produce combined heat and power and reduce the impact of its waste products. Viable CHP opportunities may be reduced unnecessarily due to Vermont's legislative requirement of 50 percent overall efficiency of systems. This requires that at least 50 percent of the initial energy input be captured for use by generating electricity and producing useable heat for another purpose. If a proposed CHP project envisions heating building(s) as the second use of the energy, there may be no market in the warm weather seasons. In such cases, this lack of a market in warm months may cause a potential CHP facility to fail to meet the 50 percent overall annual efficiency standard. Changing the legislation to accommodate this situation and reducing the annual efficiency standards for CHP projects that provide beneficial building heat could increase the opportunity for CHP development in the state. Continued review and discussion of the annual standard appears to be warranted.

xv. Natural Gas

Natural gas currently provides about 6 percent of Vermont's total energy and is mainly used for building heat, water heating, cooking, and some industrial processes, limited to a relatively small geographic region in the northwestern part of the state.[52] The *Comprehensive Energy Plan* suggests that natural gas offers certain advantages over other types of fossil fuel, including lower levels of many types of emissions, convenient and clean pipeline delivery (avoiding delivery trucks), and efficient technologies for the use of the gas. It is also publicized as an advantage to economic development activities in areas of the state where available.

[52] Vermont Department of Public Service (2011).

Two recent studies highlight the opportunities and challenges associated with natural gas as an energy source in the United States. MIT concluded that the use of natural gas is growing and will probably continue to grow in the United States.[53] Natural gas development, including resources derived from shale gas deposits, has increased, with expectations in the industry of far more resource availability than previously thought. This study suggests that the new natural gas availability, at current prices that are less than alternative fuels, creates opportunities for fuel switching to gas in most energy using sectors, including electric generation, transportation, building heat, and industrial processes.

Another report, prepared by ICF provides a comprehensive review of shale gas resources as it relates to opportunities for electricity production. It recognizes that the resource potential is large, that as a generating fuel natural gas compares favorably to coal and oil, and that there are real but manageable environmental issues related to the development of gas, in particular unconventional gas.[54] The MIT report also concludes that additional research and new regulations at the state and federal levels will be required to minimize environmental impacts and damage from wide-spread shale gas extraction. The MIT report suggests that we can expect increasing amounts of natural gas fired generation facilities to play an important role in providing the flexibility services necessary to support the variable renewable energy such as wind and solar, perhaps in conjunction with flexible distributed resources and demand-response.[55]

Alternatively to the viewpoint taken by parties such as the MIT team, other energy industry analysts suggest that natural gas may be a "bridge fuel," playing a significant role in the United States (and perhaps Vermont) for a relatively short term during the next two to three decades. Due to significant CO_2 emissions resulting from the combustion of natural gas, widespread increases in its use will not allow the achievement of aggressive greenhouse gas reduction goals even when replacing other (even dirtier) fossil fuels.[56] Other researchers, including from Stanford University and Cornell University recently concluded that natural gas should not be used as a bridge fuel at all in New York. Rather, near term New York energy programs and policies should strive for the replacement of all fossil fuels, including natural gas, with renewable energy resources by 2030.[57]

[53] Moniz, *et al.* (2011).
[54] Bluestein (2012).
[55] Moniz, *et al.* (2011).
[56] Johnston & Wilson (2012).
[57] Jacobson, *et al*. (2013).

Natural gas is widely used for electric generation in many parts of the country, including New England. Due to the abundance of the resource and current competitively low prices, it is possible its use will increase nationwide in the transportation and heating sectors (and likely in the industrial sector as well), with reduced oil use being a primary benefit. Some consider it a clean and inexpensive fuel compared to other fossil fuels and one that should be used increasingly in the United States.

A number of factors may be promoting the further use of natural gas in Vermont. Investigations of expanding pipeline infrastructure reaching many more consumers, coupled with the apparent abundant supplies and low market prices, suggest natural gas may play an increased role in Vermont's energy future. As discussed more specifically in the policy "Expand the Appropriate Use of Natural Gas," this raises a number of critical state policy questions that will need to be addressed in the coming years. These are difficult questions, reflecting the need for very tough decisions around the extent to which the state can and will benefit from the expanded use of natural gas.

c. Behavior Change Pathways

Individual preferences and habits can influence energy consumption in important ways. New techniques involving group dynamics and social media are being developed to influence individual or organizational behavior and decision-making. When combined with appropriate feedback, powerful influences can be brought to bear on energy consuming habits of end users. These include programs that provide end users with information about their energy use; allow comparisons among groups of customers; and include goal setting, rewards, and other strategies that encourage efficient and timely use of energy. On the commercial side, programs that benchmark buildings and examine the results of equipment tune-ups or operations and maintenance changes can assist these consumers in reducing energy use.

Conventional energy efficiency program design focuses almost exclusively on the link between measures and behavior. While technology-based interventions into purchasing decisions regarding energy using equipment have been successful, savings can be improved if there is an accompanying change in habits. For instance, buying and installing efficient light bulbs is good, but also turning them off when they are not needed is even better.

A case can be made for engaging social scientists to examine the evolution of the social aspects of behavior and how what is considered "normal" is evolving. The implications of that evolution for energy and resource consumption are important, and developing techniques to direct that evolution to a more sustainable path may be desirable. Many elements of our lifestyle, including diet, hygiene, mobility, and comfort flow from resource intensive consumption, which is not sustainable. These patterns will have to change. Consumption patterns represent more than just individual behavior; they represent changing social norms. In Uzzell's words "Trying to persuade people to consume and waste less through behavior change programs will not address the larger and more significant problems concerning the ways under which people need or think they need to live and consume."[58] These arguments suggest we must look at the broader context in which people consume and seek to change that context. Routine consumption is heavily influenced by individual conceptions of normality, shaped by cultural and economic forces. Effectuating change must deal not only with behavior, but also the roots of personal expectations and the definitions of normalcy.

Behavior change programs of all types represent a potential for savings that is supplemental to more traditional utility programs that focus on the adoption of efficient technologies. As the programmatic techniques become refined and applied to more fuels and end uses, this type of behavioral intervention holds promise to produce significant and reliable savings.

[58] Uzzell (2008).

III. Policy Barriers and Solutions

a. Selection Criteria

It is unlikely that any single policy will have the ability to single-handedly address Vermont's needs. Rather, it will be a suite of policies working together. Clearly, some policies will "pack more of a punch" than others. The following criteria can help stakeholders weigh the relative merits of policies and how these policies may fit into a suite of activity in response to climate change and in pursuit of Vermont's statutory goals.

- **Scale:** First and foremost, policies selected should be able to address the scale and magnitude of the legislative targets. Experience suggests that Vermont, and other states and nations, will need to take concerted steps in new directions to achieve their targets. Since the barriers we face are formidable, the policies we employ should be significant in their size and address the sectors and end-use categories that are the primary sources of greenhouse gas emissions. Furthermore, consideration should be given to the life cycle impacts of certain approaches.
- **Cost-effectiveness:** Policies that produce either the greatest net benefit or lowest net cost, should be pursued in advance of other policies. Policies that achieve the greatest net benefit should be given priority.
- **Energy efficiency:** Energy efficiency should be recognized as a first resource. Energy efficiency is usually cost-effective under any criteria and offers wide-ranging, multiple benefits that are often overlooked by policymakers and utilities.[59] Energy efficiency typically is cost-effective under even a narrow view of costs and benefits. When Vermont views its energy efficiency opportunities, it should include these broader categories of environmental impacts and impacts to public health.
- **Geographic scale:** The geographic scale of the impacts is relevant because the scope of the problem is global. Due to a variety of considerations, certain policies may be more effectively advanced at a regional rather than a state level. Policies that cannot be effectively addressed at the municipal or state level (at least for a small state like Vermont) will need to be scaled appropriately to be successful. Vermont's role in such instances will be that of a potential cooperating partner or advocate. Vermont can set a clear example of a policy agenda and an action agenda.
- **Resource opportunities and geographic proximity**: Proximity of resources is also relevant with respect to certain resource categories and policies, particularly with

[59] Energy efficiency, in addition to providing cost savings from foregone energy use, produces a host of other health, environmental, and utility system savings. Many times these benefits are not factored into cost-benefit calculations.

respect to utility-scale sources of electricity generation. Vermont has a long history of relying on clean renewable energy from our northern neighbors in Quebec. Additional large hydro and wind projects are under development in several neighboring states and provinces that offer potentially affordable access through largely established transmission corridors.

- **Uncertainty and risk:** Policies should be well designed to manage both for risk and uncertainty. For example, relying on a single solution may seem attractive, but it leaves the state vulnerable if that single solution fails and no back-up plans are made. All else being equal, the best solutions are those that perform well under a variety of major contingencies and uncertainties.
- **Equity and social justice:** The policies pursued should consider, and, as appropriate, address fundamental concerns of equity and social justice. Often, equity and social justice concerns can be addressed through the design of the policy, or by considering policies as part of package that broadly addresses such concerns.
- **Timeframe:** The timeframes for policy implementation are important for at least two reasons. Certain policies will take time to have their intended impact. Setting the course early is necessary for success because the nature of climate change is based on the longevity of the greenhouse gas molecules in the atmosphere; policies implemented earlier will be of greater impact because they will act over longer periods. Somewhat offsetting this is the persistent, but still uncertain, decline in the costs of clean energy technologies, which may suggest a somewhat measured tempo to preserve later opportunities. Stakeholders will need to balance these competing tendencies when selecting policies.
- **Practicality:** This last category speaks to the issue of other practical issues that may intervene and upset the chosen strategy. Policies should enjoy some degree of political resilience so that a change in administrations or the leanings of the legislature do not unduly upend the path chosen. Energy companies and others will make strategies and investments that will rely to some extent on the stability of the policy environment over time. Policies that can enjoy robust public and political support should be favored, provided they materially contribute toward achieving the state's energy and climate goals.

b. Featured Policies

The following discussion narrows the myriad of policy options to those consistent with the criteria outlined above. These policies rely on and use many of the technologies described in Part II. Featured policies, the policies we deem most critical and in need of engagement from stakeholders, are discussed first and at greater length. Other, less impactful implementation policies follow and are treated more briefly. It is important to note that if Vermont is to actually reach its energy and greenhouse gas goals, significant change, driven by an informed selection among the policies below, will be required.

Within each policy is a short section titled "Key Considerations." This section deals with some of the overarching considerations that must accompany every policy, rather than dealing with the subject matter of the particular policy. This section serves as a reminder to stakeholders that some general decisions must accompany every specific policy decision.

1. Place a Price on Carbon

Internalize the cost of carbon by imposing an economy-wide mechanism for pricing carbon.

i. Key Considerations

- Funding: Wholesale fuel supplier; distribution utility for electricity generated from carbon emitting sources; end-users.
- Sector Impact: Transportation, Buildings, Electric, Industry.
- Accountability: Measurement and verification by the Department of Public Service for electricity, Department of Taxes for tax, and Department of Public Service, Public Service Board, and Agency of Natural Resources for cap-and-trade oversight.
- Point of Regulation: Wholesale fuel supplier; retail utility for electricity from fossil-fuel generation.
- Scale of Implementation: State and regional for both tax and cap-and-trade.

ii. Policy Description[60]

Carbon pricing attempts to adjust the price of fossil fuels to more accurately reflect the true cost to society (including the costs of environmental effects) of their extraction and combustion. The cost of environmental effects, and in particular greenhouse gas emissions, historically have been omitted from the market price for fossil fuels. Carbon taxes and emissions caps (usually called "cap-and-trade" in the United States) are the two primary policy tools for placing a price on carbon emissions. A carbon tax is levied on the carbon content of fuels used for electric generation, transportation, industrial processes, and building heat. A cap-and-trade system puts a price on carbon by setting limits (a cap) on the quantity of emissions that polluters may produce and by establishing a system of tradable emissions allowances that allow emissions up to the level of the cap.[61] Revenues derived from either pricing policy can be "recycled" and used for a variety of beneficial purposes, including investments in energy efficiency and renewable energy projects that are the building blocks needed to attain the state's goals. The revenue collected can also be refunded to consumers as a dividend for their participation in greenhouse gas reduction initiatives. In addition, pricing carbon emissions of fuels can help mitigate the price advantage that fossil fuel energy historically has had over renewable energy because of the market failure to recognize the additional costs of fossil fuel use.

The broader the geopolitical extent of a carbon pricing policy, the more effective it can be in reducing greenhouse gas emissions. Given that Vermont is and has been for some years a

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[60] Mostly drawn from Johnston & Wilson (2012).

[61] A tax provides price certainty, although the resulting quantity of emissions reduced may vary. Conversely, a cap provides certainty on the quantity of emissions that will occur, but prices (and costs to emitters and consumers) are difficult to predict.

member and supporter of the Regional Greenhouse Gas Initiative ("RGGI"), Vermont would benefit from continuing participation in the RGGI cap-and-trade program and may consider encouraging expansion of the program to cover other fuels or other end-use sectors. Vermont's participation in RGGI has reduced greenhouse gas emissions and recycled significant revenue back to the state. See Figure 2. Vermont effectively has invested those revenues in energy efficiency and fuel-switching to cleaner, lower emissions fuels.[62] The state may also benefit from a multi-jurisdictional tax and may want to consider encouraging a multi-jurisdictional carbon tax through the New England Governor's Conference, New England States Committee on Electricity (NESCOE), Northeast Sates for Coordinated Air Use Management (NESCAUM), Vermont's Congressional delegation, and other appropriate forums.

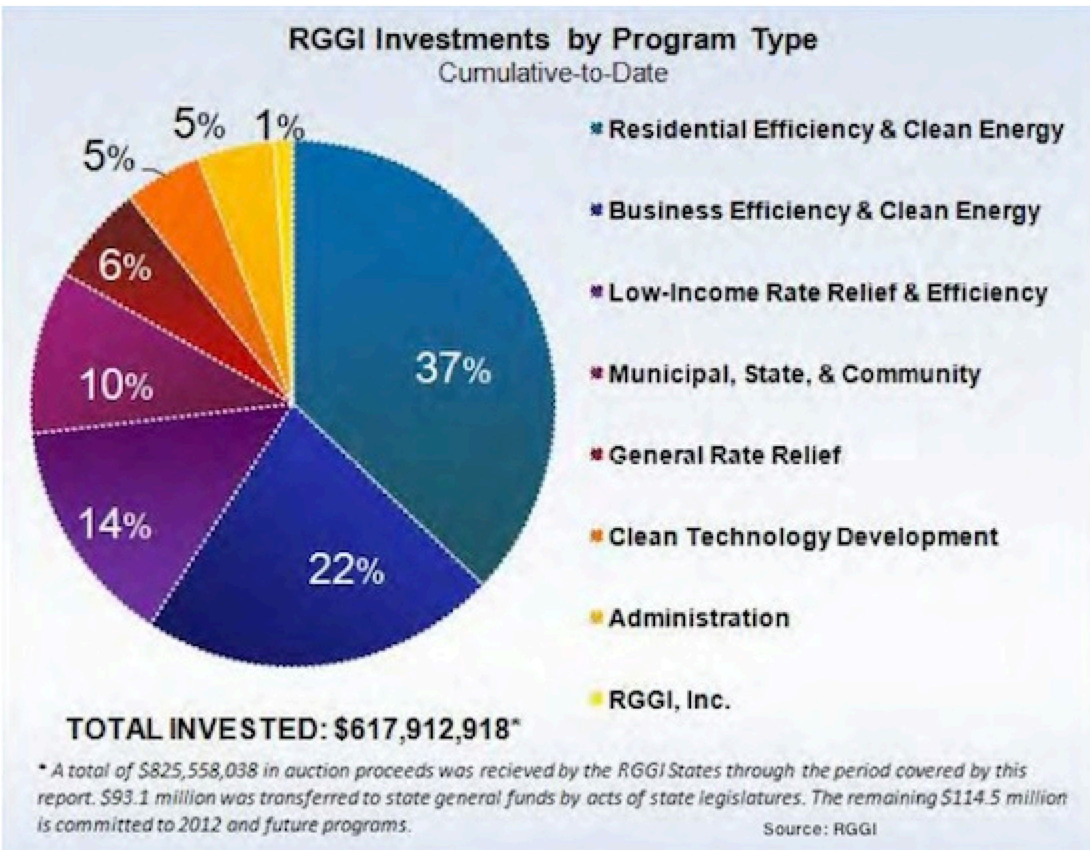

Figure 2 RGGI Investments

[62] Hibbard, *et al.* (2011).

There are advantages and disadvantages to both carbon taxes and cap and trade programs.

Carbon Tax	
Advantages	**Disadvantages**
Offers flexibility to affected sources in determining their response to the tax.	Tax does not limit the amount of carbon that can be emitted and desired reductions in emissions may not be reached using a politically viable tax rate.
Encourages a range of technical and institutional abatement options.	Taxes are politically unpopular and risky for elected officials.
Relatively easy to implement; applies to small and dispersed resources, as well as large point sources; straightforward to administer; and requires little more in the way of infrastructure and bureaucracy than a simple sales tax.	State spending decisions for carbon tax revenues may be unpopular and aggravate the unpopularity of a tax with voters.
Provides transparency and cost certainty.	
Creates a strong and continuing incentive to innovate as a mechanism for reducing emissions and associated tax payments.	
Tax revenue may also be invested in low-carbon resources to facilitate the transition to a low-carbon economy.	
Generates revenue that may be used to reduce collection of other taxes, thus making the carbon tax optionally revenue neutral.	

Cap-and-Trade	
Advantages	**Disadvantages**
Is effective to meet emissions reduction targets.	Pricing is market-based and not known in advance.
Flexibility to allow various compliance options such as: • purchase of allowances, • installation of emissions controls, or • emissions avoidance through retirement or fuel switching.	A variety of market mechanisms exist and one must be chosen for implementation: • can be complex to implement and difficult to administer, and • can have imperfections in design or application, such as issuing too many permits.
Uses a market mechanism for transfer of emissions allowances.	
Tends to have fewer political obstacles than carbon taxes.	
Better performers—those with lower emissions—benefit economically from their performance by selling allowances.	
Higher emitting sources can determine the cheapest way to comply with requirements.	
Program revenues rise as emissions decrease.	

Efforts to reduce emissions are shown to be most effective when multiple policy strategies are implemented at the same time, such as combining carbon pricing with policies to encourage energy efficiency and renewable energy. If carbon pricing is relied upon exclusively, experience suggests the carbon price needed to meet Vermont's goals may be so high that emissions reduction goals will not be attainable.[63] In addition to efficiency and renewable energy, other complementary polices Vermont may consider include establishing carbon intensity targets,[64] establishing emissions standards for electric power contracts or supply portfolios, adopting building codes and standards that address emissions, and implementing resource planning strategies—utility Integrated Resource Planning[65] (IRP) or government agency planning—that include assertive requirements to reduce emissions.

Carbon pricing-related policies are most effective if they include mandatory provisions, are long-term in design, and provide for emissions to decrease over time to meet Vermont's goals for the years 2028 and 2050. Carbon pricing lends itself to interstate and regional cooperation (as experienced with RGGI), and is most effective if all carbon emitting (and fossil-fuel using) sectors are encompassed, including electric generation, transportation, industry, and building heating.

iii. Design Considerations

The benefits of pricing carbon, both in terms of renewable energy deployment and in carbon reduction, can be greatly increased by reinvesting the proceeds of the tax or sale of permits into projects or measures that further the goals of renewable energy and carbon reduction.[66] Since these policies have the potential to raise energy prices, care should be taken to address the needs of at-risk populations within the state. Vermont is already doing so in the electric sector where revenues from the auction of RGGI allowances are used to fund low-income weatherization and other thermal efficiency programs.

There are two primary design options when considering a cap-and-trade system. One allocates a fixed number of allowances to current emitters, similar to the SO_2 trading program in the United States.[67] An alternative method provides all of the allowances to a central authority, which then auctions or sells them to emitters as needed; this is how RGGI operates. The

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[63] Cowart (2008).

[64] Carbon intensity measures show how much carbon is released per unit of energy produced or used.

[65] Electric utility IRPs currently are required to include plans for how the utilities will get to 75 percent renewable energy use by 2032.

[66] Title 30 V.S.A. § 235 directs proceeds from Vermont's sale of RGGI allowances to programs that support whole building heating and process energy efficiency and facilitate appropriate fuel switching. Half of these programs benefit low-income residential consumers. See http://www.rggi.org/rggi_benefits/program_investments/vermont.

[67] U.S. Environmental Protection Agency (2009).

allocation method promotes trading among affected parties and is revenue neutral within the affected sector. Selling allowances or imposing a tax will generate revenue for the state. Returning the funds to consumers through assistance in meeting the clean energy goals will allow those goals to be met at a lower total cost. Regardless, a tax alone cannot be sufficiently high to generate the response needed to meet the state's aggressive goals. It may, however, be a welcome complement to a well-formed policy portfolio to achieve the same ends.

iv. Ease of Application

A carbon tax is a relatively straight forward mechanism that can be applied at the wholesale supplier or retail sales levels. Although Vermont is served by suppliers outside the state, the tax would only apply to sales made in Vermont. A carbon tax would operate similarly to other taxes already in place. Such a framework could be implemented at the state level.

The institution of a cap-and-trade program to price carbon would require establishing an apparatus to create, auction, and trade emissions certificates. Additionally, sellers of energy products in Vermont would have to report their sales volumes of various products, as well as the renewable content of those products (e.g., B5, B20, B100 #2 oil). Because of the complexity of the tracking system required, participation in a cap-and-trade system would likely be better done on a regional level. Within the electricity sector, Vermont already participates in RGGI. If Vermont choses to broaden the reach beyond electricity, it may want to consider doing so in conjunction with another program. Piggybacking on another program, as Quebec has just done with the California program, should be explored as an option to lower the administrative burden.

v. Select Resources

Cowart, R. (2008). Carbon Caps and Efficiency Resources: How Climate Legislation Can Mobilize Efficiency and Lower the Cost of Greenhouse Gas Emission Reduction. *Vermont Law Review, Vol. 33, pp. 200-223*.

Hibbard, P., Tierney, S., Okie, A. & Darling, P. (2011). *The Economic Impacts of the Regional Greenhouse Gas Initiative on Ten Northeast and Mid-Atlantic States.* Boston, MA: Analysis Group. Retrieved from http://www.analysisgroup.com/uploadedFiles/Publishing/Articles/Economic_Impact_RGGI_Report.pdf.

Johnston, L. & Wilson, R. (2012) *Strategies for Decarbonizing the Electric Power Supply*. Montpelier, VT: Regulatory Assistance Project. Retrieved from http://www.raponline.org/document/download/id/259.

Measuring Progress Towards the Renewable Energy Goal

In order to determine the level of achievement in meeting the target of 90 percent renewable energy, an accounting mechanism must be set up to tally the renewable and non-renewable portions of the supply mix. The basic equation is Renewable Energy Used (BTU)/Total Energy Used (BTU).The chosen accounting mechanism must be equitable, accurate, straight-forward to implement, and treat all fuels in a consistent manner.

Difficulties arise when measuring the electric sector and when tabulating the contribution of renewables. Three approaches are possible. The most straightforward is to use the electricity or renewable output as such and to disregard the upstream energy inputs. (This approach would assign a value of 3,412 BTU/ kWh to both fossil and renewable electric generation). The most common approach is to express the electricity produced or renewable energy used in terms of the energy content of the fossil fuels that would be required if the same amount energy had been produced with a conventional thermal generator or appliance that relies on fossil fuel. In effect, this approach reflects the displacement of fossil fuel. The third approach is to quantify the actual input energy to the system. This method would quantify the fossil fueled inputs to the system, the amount of heat released by the reactors in nuclear power stations, and the input energy (sunlight and potential energy in water or wind) into a renewable system.

The second approach is recommended because it is both feasible, using existing data and accurately captures the BTU savings involved in renewables conversions, and conceptually consistent with the targets set, which are centered on the displacement of fossil fuels by renewable energy that produce electricity, heat, or power. The energy accounting for purposes of setting and meeting objectives of renewables targets should be based on the energy content in BTUs of the energy resources that were likely displaced by policies that promote electrification and associated renewable energy. For this exercise, renewable electricity production can then rely on the average heat rate of new fossil generation in New England and the BTU value of renewable thermal applications should be based on a reasonable estimate of the average efficiency of new fossil fueled boilers and furnaces in Vermont. We recommend the use of new generators and devices on the theory that they are most relevant to the types of generation that would exist in the target year 2050 that are effectively displaced.

Renewable electricity can then be assigned a value of 6,800 BTU per kWh. Electrification of the transportation system can be accounted for as incremental kWh and net gallons of fuel used. Biofuels and other transportation or building related fuels can be evaluated based on their individual BTU content as input to the system. Renewable thermal applications (including heat pumps) can be evaluated based on the net of the electric demand and the proxy fossil fuel demand displaced.

2. Enact a Total Energy Standard

Introduce a total energy standard to create a goal for renewable energy across the economy.

i. Key Considerations

- Funding: Wholesale fuel supplier; third party vendors.
- Sector Impact: Transportation, buildings, electric, industry.
- Accountability: Public Service Board or Regional Greenhouse Gas Initiative.
- Point of Regulation: Many.
- Scale of Implementation: State and regional.

ii. Policy Description

A total energy standard (TES) sets goals or requirements for an economy-wide portion of energy consumption to be met with renewable energy. Energy efficiency can also play an important role in a TES because it can reduce the quantity of renewable energy necessary to meet the standard. The standard is broadly defined to include all energy use in all sectors of the economy. Units of measurement are BTUs and can be measured in absolute terms, such as a set number, or in relative terms, such as BTU per unit of gross state product (GSP) or relative to population. Variants can target the composition of the energy supply over a limited number of energy consuming sectors or over a subset of the fuels used by those sectors. Such a system uses market mechanisms to encourage achievements in the most cost-effective way. Goals are met through tradable certificates or some other method of efficient exchange with other sectors that may find achieving the stated goals to be more costly. At least in principle, this type of market-based approach allows achievement of the desired goals with a minimal impact on the economy as a whole. A disadvantage is that accounting and attribution can be challenging, given the proportion of smaller size projects likely to be undertaken in Vermont. If a TES is to be mandatory, obligated parties must be created and have mandatory participation levels.

A total energy standard offers flexibility and the ability to initially cover a limited section of the economy and later expand. A total energy standard can drive the adoption of renewable resources, energy efficiency resources, or both. Targets also can be tailored for the different sectors covered by the standard. For example, the transportation sector can have an obligation to achieve a certain biofuel content in vehicle fuel sold in the state.

A total energy standard can be a goal or can be made mandatory by assigning a series of obligations. Parties must be assigned a portion of the overall goal for which they are responsible. For an obligation to be successful, there must be consequences for not meeting the objectives. Obligations could include tradable certificates, which could be bought and sold to assist in reaching the goal. Determining an obligated party may be difficult for some sectors. For example, a requirement could be that all sellers of heating oil must achieve a certain proportion of renewable content in their sector. This renewable energy does not have to be used by any one firm's customers but must be used within the sector, or tradable credits must be acquired from another sector. Obligations also must be constructed with penalties or consequences for non-compliance. Similar to Vermont's SPEED requirements, a total energy standard can impose a stricter control measure if the targeted sectors fail to meet their goals. [68]

iii. Design Considerations

In establishing a total energy standard, a number of aspects must be considered, in addition to those mentioned above. A legal authority must be established for those who promulgate the standard. A sufficiently long timeframe must be set for achieving the objectives so parties can make strategic decisions in an orderly way, especially if investment in new equipment is the preferred strategy for complying entities or entities want to sell compliance credits. A procedure also must be established for parties to report savings to an appropriate authority capable of verifying savings claims. Consideration should be given to performance incentives if appropriate. Enable third parties to participate in the system if appropriate. For example, energy service companies (ESCOs) may be able to market the product from their efforts to obligated parties. A system for measurement and verification must be established with robust feedback to participants. If trading is desired, a system of certificates and a market must be established to facilitate this activity. Finally, consideration should be given to cost recovery for obligated parties.[69]

A total energy standard is an excellent method to achieve economy-wide objectives for renewable energy. Broad-based standards covering multiple fuels and sectors have been applied in only a few countries and usually on larger suppliers. For example, the cap and trade program in California, mandated by AB 32, targets electric generation and emitters of more than 25,000 metric tons of carbon per year. As a small state, Vermont may have difficulty establishing the regulatory mechanisms necessary to support such an effort in the efficiency realm, and may have better success with a regional approach similar in scope to RGGI.[70] However, a total renewable energy standard could be successful on a smaller scale, assuming proper consideration is given the design elements discussed above.

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[68] SPEED is a Vermont program to encourage the development of renewable energy resources in Vermont, as well as the purchase of power generated by renewable generators by the state's electric distribution utilities. See www.vermontspeed.com. The 2005 SPEED statute included a provision requiring the imposition of a binding renewable portfolio standard if the 2012 voluntary SPEED goal was not met.

[69] Taken generally from Crossley, *et al.* (2012).

[70] The RGGI program has discussed expanding its coverage. On December 30, 2009, the governors of the participating states and Pennsylvania signed a "Memorandum of Understanding" to "work to develop a low-carbon fuel standard to reduce greenhouse gas emissions from cars and trucks despite objections from the oil industry."

iv. Select Resources

Budischaka, C., Sewell, D.,Thomson, H., Mach, L., Veron, D & Kempton, W. (2013). "Cost-minimized combinations of wind power, solar power and electrochemical storage, powering the grid up to 99.9% of the time." *Journal of Power Sources* 225 (2013) 60-74. Retrieved from http://www.udel.edu/V2G/resources/BudischakEtAl-2013-CostMinimizedWindSolarPJM.pdf.

California ISO. (2013). *Integration of Renewable Resources*. Folsom, CA: California ISO. Retrieved from http://www.caiso.com/informed/Pages/StakeholderProcesses/IntegrationRenewableResources.aspx.

U.S. Environmental Protection Agency. (2013c). *Renewable Fuel Standard (RFS)*. Retrieved from http://www.epa.gov/otaq/fuels/renewablefuels/.

Schnepf, R. & Yacobucci, B. (2013). *Renewable Fuel Standard (RFS): Overview and Issues*. Washington, DC: Congressional Research Service. Retrieved from http://www.fas.org/sgp/crs/misc/R40155.pdf.

3. Leverage Markets to Achieve Efficiency and Renewable Goals

Create value streams that can be accessed by third parties or individual homes or businesses that reward energy efficiency or renewable energy actions.

i. Key Considerations

- Funding: Varies.
- Sector Impact: Buildings, electric.
- Accountability: Public Service Board, Department of Public Service, Agencies of Agriculture and Transportation, and permitting authorities.
- Point of Regulation: Could be done at multiple levels.
- Scale of Implementation: Local or state.

ii. Policy Description

Markets can spur creative solutions to energy and environmental objectives. The goal of this policy is to harness the power of market forces toward Vermont's energy goals by "figuring out" ways for participants to profit from helping Vermont meet its climate and emissions goals. By identifying and removing policy and regulatory barriers that hinder the development of new business models or by enacting new policies that foster the development of new business models, Vermont can open the door to private innovation in the service of the state's environmental and energy goals.

The Public Utility Regulatory Policy Act (PURPA) is a historic example of a policy that transformed the electric industry by allowing private developers of renewable energy to have access to utility revenue streams. This brought new capital into the sector and created a business dynamic that extended well beyond the provision of electricity.

As solar PV prices continue to fall, new opportunities will arise to incorporate this technology into the resource portfolio. Vermont is already experiencing a new business model in the form of solar leasing that allows customer participation with no upfront cost. Other examples could include an electric vehicle manufacturer offering a discounted product, in return for customer participation in a load response program operated by the company. An appliance manufacturer might offer a similar program—a control device included in a water heater could be activated to provide services to the electric grid and create an additional revenue stream to the manufacturer.

To encourage new business models and opportunities, particularly in the energy sector, regulators and stakeholders must carefully scrutinize the existing body of regulations to determine if existing regulations undermine business innovation and then decide how to alter regulations so they enhance rather than undermine innovation. Policies can and should be created that empower non-utility actors, particularly those in demand-side efforts, to enter into and compete in the electric power markets. Vermont already has experience in this activity through its work with New England ISO.

The complementary systems and policies discussed elsewhere in this report can assist in creating the market dynamics that foster new market entrants. Revenues from a carbon pricing scheme can be directed to support new entrants into electricity markets. Efficiency savings certificates or white tags may also enable various non-traditional players to enter the market. To achieve the goals set out by Vermont, participation and effort from many sectors will be necessary. Tapping into the power of the private sector can create large dividends in achieving this goal.

iii. Select Resources

Cappers, P., MacDonald, J. & Goldman, C. (2013). *Market and Policy Barriers for Demand Response Providing Ancillary Services in U.S. Markets*. Berkeley, CA: Lawrence Berkeley National Laboratory. Retrieved from http://emp.lbl.gov/sites/all/files/lbnl-6155e.pdf.

New England Demand Response Initiative. (2003). *Dimensions of Demand Response: Capturing Customer Based Resources in New England's Power Systems and Markets*. Boston, MA: Raab Associates. Retrieved from http://www.raabassociates.org/Articles/FinalNEDRIREPORTAug%2027.doc.

York, D. and Kushler, M. (2011). *The Old Model Isn't Working: Creating the Energy Utility for the 21st Century.* Washington, DC: American Council for an Energy-Efficient Economy. Retrieved from http://aceee.org/files/pdf/white-paper/The_Old_Model_Isnt_Working.pdf.

4. Expand Binding Energy Efficiency Targets[71]

Enhance and expand binding energy efficiency targets for the buildings and power sectors.

i. Key Considerations

- Funding: Utilities and fuel suppliers.
- Sector Impact: Transportation, buildings, electric, industry.
- Accountability: Retail utilities, including Efficiency Vermont, fuel suppliers.
- Point of Regulation: Retail utilities, including Efficiency Vermont, fuel suppliers.
- Scale of Implementation: State.

ii. Policy Description

Binding energy efficiency targets are statewide obligations requiring achievement of a level of energy efficiency savings. Generally established through statute,[72] these limitations are imposed on specific entities, such as a regulated utility, an industrial customer, an unregulated fuel supplier, or an independent provider (e.g. Efficiency Vermont). The targets or caps can be set in a variety of forms: "a specific energy or demand goal (kWh or kW), savings (percent as compared to base or baseline), emissions reduction (tCO2e), or in terms of energy or emissions intensity (kWh or tCO2e per GDP)."[73] Whatever form they take, efficiency targets should be long-term, mandatory, and sufficiently aggressive to be meaningful but not so aggressive as to render their achievement impossible. Optimally, targets will become more stringent over time. A scheme that includes both incentives for performance and penalties for non-compliance is more likely to achieve success.

The method for judging performance must be transparent and the party conducting that analysis independent. The method for establishing baseline usage must be clear and coherent; this is often made easier if the jurisdiction has access to plentiful historical data on consumption levels and patterns. Once baselines are established, all parties must understand how performance against those baselines will be measured, verified, and compliance determined. In addition to measurement and verification, there must be a clear method through which obligated entities can recover costs and be assessed incentives or penalties. In some instances, it may make sense to verify efficiency savings by awarding the obligated entity a certificate of compliance (sometimes referred to as a white certificate), which allows for the creation of peripheral markets through which these certificates can be traded.

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[71] This subsection relies heavily on the work of Wasserman & Neme (2012).

[72] Vermont statute requires sufficient utility funds be directed to energy efficiency to acquire all reasonably available, cost-effective energy efficiency (30 V.S.A. § 209, d (4)). Additionally Vermont has an advanced oversight and management structure for managing utility funded energy effici8ency programs.

[73] Wasserman & Neme (2012).

In order to encourage deep savings levels, Vermont should look to lifetime savings targets that can be derived from annual consumption figures.

Regulated utilities have been the focus of these obligations, but it is possible to extend the obligation to non-regulated fuel suppliers as well, in the form of a requirement to obtain a certain level of savings per gallon or BTU of fuel sold in Vermont. In the United States, energy efficiency obligations typically have not been placed on non-regulated fuel suppliers. However, three European countries - France, Ireland, and Denmark - have created energy efficiency obligations on retail suppliers of non-regulated fuels.[74] In France, the obligation extends to importers of transport fuel who can meet their obligation through savings in the commercial or residential sector. Obligations can also be segmented to have a certain amount come from low income consumers. Since this is a new concept, one possible initial step would be to have non-regulated fuel suppliers report their energy saving activities.

iii. Select Resources:

Wasserman, N. & Neme, C. (2012). *Policies to Achieve Greater Energy Efficiency*. Montpelier, VT: Regulatory Assistance Project. Retrieved from www.raponline.org/document/download/id/6161 .

Nowak, S., Kushler, M., Sciortino, M., York, D., & Witte, P. (2011). *Energy Efficiency Resource Standards: State and Utility Strategies for Higher Energy Savings*. Washington, DC: American Council for an Energy-Efficient Economy (No. U113). Retrieved from http://www.aceee.org/node/3078?id=3926.

Crossley, D., Gerhard, J., Lees, E., Kadoch, C., Bayer, E., Xuan, W., Watson, E. Wasserman, N. & Sommer, A. (2012). *Best Practices in Designing and Implementing Energy Efficiency Obligation Schemes*. Montpelier, VT: Regulatory Assistance Project. Retrieved from http://www.raponline.org/document/download/id/5003.

[74] Crossley, *et al*. (2012).

5. Expand the Use of Voluntary Agreements for Energy Efficiency

Enhance and expand programs for agricultural or industrial users to undertake energy efficiency projects in return for recognition or relaxed requirements in other areas.

i. Key Considerations

- Funding: N/A.
- Sector Impact: Buildings.
- Accountability: Department of Public Service, Public Service Board, and participating customers.
- Point of Regulation: Contract.
- Scale of Implementation: State.

ii. Policy Description

Voluntary agreements are usually entered into by a government (state or national) that is imposing an energy efficiency or pollution requirement on a large energy user that seeks to satisfy that requirement outside of typical, programmatic mechanisms already in place. These agreements, like a private contract, often have incentives (i.e., avoiding some tax consequence) if the target is hit and monetary penalties (i.e., the imposition of taxes) linked to a failure to meet obligations. Given Vermont's large population of small to mid-sized farms, the agricultural sector may be a promising area in which to consider voluntary agreements.

Voluntary agreement programs can be divided into three broad categories: "1) programs that are completely voluntary, 2) programs that use the threat of future regulations or energy or greenhouse gas emissions taxes as a motivation for participation, and 3) programs that are implemented in conjunction with an existing energy or greenhouse gas emissions tax policy or with strict regulations."[75] As might be expected, the more binding the agreements are, the more likely they are to achieve real energy or emissions reductions.[76]

Voluntary agreements can take many different forms: they can be set "in terms of absolute energy consumption or consumption per unit of the consumer's output, such as MWh per unit of value added or per unit of service provided."[77] In any category or form, it is critical to establish a clear baseline of performance against which progress will be measured and a clear methodology of evaluating and measuring performance.

iii. Select Resources

Price, L. (2005). *Voluntary Agreements For Energy Efficiency Or GHG Emissions Reduction In Industry: An Assessment Of Programs Around The World.* Berkeley, CA: Lawrence

[75] Price (2005).
[76] *Id*.
[77] Wasserman & Neme (2012).

Berkeley National Laboratory *(No. LBNL-58138)*. Retrieved from http://ies.lbl.gov/iespubs/58138.pdf.

Wasserman, N. & Neme, C. (2012). *Policies to Achieve Greater Energy Efficiency*. Montpelier, VT: Regulatory Assistance Project. Retrieved from www.raponline.org/document/download/id/6161.

6. Electrify the Buildings Sector

Electrify end uses in the buildings sector, fueled with renewable electricity.

i. Key Considerations

- Funding: Consumers with incentives that support fuel-switching to electricity.
- Sector Impact: Buildings.
- Accountability: Voluntary through inducement by incentives.
- Point of Regulation: Voluntary, unregulated fuel switch.
- Scale of Implementation: Local and state.

ii. Policy Description

As discussed above in the pathways section, meeting the state's renewable energy and carbon goals necessitates a shift away from fossil fuels to electrically powered systems for building heat and industrial activity. As described below, and in the earlier review of technology options, there are promising ways to cost-effectively improve the heating and cooling performance of both the new and pre-existing building stock.

The use of fossil fuels is entrenched solidly in the infrastructure of buildings, and a pathway to change is required to move a large number of Vermonters to electrify this infrastructure. For much of the past three decades, state energy policy focused the building sector away from the increased use of electricity, especially for space heating. To be effective, a new policy of electrification will have to be combined with a substantial and enduring consumer education and information program, as well as be tailored to work in tandem with other policies, such as a renewable portfolio standard or a total energy standard. Electrification policies must be long-term policies designed to play out over decades, not years, as substantial costs and investments are incurred to ensure reliability and functionality during the evolution of both the energy supply and use sectors.

To enhance the implementation of this policy, energy efficiency, conservation, and electric demand management measures can be implemented aggressively to reduce the overall energy requirements of structures, and the electric generation sources serving Vermont must also be transitioned to using renewable fuels. Power sector planning must also adapt and take into account the need for additional generation and delivery requirements, beyond a base-case scenario, due to the demands created by electrification. Consideration should be given to developing a utility business model able to support this transition, including potential changes in the ancillary services[78] markets to the electric grid through smart grid-enabled controls on

[78] Ancillary services are those "[s]ervices needed to support the transmission of energy from generation to loads, while maintaining reliable operation of the transmission system. These include regulation and frequency response,

end uses. These services likely will be in higher demand as the power supply transitions to one with a higher percentage of intermittent resources.

Historically, policies regarding fuel switching have been difficult to develop. From the consumer viewpoint, the government is recommending a specific fuel, directing the consumer to assume the price and other risks associated with that fuel. From an energy business standpoint, state policy is directed at moving customers from one category of service-provider to another. Further, this must be done against Vermont's historical background of discouraging electric heat through Act 250. However, to achieve the state's energy and climate goals, this type of initiative may be precisely in keeping with the scale of the ambition.

Several strategies are possible. Working with Act 250 commissions to explain the policy rationale for heat pumps and other efficient electric technologies can help to address applications in new construction. Supporting technology demonstration projects in Vermont can help with consumer anxiety remaining from prior efforts with less efficient heat pumps. On a larger scale, there is a federal tax credit available for ground source heat pumps. This may be extended to efficient air source heat pumps. Heat pumps can also be eligible for any and all incentives directed to thermal initiatives. PACE loans, Efficiency Vermont thermal programs, and other thermal initiatives can include heat pumps as eligible to participate. In retrofit applications it generally does not make sense to install a unit capable of meeting the peak heating load of the structure, so it is frequently desirable to leave the existing heating system in place. Having a backup system enables certain heat pump installations to be a demand response candidate. Utility rates can be developed to encourage and reward customers who can use alternate systems on the coldest, peak load winter days.

iii. Select Resources

European Climate Foundation. (2010). *Roadmap 2050: A Practical Guide to a Prosperous, Low-Carbon Europe*. Hague, Netherlands: The European Climate Foundation. Retrieved from http://www.roadmap2050.eu/project/roadmap-2050.

Johnston, L. & Wilson, R. (2012). *Strategies for Decarbonizing the Electric Power Supply*. Montpelier, VT: Regulatory Assistance Project. Retrieved from http://www.raponline.org/document/download/id/259.

spinning reserve, non-spinning reserve, replacement reserve, and reactive supply and voltage control." Lazar (2011).

7. Use Efficient Rate Design to Unlock Demand-Side Resources

Employ a pricing framework enabled through technology to allow demand-side resources to more efficiently manage loads and supporting system adequacy.

i. Key Considerations

- Funding: Retail utilities and ratepayers.
- Sector Impact: Buildings, electric, industry.
- Accountability: Public Service Board.
- Point of Regulation: Retail utilities.
- Scale of Implementation: State.

ii. Policy Description

Effective rate design provides price signals to encourage efficient use of electricity and natural gas resources. Time-varying pricing of various forms will be helpful in managing challenges to system reliability. Effective use of advanced forms of dynamic pricing may also begin a path toward more responsive end-user loads that will help promote cleaner generation resources by increasing system flexibility.

Vermont utilities implemented smart meter technology throughout the state in 2012 and 2013. In the short term, smart meters provide benefits through reduced meter reading expenses, better outage management, and improved customer information capabilities. To date, rate offerings have not exploited this technology to provide customers with the ability to participate in managing utility loads and providing other services needed by the utility.

As the electric sector transitions from one that has traditionally developed supply to meet anticipated demands, to one that integrates variable renewable resources to meet the net demands of consumers (net of renewable contribution), pricing strategies can offer a potent opportunity to influence customer behavior in a way that promotes policy objectives. Vermont utilities took the first step by deploying infrastructure capable of advanced communications with the loads it serves. Designing service and rate offerings that extract value from consumers, while providing them benefits, is the next step in this process.

iii. Select Resources:

Crossley, D. (2013). *Effective Mechanisms to Increase the Use of Demand-Side Resources*. Montpelier, VT: The Regulatory Assistance Project. Retrieved from http://www.raponline.org/document/download/id/6359.

Dallinger, D., Shulbert, G., & Weitschel, M. (2012). *Grid Integration of Intermittent Renewables Using Price Responsive Plug- in Electric Vehicles*. Berkeley, CA: Lawrence Berkeley National Laboratory. Retrieved from http://eetd.lbl.gov/news/events/2012/05/02/grid-integration-of-intermittent-renewables-using-price-responsive-plug-in-el.

Faruqui, A., Hledik, R. & Palmer, J. (2012). *Time-Varying and Dynamic Rate Design*. Montpelier, VT: The Regulatory Assistance Project. Retrieved from http://www.raponline.org/document/download/id/5131.

Lazar, J. (2013). *Rate Design Where Advanced Metering Infrastructure Has Not Been Fully Deployed,* Montpelier, VT: The Regulatory Assistance Project. Retrieved from http://www.raponline.org/document/download/id/6516.

8. Enhance and Enforce Building Energy Codes

Adopt and enforce building energy codes. Develop and promote stretch codes more stringent than current ASHRAE or IECC codes. Expand the conditions where code review is applicable and ensure enforcement.[79]

i. Key Considerations

- Funding: Fee for building permits.
- Sector Impact: Buildings.
- Accountability: Building owner, designer.
- Point of Regulation: Building permit, certificate of occupancy.
- Scale of Implementation: State and local.

ii. Policy Description

Buildings are long-lived assets with only occasional opportunities for retrofit and upgrade. Designing and building them right the first time is much more cost-effective than retrofitting them later. Properly enforced codes ensure buildings are built right the first time.

Building codes and standards are statewide rules (often implemented locally) that mandate a minimum level of safety in the design and construction or rehabilitation of both commercial and residential buildings. The primary objective of building codes is to protect human safety, but they also serve other purposes, such as requiring a certain level of energy efficiency from the materials, techniques, and systems used in construction. Improving the energy efficiency of new construction and of buildings being renovated or rehabbed by adopting and implementing progressive building codes is one of the most cost-effective ways in which to save energy and to reduce the emissions of greenhouse gases.[80]

At state or local discretion, the impact of codes can be expanded in several directions by making them more stringent or by making them applicable in more situations. National organizations, such as ASHRAE or the International Code Council, promulgate model standards that have been thoroughly vetted by trade groups and interested stakeholders to assure compliance with health and safety codes. Vermont has adopted such a standard, and legislation passed in 2013 allows for the development of a "stretch" code. A stretch code has more stringent requirements and increased requirements for inspection relative to a standard code. In the new legislation, those who demonstrate compliance with the stretch code gain presumptive conformance with Act 250, criteria 9(F). A stretch code can also be made

[79] Energy Futures Group, *et al.* (2012).
[80] National Action Plan for Energy Efficiency (2009) and Levine, *et al*. (2012).

mandatory if adopted by certain communities. Massachusetts developed such a code, and adopting it is a requirement to qualify for the state's green community designation.[81]

Codes also can be expanded to be applicable in more situations. Requirements to upgrade efficiency at the time of a building's sale will bring more structures into compliance, as well as offer prospective buyers the chance to finance improvements with their mortgage. Other associated policies that may improve the effectiveness of building codes and standards are disclosure requirements when selling a building and building energy performance labeling.[82] Each of these options can further increase the number of structures that are subject to code compliance.

Zero net energy buildings, a step beyond stretch codes, are being constructed in Vermont and New England. A zero net energy building requires extremely efficient structures that generate sufficient renewable energy onsite to offset the total amount of energy consumed in the building over the course of a year. Higher initial costs are recovered through energy savings over the life of the building. While probably not appropriate at this time as a code requirement, increasing awareness of the possibility can inspire building owners and designers to reach for that goal.

Enforcement is a key, but often neglected, aspect of effective building codes and standards.[83] In the U.S., enforcement tends to take one of four shapes: state, local, third-party, or self-enforcement.[84] In Vermont, enforcement differs between residential and commercial energy codes. For residential development, the enforcement is a local responsibility, through code officials in the larger towns. Some enforcement also happens through Act 250, for those developments covered by that law. The Department of Public Safety is not supposed to issue a Certificate of Occupancy for commercial developments unless the developer has shown that the structure meets code. However, since enforcement resources are scarce, safety related issues often take precedence over energy issues. The state, through the Department of Public Safety, is responsible for developing building safety codes. The Public Service Department is responsible for developing energy codes but lacks resources to enforce them. Vermont's current residential code is based on the 2009 IECC Mandatory code, and the commercial code is based on the 2009 IECC, ASHRAE 90.1-2007 Mandatory code.[85] Vermont is on a timetable to update these codes every three years.

[81] Executive Office of Public Safety and Security (2013).
[82] Building Energy Disclosure Working Group (2011).
[83] Levine, *et al*. (2012).
[84] *Id*.
[85] Online Code Environment and Advocacy Network (2013).

Because enforcement efforts have a cost, it is critical that proper and sufficient funding streams are established. The *Vermont Energy Code Compliance* study provides recommendations on achieving higher levels of compliance.[86] The return on this investment in the form of energy savings and greenhouse gas reductions justifies the investment.

iii. Select Resources

Executive Office of Public Safety and Security. (2013). *Stretch Energy Code – Information*. Retrieved from http://www.mass.gov/eopss/consumer-prot-and-bus-lic/license-type/csl/stretch-energy-code-information.html.

Levine, M., de la Rue de Can, S., Zheng, N., Williams, C. , Amann, J., & Staniaszek, D. (2012). *Building Energy-Efficiency Best Practice Policies and Policy Packages*. Berkeley, CA: Lawrence Berkeley National Laboratory. Retrieved from http://eaei.lbl.gov/sites/all/files/GBPN_Final.Oct_.2012.pdf.

National Action Plan for Energy Efficiency. (2009). *Energy Efficiency Program Administrators and Building Energy Codes*. Washington, DC: U.S. Environmental Protection Agency. Retrieved from www.epa.gov/eeactionplan.

[86] Energy Futures Group, *et al*. (2012).

9. Increase the Use of Local Biofuels

Increase the production and use of locally grown woody biomass, while simultaneously supporting and incenting the greater use of farm and landfill methane and liquid biofuels using renewable, agricultural-based resources.[87]

i. Key Considerations

- Funding: Consumers through purchases of heating and other fuels; ratepayers through inclusion of costs in rates.
- Sector Impact: Transportation, buildings, electric, industry.
- Accountability: Department of Public Service, SPEED facilitator, Agencies of Agriculture and Transportation, and permitting authorities.
- Point of Regulation: Self-regulation through incentives, project developers, and fuel processors.
- Scale of Implementation: Local or state.

ii. Policy Description

Woody biomass and biofuels can be advanced through effective public education and the use of local and statewide tax supports or relief. Biofuels and woody biomass also can be promoted through purchase and investment practices of municipalities, the state, and the schools.

iii. Wood and Woody Biomass

The Governor's Commission on Climate Change released a report recommending a goal of increasing production and use of woody biomass for energy by 30 percent by 2028, and the state's 2011 *Comprehensive Energy Plan* reported that heating from wood (now 14 percent of Vermont's heating needs) can be doubled.[88]

Woody biomass is renewable when harvested appropriately, however it is not inexhaustible. Vermont must consider the importance of policies furthering the sustained use of woody biomass while protecting human health, forest ecology, and environmental and related matters. In addition, stakeholders should consider that wood burning employing current technologies releases CO_2, particulates, and other harmful emissions. While use of wood and other biomass for heating and other energy purposes may create local economic and employment benefits and is renewable (when properly managed), it may not significantly reduce CO_2 emissions on yearly or decadal timescales.

It is likely that financial incentives will be needed to promote the increased use of this resource, especially if designed to encourage the change-out of old, inefficient wood-burning units with more efficient, cleaner-burning appliances; for the conversion to pellet-burning units; and for

[87] Governor's Commission on Climate Change (2007).
[88] *Id.* and Vermont Department of Public Service (2011).

the installation of district heating systems. Promoting and incenting fuel-switching from fossil fuel to wood heat, particularly in schools, government offices, hospitals, industrial parks, college campuses, and for municipal district heating, may offer potential to increase significantly the use of the state's wood resources.

Stakeholders must consider if production of electricity or transportation fuels is a desired and wise use of the Vermont wood resource. For instance, making liquid fuels from woody feedstock generally requires operations at considerable scale, meaning this is an all-in or all-out proposition regarding the available wood supply. Likewise, utility scale electrical generation, even when combined with combined heat and power technology, could use a significant amount of available harvested wood, taking the feedstock away from other uses, such as direct combustion for building heat. Limits to the wood and woody biomass resource in Vermont may require choices regarding the use of the available fuel.[89]

iv. Farm-based Biomass and Methane

Grass and other plant-based biomass may become a viable alternative in Vermont for institutional heating or combined heat and power applications. Production of this resource (i.e. growing a switch grass hay crop) is consistent with existing farming practices, can employ currently underutilized farmland, and can contribute to good farmland management. Promotion of plant-based biofuel production at the local level and incentivizing the development of convenient processing facilities may offer benefits for both a useful fuel supply and farm revenue streams. Locally-produced biodiesel fuel may be able to contribute meaningfully to fuel-switching away from petroleum-based diesel fuel for use in farm equipment and possibly for local fleets of heavy duty vehicles (HDVs) that have daily travel circuits within range of the fueling site. Presently, some Vermont farms grow plants that can be processed into high quality biodiesel for on-farm and HDV use. As with grass-based biofuel, this area offers potential for expansion, especially with farm incentives to grow feedstock and to develop and expand local processing capabilities.

Farm methane digester development and use has gained a respectable foothold among Vermont's dairy farms. While there are a limited number of farms large enough to use only animal manure for this process, alternative digester designs (e.g., "mixed-substrate" anaerobic digesters) can use both livestock manures and certain crops, other farm waste, and food-processing waste. Smaller farms may be able to take advantage of this approach and employ the technologies. While there are challenges, this technology may be able to generate up to 30 megawatts of renewable base load power by 2025.[90]

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[89] Biomass Energy Development Working Group (2012).
[90] Vermont Department of Public Service (2011).

v. Landfill Methane

There is a limited capacity for new landfill biogas generation in the state. However, stakeholders may weigh the possibilities for expansion of existing systems or installation of generators on smaller landfills.

vi. Select Resources

Biomass Energy Resource Center. (2009). *Grass Energy: The Basics of Production, Processing, and Combustion of Grasses for Energy*. Retrieved from http://www.biomasscenter.org/resources/fact-sheets/grass-energy.html.

Governor's Commission on Climate Change. (2007). *Plenary Group Recommendations to The Governor's Commission on Climate Change*. Montpelier, VT: Governor's Office. Retrieved from http://www.anr.state.vt.us/air/Planning/docs/GCCC%20Appendix%202_Plenary%20Group%20Recommendations%20&%20Appendices.pdf

Legislative Council. (2012). *Biomass Energy Development Working Group Final Report*. Montpelier, VT: Legislative Council. Retrieved from http://www.leg.state.vt.us/REPORTS/2012LegislativeReports/272678.pdf.

Vermont Department of Public Service. (2011). *Comprehensive Energy Plan*. Montpelier, VT: Vermont Department of Public Service. Retrieved from http://publicservice.vermont.gov/publications/energy_plan/2011_plan.

10. Expand the Appropriate Use of Natural Gas

Support the expanded use of natural gas to displace higher carbon content fuels in all sectors of the economy.

i. Key Considerations

- Funding: Vermont Gas, ratepayers.
- Sector Impact: Buildings, electric, industry.
- Accountability: N/A.
- Point of Regulation: Vermont Gas, land use.
- Scale of Implementation: Local or state.

ii. Policy Description

Among fossil fuels, natural gas is the least carbon intensive, and its combustion results in the emission of fewer air pollutants, including particulates, sulfur dioxide, nitrogen oxides, and mercury. While natural gas still produces significant emissions, when it displaces a more carbon-intensive fuel like oil it can lower greenhouse gas emissions and help Vermont to meet its emissions reduction targets. There are a number of applications where natural gas potentially can serve as a bridge fuel to help Vermont meet its energy needs while driving toward a total or nearly total renewably-powered future:

- Natural gas electricity generation can replace dirtier fossil fuel generation (i.e. coal or oil).
- Natural gas can contribute toward needed system balancing and flexibility for variable energy renewable generation resources, furthering their expanded use on the grid.
- Methane made from renewable sources can be injected into a natural gas pipeline to create a partially renewable fuel.
- Natural gas can be used to power vehicles. For example, heavy-duty vehicles could achieve a nearly 29 percent reduction in CO_2 emissions when compared to diesel vehicles, depending on natural gas leakage rates.[91]
- Natural gas is a promising and cost effective alternative to oil or coal for building heat in areas where it is available.[92]
- Natural gas can be used to power industrial processes including combined heat and power systems.

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[91] California Air Resources Board (2009).

[92] An additional advantage of fuel switching to natural gas for heating is that customers currently using non-regulated fuels would be eligible for participation in utility sponsored efficiency programs. This could open new opportunities for customers not yet taking advantage of beneficial utility programs to insulate their homes and install more efficient appliances.

Vermont Gas Systems actively is exploring expansion plans for its gas pipeline and local distribution system with the goal of reaching more communities and customers in the Champlain Valley. As a result, natural gas may play an increased role in Vermont's energy future. While natural gas has attractions, its use does not come without potential hazards. Vermont stakeholders will need to analyze the extent to which they consider natural gas a beneficial bridge fuel. These policy questions, revolving around the extent to which the state can and will benefit from expanded use of natural gas, include discussions of items such as:

- Do we as a state consider natural gas to be cleaner than other fossil fuels and offer enough advantages to support expanding its use?
    - If we do support expanding its use, in what time frame and for what duration do we believe natural gas will provide a benefit to meeting Vermont greenhouse gas reduction goals?
    - What market and climate conditions, and which energy using sectors, will support expanding natural gas use in Vermont?
    - Will expanding the use of natural gas in Vermont help or hinder meeting the required renewable goals?
    - Is it beneficial, both economically and environmentally, to offer support to marketing and development efforts of Vermont Gas Systems for service expansion and increase access for consumers to natural gas? This would likely foster opportunities to substitute natural gas for other fossil fuels over at least the next 2 – 3 decades (as opposed to attempting to introduce substantially more renewable energy over the same time period from possibly undefined sources)?
    - Natural gas service expansion likely will provide near term benefits, including relatively inexpensive energy and economic development opportunities. However, will substantial expansion of the gas delivery infrastructure be consistent with long term renewable goals beyond 2 - 3 decades into the future?
    - Is continuing to provide incentives from the energy efficiency utilities and Vermont Gas for fuel switching from electric, fuel oil, and propane to natural gas consistent with the renewable energy and greenhouse gas reduction policies? Could a near term transition to natural gas, instead of switching to renewables, result in the use of natural gas over an extended period of time, and over what time frame would this lessen the introduction of renewable energy resources to provide the same services?

The Legislature has banned shale gas extraction in the state, raising the question about use in Vermont of shale gas from other jurisdictions. Vermont's gas is presently supplied from Alberta, Canada, but the extensive pipeline and delivery system in North America possibly offers potential for future supplies to come from other regions, including northeastern U.S. shale gas deposits. What should Vermont public policy be regarding the use in Vermont of gas from nearby shale gas deposits, in the context of relatively low energy prices, useful jobs, and economic investment in the northeastern U.S.?

iii. Select Resources

Bluestein, J. *et al.* (2012). *New Natural Gas Resources and the Environmental Implications in the U.S., Europe, India, and* China. Montpelier, VT: Regulatory Assistance Project. Retrieved from http://www.raponline.org/document/download/id/6097.

California Air Resources Board. (2009). *Detailed California-Modified GREET Pathway for Compressed Natural Gas (CNG) from North American Natural Gas*. Sacramento, CA: California Environmental Protection Agency. Retrieved from http://www.arb.ca.gov/fuels/lcfs/022709lcfs_cng.pdf.

11. Electrify the Light-Duty Vehicle Fleet

Set targets for the increased electrification of transportation sectors.

i. Key Considerations

- Funding: Consumers, incentives from carbon pricing revenues.
- Sector Impact: Transportation.
- Accountability: Voluntary through inducement by incentives.
- Point of Regulation: Voluntary, unregulated fuel switch.
- Scale of Implementation: Federal and state.

ii. Policy Description

As discussed above, the electrification of the transport sector must be a major component to allow the transportation sector to meet the renewable and carbon goals established in Vermont law. Achieving a meaningful penetration of electric vehicles will require a combination of strategies to overcome the current limitations and consumer concerns surrounding electric vehicles and to create a supply network that is able to supply sufficient quantities of electricity reliably and conveniently.

The technology pathway for electric vehicles looks promising as battery prices are decreasing and new materials are reducing the weight and price of vehicles. As a small state, Vermont is in a very good position to act as an enabler, promoting policies and strategies to support an expanding electric vehicle fleet. The Transportation Renewable Fuels Standard discussed below can provide a strong incentive for electric vehicle adoption. Additionally, the state can continue its demonstration program and expand it to include vehicles in the state fleet. Advantages can be given to electric vehicles through registration fees, feebate programs, and similar programs where vehicles achieving lower fuel efficiency standards pay a higher registration fee, with some of that given to support a lower fee for more fuel-efficient vehicles. Similar incentives can be developed for businesses that maintain car fleets.

Electrification of significant elements of the light vehicle fleet is critically important to meeting Vermont's goals. Electric vehicle availability, supporting infrastructure, cost, and governing policies cannot be entirely controlled by relatively small Vermont. The evolution to greater electrification of the transportation sector doubtless will require a coordinated effort from many actors. However, there are some steps Vermont can take to help electric vehicles to compete with petroleum vehicles. One step is the establishment of a visible charging network as a state priority. In connection with this, Vermont could also establish an electric vehicle charging station tax credit for homeowners and businesses. The PACE program could be expanded to include home or business charging stations as eligible measures. Utilities could be permitted and encouraged to include charging stations as rate base items. Moreover, legal and other barriers, as discussed below, could be removed to allow third-parties to operate charging stations and resell electricity to customers.

The state must advance this policy through widespread education and information efforts. In this regard it may wish to sponsor education, outreach, and planning initiatives on the use of electricity as a replacement fuel for vehicles. This educational effort can explore both technical feasibility and costs and benefits. Associated with the education effort, the state can include an official website for Vermont-specific electric vehicle information. The state can create information guides for local governments to facilitate the use of electric vehicles and related equipment and charging infrastructure. These guides can be aimed at supporting necessary additions to the transportation and energy sections of existing regional and local plans, as well as for the zoning and building codes. Another step is Vermont's continued adoption of California's zero emission vehicle (ZEV) program. The goal of the ZEV program is to commercialize ZEV technologies (e.g., pure battery electric, plug-in hybrid electric, and hydrogen powered vehicles) to achieve substantial reductions of emissions of greenhouse gases and other air pollutants. Under the ZEV program, major auto manufacturers must sell an increasing percentage of ZEVs over time in the states with ZEV programs.

On the electric supply side, utilities must plan for the increased load from the supply side and attend to distribution system issues. An increased load will mean an increased need for renewable supplies of power. Additionally, clustering of plug in vehicles in neighborhoods served by lower voltage distribution systems could require improvements to the system. Utility rates and procedures may need an overhaul too. Currently, third parties cannot sell electricity at retail, so a charging station owner cannot charge by the kWh. Also, Vermont utilities do not have tariffs to allow them to sell to a "mobile account" (i.e., charging at a remote location and having the cost reflected in the monthly home or business electric bill). Providers are able to get around this by charging for parking with an option to recharge, assessing a flat fee for a charging service, or in the case of Tesla, not charging for recharging at all. In conjunction with the Public Service Board, a utility business model should be developed to support this transition, which would include measures to facilitate siting of charging stations. In addition, electrified end uses have the potential to provide increased ancillary services[93] to the electric grid through vehicle to grid (V2G) technologies or smart grid-enabled controls on end uses. These services likely will be in higher demand as the power supply transitions to one with a higher percentage of variable resources.

[93] "Services needed to support the transmission of energy from generation to loads, while maintaining reliable operation of the transmission system. These include regulation and frequency response, spinning reserve, non-spinning reserve, replacement reserve, and reactive supply and voltage control." Lazar (2011).

In addition to the above, there are a number of strategies that Vermont can take to promote transportation electrification of Vermont's light duty vehicle fleet:[94]

- Increase consumer awareness and demand for electric vehicles through public outreach.
- Reduce electric vehicle costs.
- Simplify and prioritize home charging installations.
- Optimize placement of non-residential charging infrastructure.
- Ensure that the electricity infrastructure (e.g., vehicle recharging facilities and distribution transformers) is sufficient to accommodate the rapid adoption of electrification.
- Encourage and coordinate local and regional government efforts.
- Support fleet purchases of electric vehicles.
- Research and demonstrate opportunities for electric vehicles to support Vermont's electricity grid.

iii. Select Resources

European Climate Foundation. (2010). *Roadmap 2050: A Practical Guide to a Prosperous, Low-Carbon Europe*. Hague, Netherlands: The European Climate Foundation. Retrieved from http://www.roadmap2050.eu/project/roadmap-2050.

Maryland Electric Vehicle Infrastructure Council. (2012). *Final Report to the Governor and Maryland General Assembly by the Electric Vehicle Infrastructure Council*. Hanover, MD: Maryland Department of Transportation. Retrieved from http://www.mdot.maryland.gov/Office%20of%20Planning%20and%20Capital%20Programming/Electric_Vehicle/Documents/Final_Report_Full_Document.pdf.

California Plug-In Electric Vehicle Collaborative. (2013). *Resources for Policy Makers*. Retrieved from http://www.evcollaborative.org/policy-makers.

Governor's Interagency Working Group on Zero Emission Vehicles. (2013). *2013 ZEV Action Plan, A Roadmap Toward 1.5 Million Zero Emission Vehicles on California Roadways By 2025*. Retrieved from http://opr.ca.gov/docs/Governor's_Office_ZEV_Action_Plan_(02-13).pdf.

[94] Plug-in Hybrid & Electric Vehicle Research Center (2010). See also California Council on Science and Technology (2011).

12. Establish a Transportation Renewable Fuels Standard

Advance the state's commitment to the establishment of a Renewable Fuel Standard (RFS) for the Northeast region by establishing targets for use of various renewable energy-based fuels, including electrification, in the transportation sector.

i. Key Considerations

- Funding: Wholesale fuel suppliers and consumers through purchases.
- Sector Impact: Transportation.
- Accountability: Fuel suppliers.
- Point of Regulation: Fuel suppliers.
- Scale of Implementation: State and regional.

ii. Policy Description

The transportation renewable fuels standard (RFS) is a policy of promoting the use of electricity from renewable generation sources, as well as a course of action "whereby a minimum percentage of biofuels is to be used in the state or regional transportation fuel supply each year."[95] The policy pathway should have electricity included in the standard, to affect actions as described in the previous policy on electrifying light vehicles.

A transportation RFS also must focus on liquid transportation fuels, and it is advisable for the conversation to be expanded to include agricultural equipment fuels. Typically, fuels in this discussion include wood and woody biomass derived products, biodiesel, and other biofuels like ethanol. Other approaches in this area include a clean fuels standard (CFS) and low-carbon fuel standards (LCFS). The LCFS regulatory framework is distinct from the RFS in that it forces transportation fuels to compete based on carbon intensity. This differs fundamentally from RFS-like programs that mandate specific percentages or volumes of biofuel. Another important feature of a fuel standard is that it is designed to reduce the intensity of greenhouse gas emissions from fuels on a per unit basis, rather than to cap transportation emissions. Federal law establishes a RFS for the nation aimed at promoting the use of a minimum volume of biofuels additives to the petro-fuels in the transportation sector (i.e. adding ethanol to gasoline).[96] Continued support by Vermont for the establishment of a CFS for the Northeast region through the Northeast States for Coordinated Air Use Management is fully consistent with this RFS approach.

Renewable fuel standards work best with a regional or national scope; however, efforts by Vermont to expand the availability and use of renewable fuels transportation and on-farm agricultural equipment may offer benefits in energy supply, emissions reduction, resource

[95] Schnepf & Yacobucci (2013).
[96] See the 2005 and 2007 Energy Acts.

production and markets, and other areas. RFS programs must be long-term because significant infrastructure evolution is required, including manufacturing, transport, and distribution of fuels and end-user adaptations to accommodate such fuels as they become available and economically competitive.

RFS fosters the use of fuels from renewable resources that displace fossil fuels, support local economies and job growth, and lead to lower greenhouse gas emissions. Renewable fuels may fill a niche for reducing fossil fuel use in transportation sectors where electrification is not effective or convenient.

Availability of and access to fueling stations and technical assistance will be needed to expand retail siting of renewable fuel infrastructure. Vermont requires additional investment and coordination among stakeholders, especially in the liquid biofuels sectors.

A renewable fuel standard is most effective when deployed in conjunction with complementary state and regional policies, such as energy efficiency, increased electrification in transportation and building heating, district or community heating initiatives, and a state school heating conversion program, such as Fuels for Schools.[97] In addition, the policy is consistent with initiatives for a statewide bioenergy industry targeted at transportation and other energy consuming sectors.

iii. Select Resources

U.S. Environmental Protection Agency. (2013). *Renewable Fuel Stand (RFS)*. Retrieved from http://www.epa.gov/otaq/fuels/renewablefuels/.

Schnepf, R. & Yacobucci, B. (2013). *Renewable Fuel Standard (RFS): Overview and Issues*. Washington, DC: Congressional Research Service. Retrieved from http://www.fas.org/sgp/crs/misc/R40155.pdf.

Vermont Department of Public Service. (2011). *Vermont Comprehensive Energy Plan*. Montpelier, VT: Department of Public Service. Retrieved from http://publicservice.vermont.gov/publications/energy_plan/2011_plan.

Maryland Electric Vehicle Infrastructure Council. (2012). *Final Report to the Governor and Maryland General Assembly by the Electric Vehicle Infrastructure Council.* Hanover, MD: Maryland Department of Transportation. Retrieved from http://www.mdot.maryland.gov/Office%20of%20Planning%20and%20Capital%20Programming/Electric_Vehicle/Documents/Final_Report_Full_Document.pdf.

[97] Biomass Energy Resource Center (2013).

13. Transition the Heavy-Duty Vehicle Fleet to Biofuels or Natural Gas

Adopt and support policies to transition the heavy duty vehicle fleet away from petroleum based fuels.

i. *Key Considerations*

- Funding: Developers, state transportation funds.
- Sector Impact: Transportation.
- Accountability: N/A.
- Point of Regulation: Many.
- Scale of Implementation: National and state.

ii. *Policy Description*

Diesel fuel use accounts for a significant portion of Vermont petroleum use, mostly for heavy-duty vehicles (HDV) and off-road vehicles used in agriculture. Since much of the diesel fuel used in Vermont is from heavy duty vehicles whose trips do not originate in Vermont and may not end in Vermont, transitioning heavy-duty vehicles away from petroleum based diesel fuel may require different approaches for these different types of uses. Various alternatives are available to overcome the legacy of market barriers and existing conditions created from years of fossil fuel dependence. These range from pure market instruments such as carbon taxes to prescriptive mandates and voluntary actions. As with any emissions abatement strategy in the transportation sector, success requires a complementary approach involving increased vehicle fuel efficiency, reduced carbon intensity of fuels, and reduced vehicle miles traveled (VMT). To date, much policy in this area is driven by federal fuel efficiency standards, which were recently announced for HDVs, and federal actions regarding biofuel production and blending requirements. This policy is directed at lowering the carbon content or increasing the renewable content of fuels used.

iii. *Biofuels*

As a result of their design characteristics, diesel engines are better able to combust a range of hydrocarbons to provide motive power. This can include everything from used fryer grease to advanced refined fuels that closely resemble diesel fuel. This characteristic has encouraged many backyard fuel producers to set up operations in Vermont. However, the over the road trucking industry needs a fuel dependably blended to serve their needs. Even so, vehicle manufacturer's warrantees and guidelines vary regarding the use of biofuels. Vermont will have to depend on manufacturers to work this out.

Implementation of a biofuels policy for Vermont can start with increasing the availability of blended fuels. Many stations are reluctant to install the necessary tanks and other required equipment because, in addition to the cost, they are reluctant to take on the challenges of handling and storing biodiesel and the challenges of the Vermont permitting system. Technical assistance could help here. Financial incentives, through a reduced fuel tax, exemption from a carbon pricing scheme discussed above, or other measures could ease that reluctance.

Working with in-state operators of trucking fleets may produce results, especially if there are some tangible benefits or recognition awarded to the operator. Agricultural operations also can use biofuels and grow crops to produce biofuels. Self-producing the fuel for the farm machinery can contribute to the financial viability of the farm and make it more self-reliant.

iv. Natural Gas

As discussed above in the natural gas policy, while natural gas is a lower carbon content fuel than gasoline or diesel fuel, it is still a hydrocarbon. Natural gas is neither sufficiently renewable nor sufficiently low in carbon to meet the goals established for Vermont. Stakeholders must consider if it may be best viewed a bridge fuel – one that can save carbon in the short term while other alternatives are being developed, but a fuel that does not represent a solution for meeting 2050 goals. The questions posed in the natural gas sector are appropriate to include in a discussion about natural gas in the transportation sector. Vermont should consider if there are relative benefits that justify the use of natural gas as a fuel in the coming decades, especially in the heavy duty transportation section. However, such use is likely to be a decision made by influences outside of Vermont. The national trucking industry, for instance, may adopt a technology independent of any action taken by Vermont.

v. Select Resources

U.S. Environmental Protection Agency. (2013c). *Renewable Fuel Standard (RFS)*. Retrieved from http://www.epa.gov/otaq/fuels/renewablefuels/.

Moniz, E. J., *et al.* (2011). *The Future of Natural Gas An Interdisciplinary MIT Study*. Boston, MA: Massachusetts Institute of Technology. Retrieved from http://mitei.mit.edu/publications/reports-studies/future-natural-gas.

Jacobson, M., *et al*. (2013). "Examining the feasibility of converting New York State's all-purpose energy infrastructure to one using wind, water, and sunlight." *Energy Policy*, 57 (2013) 585–601. Retrieved from http://www.stanford.edu/group/efmh/jacobson/Articles/I/NewYorkWWSEnPolicy.pdf.

14. Reduce Vehicle Trips and Increase Mobility Options, Enabled by Smart Growth

Adopt and support policies to encourage non-motorized and public transport by fostering their consideration in development.

i. Key Considerations

- Funding: Developers, state transportation funds.
- Sector Impact: Transportation.
- Accountability: N/A.
- Point of Regulation: N/A.
- Scale of Implementation: National, state, and local.

ii. Policy Description

The purpose of this policy is to encourage greater levels of walking, bicycling, and the use of public transit options as alternatives to driving, by making it safe, convenient, and popular. Because much of the state's energy is used to move people from homes to work, shopping, school, or social gatherings, a compact development pattern allows the energy used in moving those people to be reduced. Compact development means trips are often shorter, which facilitates people walking, biking, and using alternative modes of transportation to reach their destinations. Transit systems are also less viable outside of compact settlement areas. Conversely, sprawl reduces transportation options and leads to increased reliance on single occupancy vehicles.

The state's long-standing land use planning goal is to plan development to maintain the historic settlement pattern of compact village and urban centers separated by rural countryside.[98] This requires the encouragement of concentrated mixed-use development within our community cores. This goal is integral to a variety of public interests, including reduced development pressures on agricultural, productive forest, and natural resource lands and the creation of strong community centers with economic development in those centers. The goal also has a major influence on the functionality of the transportation system and, as a result, on energy consumption.

Many town ordinances and town planning efforts attempt to separate residential areas from commercial and industrial activities. While there are valid reasons for this, it also leads to people living farther away from where they work and shop, which increases the likelihood that

[98] The Downtown Development Act establishes programs to support downtowns, villages, and growth centers in the form of transportation grants, rehabilitation tax credits, Tax Increment Financing (TIF) districts, and relaxed Act 250 thresholds, as well as prioritizing state funding to these areas.

they will use a vehicle rather than alternative modes of transportation. Fortunately, Vermont is already a national leader in employing Smart Growth principles.

Areas to develop and implement policies include:

- Explore implementation measures (incentives, regulations, and outreach) critical to enabling and encouraging land use decisions that support "smart growth" and assess progress toward that vision.
- Strengthen and streamline state smart growth "designation" programs, link state programs and funding sources to "designation" criteria, and review Act 250, Act 248, and Agency of Natural Resource programs to determine what provisions support or impede development within designated areas and other smart growth locations.
- Improve data collection regarding the composition of the Vermont vehicle fleet, penetration of alternatively fueled vehicles, and use patterns.
- Define techniques to better integrate land use, transportation planning, and economic development efforts at the state, regional, and local levels.
- Encourage telecommuting and teleconferencing by developing telecommunications infrastructure.
- Conduct the necessary scenario analysis combined with other planning techniques to determine the degree of build-out of rail, transit, bike/pedestrian, park and ride, and other facilities identified in the *Comprehensive Energy Plan* needed to meet the state's goals. Identify the costs and revenue sources available to accomplish these objectives.
- Encourage transit-oriented development, with the goal to create walkable communities integrated with an efficient mass transit system where residents have access to amenities without depending on a personal vehicle to access them.[99]
- Support the continued implementation and enhancement of Vermont's Complete Streets legislation passed in 2011.[100]
- Keep the needs of all users – drivers, pedestrians, transit users, and bicyclists – in mind when facilities are designed or constructed.
- Ensure projects supported by state funding are designed flexibly to include pedestrian and cycling amenities.
- Infuse projects with the unique "sense of community" that is alive in so many areas of Vermont.

Integral to compact growth strategies is improving the availability of public transit. Vermont should adopt policies to balance its state and federal transportation investments to support efficient and timely public transportation service. Services should be designed to encourage and

[99] TransitOrientedDevelopment.org (2013).
[100] Smart Growth America (2013).

enable increased public transit ridership, carpooling, and other commuting strategies. Strategic leveraging of Vermont community resources, such as town energy and transportation committees, can create opportunities for targeted outreach to increase public awareness of transit options.

iii. Public Transportation Improvements

Vermont should consider implementing policies that expand public transportation by offering increased service on existing routes, subsidizing fares, expanding routes where justified, or building new infrastructure. A fare structure can be subsidized so all riders receive an incentive to use public transportation, or specific classes of riders can be subsidized through low-income support programs or by policies like time-of-day fare differentials. Increased service can come in the form of more frequent service, expanding scheduled stops, or adding new routes.

Passenger rail transportation opportunities come from improving interconnections to neighboring states and Canada, although establishing passenger rail service from Montpelier to Burlington or Burlington to Rutland has attracted interest in the past. Increasing the efficiency of freight rail activity for local shipping has some potential, although most rail traffic in Vermont is thru traffic, with origins and destinations outside of the state.

iv. Ride-sharing, Car-sharing, and Other Commuting Strategies

Vermont should consider implementing policies to expand services and provide incentives to travelers to choose transportation options other than a single occupancy vehicle. Carpoolers need a collector lot at the beginning of their journey and parking at the end. Expanding carpool lots at strategic junctures around the state will open up possibilities for ridesharing, while rewarding carpoolers with reserved parking at their destinations will provide an additional incentive to join a carpool. Go Vermont (http://www.connectingcommuters.org/) is a web-based service matching commuters with potential ride sharers. Additionally it functions as an intake point for commuters interested in establishing a vanpool. These services should be broadened where appropriate. Social media can be used to inform and improve service in this area.

v. Select Resources

Fehr & Peers. (2013) *Traffic Calming*. Retrieved from http://trafficcalming.org/.

TransitOrientedDevelopment.org. (2013). *Transit Oriented Development*. Retrieved from http://www.transitorienteddevelopment.org/.

Smart Growth America. (2013). *National Complete Street Coalition*. Retrieved from http://www.smartgrowthamerica.org/complete-streets.

Form Based Codes Institute. (2013). *What Are Form Based Codes?* Retrieved from http://www.formbasedcodes.org/what-are-form-based-codes.

Bhatt, N., Peppard, C. & Potts, S. (2010). *Getting Back on Track: Aligning State Transportation Policy with Climate Change Goals*. Washington, DC: Natural Resources Defense Council.

Retrieved from http://www.nrdc.org/smartgrowth/files/GettingBackonTrack_report.pdf.

Cambridge Systematics, Inc. (2009). *Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions*. Washington, DC: Urban Land Institute. Retrieved from http://www.rockefellerfoundation.org/uploads/files/6e40c2cf-a33e-4f7a-ba1f-39069e6e1214.pdf.

15. Use Creative Price and Tax Mechanisms to Encourage Use of Transportation Alternatives

Develop pricing initiatives and tax incentives to influence transportation choices.

i. Key Considerations

- Funding: Consumers, Agency of Transportation, insurance companies.
- Sector Impact: Transportation.
- Accountability: Agency of Transportation.
- Point of Regulation: Auto registration, insurance purchase.
- Scale of Implementation: State and federal.

ii. Policy Description

Fees assessed to motorists are both fixed and variable. The gasoline tax is a variable fee, based on the number of gallons of gasoline purchased. Registration fees and insurance premiums are generally fixed and independent of miles driven. Policies that enable the conversion of some of these fixed costs associated with the use of the transportation system into variable costs can make those costs avoidable through efficient transportation decisions. This includes local and regional pricing strategies, such as pay-as-you drive fee assessments and variable registration fees. These pricing policies provide an incentive for drivers to change their behavior with respect to driving miles or purchasing a vehicle.

Instituting a carbon tax or emissions fee generally will raise the cost of fuel, resulting in increased incentives for drivers to be more efficient with their choices. Any policy like this must include safeguards for the most vulnerable in the population to ensure adequate mobility for them. This can be done through revenue recycling to promote efficiency in a particular sector or through direct subsidies.

Weight-based registration fees are another policy that turns a portion of the vehicle registration fee into a variable cost and promotes more efficient transportation choices by consumers. This can include feebates, whereby fees are increased on a less desirable option with corresponding fees decreased or rebated for more desirable options. For example, California's proposed "Clean Car Discount" program imposed a fee of up to $2,500 on new, high-carbon emitting vehicles (starting in 2011) and then rebated the fee to buyers of new, low-emission vehicles, thereby shifting some of the external costs resulting from the operation of a less efficient vehicle onto those who create the impact.[101]

[101] See A.B. 493 at http://www.leginfo.ca.gov/pub/07-08/bill/asm/ab_0451-0500/ab_493_bill_20070220_introduced.html.

A vehicle miles traveled (VMT) tax is a policy of taxing motorists based on the number of miles they travel each year.[102] It has been proposed in other states as an infrastructure funding mechanism to replace the fuel tax, which has been generating significantly less revenue due to the effects of more fuel efficient vehicles and higher gasoline prices. A tax levied on the miles travelled will have the effect of discouraging excess travel and encouraging more efficient means of travel. The principle can also be applied to insurance payments. Pay-as-you-drive insurance appeals to consumers because it offers the possibility of lower rates. Insurance companies like it because telematics devices, which are required in most pay-as-you-drive plans, transmit accurate driving data and let insurers match the price of their coverage to the actual risk posed by drivers.

Implementing a VMT requires a system to collect fees. This could be as simple as a self-reporting system with spot checks or as sophisticated as a GPS system to monitor usage. A successful usage-based policy must inform motorists of their resulting obligations on a regular basis. Additionally, the taxes or insurance premiums must be collected on a regular basis, possibly at a fuel refilling station.

In addition to sending appropriate price signals to impact marginal driving decisions, usage-based fees collect taxes in a more equitable manner than fixed fees. Over time, other costs and fees could be included, such as a pollution tax or congestion fees, either of which can be time of day based.

iii. Select Resources

Cambridge Systematics, Inc. (2009). *Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions*. Washington, DC: Urban Land Institute. Retrieved from http://www.rockefellerfoundation.org/uploads/files/6e40c2cf-a33e-4f7a-ba1f-39069e6e1214.pdf.

Cambridge Systematics, Inc. (2009). *Moving Cooler: Technical Appendix*. Washington, DC: Urban Land Institute. Retrieved from http://www.acogok.org/Programs_and_Services/Transportation_and_Data_Services/documents/MovingCooler_Appendix%20A_Strategies.pdf.

[102] National Surface Transportation Infrastructure Financing Commission (2009).

16. Adopt a Renewable Portfolio Standard

Implement a Renewable Portfolio Standard (RPS) that sets specific and aggressive targets for new electric generation from renewable sources over the period of 2015 to 2050. The RPS obligations should be mandatory for all Vermont electric utilities serving retail customers.

i. Key Considerations

- Funding: Ratepayers through inclusion of costs in rates.
- Sector Impact: Electric.
- Accountability: Measurement and verification by Public Service Board.
- Point of Regulation: Retail utilities.
- Scale of Implementation: State.

ii. Policy Description

A RPS requires an electric utility to buy or generate a minimum amount of renewable energy as a percentage of the utility's overall retail sales. While Vermont does not presently have a RPS, Vermont electric utilities have met the 2004 legislative goal of serving all kWh load growth during the years 2005 to 2012 from SPEED resources.[103] In addition, the SPEED program establishes in-state generation goals, expanded by legislation in 2012—127.5 MW must be phased-in over several years, supplied by generation sources of 2.2 MW or smaller. Vermont may now consider expanding both of these approaches or adopt a new RPS policy that more aggressively promotes the development of renewable generation.

Vermonters strongly support the use of clean power and, as with environmental and social laws, many wish to see Vermont stand out as a national leader in the development and use of renewables. The goal of acquiring 90 percent of Vermont's energy from renewable sources by 2050 will require that renewables be deployed more extensively and at a faster rate than current prices with lack of pricing for externalities would dictate. A RPS policy that sets aggressive goals decades into the future can help foster this enhanced deployment. The RPS can be used to support overlapping benefits—development of renewable energy provides cleaner energy sources and also practical opportunities for significant economic development, expansion of the tax base, and growth of local jobs. In addition, an aggressive RPS can stimulate development and use of emerging technologies, distributed generation, in-state generation, and customer-sited generation.

Stakeholder consideration of a full RPS program in Vermont may include the following steps:

- Review the legislative definition of qualifying renewable resources.

[103] A SPEED electrical resource is power produced by a renewable source for which the renewable attributes are not required to be retained to qualify. See footnote 65.

    - Determine if any changes to the existing definition are appropriate.
    - Determine if out-of-state renewable generation is appropriate to meet Vermont's RPS requirements.
    - Consider the treatment of small and large hydroelectric facilities:
        - Consider if in-state, new, large dams qualify.
        - Consider if imports from Hydro-Quebec qualify.
- Consider whether to promote any particular technology or energy resources:
    - Establish sub-targets (e.g., "set-asides" or "carve-outs") that encourage set amounts of a particular resource, or
    - Establish favorable payment policies to promote particular technologies.[104]
- Determine whether existing renewable facilities can participate in a new RPS program.
- Establish penalties for utilities that fail to reach the specified renewable targets.
    - Would harsher penalties apply if failure to meet any intermediate or sector goals?
- Consider mitigating the cost of the program to ratepayers.
    - Allow the Public Service Board discretion to suspend temporarily the program or allow exceptions if ratepayer costs become burdensome.
- Consider utility recovery of the additional cost of procuring renewable power.
    - How much cost recovery is allowed and how to collect it?
        - treatment of RPS related costs in normal rate-making,
        - a ratepayer surcharge, or
        - utilities to include costs in rate base.
- Determine the treatment of the penalties utilities incur associated with non-compliance.
    - Do ratepayers, shareholders, or both pay?
    - Treatment of public power utilities that have no shareholders.
- Set year-by-year program targets to meet the 90 percent by 2050 goal.
    - Consider year-by-year sub-targets ("set-asides") for specific technologies.
- Consider the benefits of a central procurement program where all ratepayers participate equally vs. utility specific requirements where each utility acts individually.
    - Is it useful to employ a hybrid approach that allows a utility to obtain resources either through central procurement or through their own individual efforts?
- Consider whether different rate classes should have the same renewable requirements. (e.g. industrial rate class energy could be less renewable in order to maintain inter-jurisdictional competitiveness)

The market mechanisms upon which the RPS relies provide price competition among suppliers and between different technologies and energy resources. To the extent these markets provide competition, they are likely to stimulate efficiency and creative innovation as renewables compete among themselves and with conventional sources. RPS is most effective when established to mandate medium- and long-term goals that progressively increase over time.

[104] Grace, *et al.* (2011).

With no traditional RPS requirement in place, Vermont allows the sale of renewable attributes from renewable energy generation (known as renewable energy credits or RECs) to be sold into markets in other states. Critics of this practice argue that this is double counting the renewable attribute and that allowing Vermont REC sales defers additional development of clean resources that would have otherwise been required to meet regional clean energy goals. As a result, Vermont is left with higher priced power stripped of its clean attributes. Supporters of the practice note that Vermont has in place a planning requirement for electric utilities to determine how they will accomplish targets of 55 percent renewables in their supply mix in 2017, climbing to 75 percent renewable in 2032. In addition, supporters contend that Vermont ratepayers benefit from the sale of the RECs into out-of-state markets and argue that the practice should continue or, at a minimum, the sale of RECs from existing generation should be "grandfathered" by any new policy. State policy going forward can address the treatment of REC sales from existing and future renewable generation sources. State policy should be clear on the sale of renewable attributes and clarify whether such a sale eliminates that source from meeting the 90 percent goal.

As with most policies to encourage renewable energy use and carbon emissions reduction, RPS works best to meet established goals when combined with energy efficiency, conservation, electric demand response, and federal production tax credits.

iii. Select Resources

Database of State Incentives for Renewables & Efficiency. (2013). *Portfolio Standards/Set Asides For Renewable Energy*. Retrieved from http://www.dsireusa.org/incentives/index.cfm?SearchType=RPS&&EE=0&RE=1.

Grace, R., Donovan, D. & Melnick, L. (2011). *When Renewable Energy Policy Objectives Conflict: A Guide for Policymakers*. Silver Spring, MD: National Regulatory Research Institute. Retrieved from http://www.nrri.org/pubs/electricity/NRRI_RE_Policy_Obj_Conflict_Oct11-17.pdf.

Yang, C., Williams, E. & Monast, J. (2008). *Wind Power: Barriers and Policy Solutions*. Charlotte, NC: Duke University's Nicholas Institute. Retrieved from http://nicholasinstitute.duke.edu/sites/default/files/publications/wind-power-barriers-and-policy-solutions-paper.pdf.

M.J. Beck Consulting. (2013). *The RPS Edge*. Retrieved from http://mjbeck.emtoolbox.com/?page=Renewable_Portfolio_Standards.

17. Import Utility Scale Renewables, Including Large-Scale Hydroelectric Power, from Canada

Look to regional trading partners as suppliers of renewable energy generation.

i. Key Considerations

- Funding: Ratepayers through inclusion of costs in rates.
- Sector Impact: Electric.
- Accountability: N/A.
- Point of Regulation: Retail utilities.
- Scale of Implementation: State and Region.

ii. Policy Description

Vermont has purchased significant amounts of electricity (up to approximately one-third of the state's power supply) from Hydro-Québec for the previous several decades. Presently, purchase contacts are in place through 2038 that will provide Vermont with over 200 MW of electric power from Hydro-Québec supplied by at least 90% hydro-electricity, which the Vermont Legislature has determined qualifies as renewable power.[105] The DPS advises that this contract provides a long term source of electric generation with low air emissions, relative price stability, renewable fuel, freedom from relying on a single generator, and other potential benefits.

Hydro-Québec and Nalcor Energy in Newfoundland and Labrador are expected to have surplus generation, mostly from hydroelectric power, for sale into the New England market in coming years.[106] Vermont utilities should investigate securing purchase contracts and delivery options for additional, stable, long-term hydropower supply potentially available from Canadian provinces.[107]

The New England Wind Integration Study suggestes that up to 12,000 MW of wind power could be available by 2020 under certain assumptions.[108] Most of this is in Northern New Hampshire, and Maine. Additional supplies of wind power could become available from Northern New York State as well. These projects may be able to achieve economies of scale, enabling Vermont to procure renewable resources at a lower cost than may be available through smaller scale projects.

TransCanada owns and operates eight hydroelectric dams on the Connecticut and Deerfield Rivers totaling roughly 500 MW. Many of these generating facilities are either located in Vermont or easily accessible through exiting electrical transmission. The DPS advises that "it would be a positive step for Vermont utilities to enter into contracts for power from the eight dams, if acceptable price and quantity terms could be negotiated. The state will also watch for

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[105] Vermont Department of Public Service (2011).
[106] Hydro-Québec (2009) and Nalcor Energy and Newfoundland and Labrador Hydro (2011).
[107] Vermont Department of Public Service (2011).
[108] ISO-New England (2010).

any new opportunity to purchase these hydro facilities if they become available."[109] Vermont policy should include such purchased power agreement or facility acquisition to the extent such "acceptable price and quantity terms" are obtainable.

[109] ISO-New England (2010).

18. Improve Vermont's Standard Offer (Feed in Tariff) Program

Enhance and improve the state's standard offer program for renewable energy generation.

i. Key Considerations

- Funding: Ratepayers through inclusion of costs in rates.
- Sector Impact: Electric.
- Accountability: Measurement and verification by Public Service Board and SPEED facilitator.
- Point of Regulation: Retail utilities.
- Scale of Implementation: State.

ii. Policy Description[110]

A fixed-price standard offer or feed-in tariff (FIT) is designed to increase the amount of renewable energy projects developed in a jurisdiction by guaranteeing a price and a term for the purchase of the output of a project at a level and duration sufficient to support the investment decisions that must be made by project developers. The contract price is often set through an administrative process, although Vermont has moved toward a market-based pricing scheme in its recent solicitation. In either case, once set, the price is guaranteed, or "fixed," for the life of the contract, usually 10 to 25 years, long enough to secure project financing and amortize other fixed costs.[111] A successful FIT strikes a reasonable balance of risk allocation between project owners who produce power and utility consumers who pay for and consume it. FIT stands in contrast to RPS, which sets the amount of renewable energy to be secured and allows the price to be set by market forces (i.e. competitive bidding). FITs are the most widely used policy in the world to increase the pace at which renewable energy projects are developed.[112] Vermont's FIT is called the Standard Offer Program.

In Vermont, unlike most other states, a third-party purchasing agent functions as a middleman in the transaction. Payment is made by this purchasing agent to the individual project owners; the renewable power, RECs, and costs are then allocated and billed, pro rata, to the Vermont utilities by the purchasing agent.[113] The per-kWh charge for renewable power differs based on the generation technology and is intended to reflect the costs of owning and operating different types of renewable systems rather than the market value of the power. Wind resources, for example, receive a different level of payment per kWh than solar resources.

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[110] Some of the material from this subsection is drawn from an unpublished report by John Nimmons, John Nimmons Associates, for the Regulatory Assistance Project.
[111] It is not uncommon for the price to decline at a set rate over the term of the contract, but the price is still guaranteed.
[112] Couture, *et al.* (2010).
[113] This applies to all Vermont distribution utilities, except Washington Electric Coop, which received a legislative exemption.

Vermont's most recent solicitation completed May 1, 2013 introduced a new offer-based bid structure, combined with price caps, in an effort to infuse market forces into the price.[114] This market-based strategy attempts to address a key challenge for FITs: setting the price correctly so developers have sufficient incentive to build but consumers are protected from overpaying for energy.[115] A number of jurisdictions have tried different ways of establishing the "right" price: set the price based on the value of the electricity supplied, set the price based on the generation cost of eligible technologies, or use a variety of competitive benchmarks or auctions to establish the price.[116]

A well-designed FIT scheme will guarantee access to the grid for the renewable energy projects. In addition, the administration should be simple, the transaction costs low, time requirements brief (i.e. queues for interconnection), and policies stable. In an effort to clarify the relationship between Public Utility Regulatory Policies Act (PURPA) avoided cost rates for renewable technologies and FITs, the Federal Energy Regulatory Commission (FERC) overturned a long-standing PURPA precedent that required utilities to pay avoided costs to renewable facilities. This construct under PURPA had restricted the discretion of states to set rates for renewable energy that were sufficient to enable a return on an investment. As a result of this FERC decision, payments to renewable generators can be differentiated based on the requirements of each renewable energy technology.

FITs can be varied according to different needs or situations.[117] For instance, one variation, called a premium FIT, has two payment parts: a reduced FIT payment (i.e. the price per kWh but at a lower price than a fixed FIT), plus the hourly market price for electricity. This construct exposes the generator to market variability in the price of electricity. Floors and caps can be added to ensure the variability is not too great. A FIT's flexibility enables it to be crafted to work with other policies, such as a RPS or other quota system.

Vermont should more fully develop the locational incentives included in its FIT design. Through the Vermont System Planning Committee process, Vermont has identified areas of transmission congestion in the state. Encouraging generators to locate their projects in these stressed zones

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[114] That solicitation produced a number of bids and the selection of 6.4 MW of solar projects to be awarded contracts. The bid price was between 13 and 15 cents per kWh.

[115] The standard FIT contract ought to resolve ownership of the REC in order to accurately value the transaction and to treat the generator (large and small) fairly.

[116] Grace, *et al.* (2009).

[117] When exercising this flexibility, states should be cautious to avoid a level of compensation that may appear to be an entitlement to any particular technology. Just as gasoline prices and home prices vary from time to time to reflect market realities of supply and demand, so may FIT prices.

could help defer transmission upgrades and create additional value for ratepayers. For example, generators locating in a stressed area could receive an adjustment in their bid price to reflect this additional value. This adjustment could be published with the bid solicitation to encourage favorable location choices by developers.

The purpose of FIT is to encourage the development of resources that contribute to carbon and renewable energy goals but may be unable to compete at market prices for the present moment. As technology evolves, new applications are developed, and others mature and achieve economies of scale, a reevaluation of resource types suitable for FIT will be warranted. Vermont may also look to broaden its FIT by incorporating other beneficial technologies, such as combined heat and power.

iii. Select Resources

Couture, T., Cory, K., Kreycik, C. & Williams, E. (2010). *A Policymaker's Guide to FIT Policy Design*. Golden, CO: National Renewable Energy Laboratory. Retrieved from http://www.nrel.gov/docs/fy10osti/44849.pdf.

Delmas, M. and Montes-Sancho, M.J. (2011). "U.S. State Policies For Renewable Energy: Context and Effectiveness." *Energy Policy*, *Vol. No. 39* (Issue No. 5), 2273 - 2288. Retrieved from http://www.sciencedirect.com/science/article/pii/S0301421511000449.

Grace, R., Rickerson, W., Corfee, K., Porter, K. & Cleijne, H. (2009). *California Feed-In Tariff Design and Policy Options.* California Energy Commission. Publication Number: CEC-300-2008-009F. Retrieved from http://www.energy.ca.gov/2008publications/CEC-300-2008-009/CEC-300-2008-009-F.PDF.

19. Facilitate Renewable Energy Siting, Permitting, and Interconnection

Maintain adequate and robust planning and approval processes to facilitate renewable energy siting, permitting, and grid interconnection (including distributed generation and net metering generation facilities).

i. Key Considerations

- Funding: Renewable generation project developers.
- Sector Impact: Electric.
- Accountability: Public Service Board and SPEED facilitator.
- Point of Regulation: Project developers, retail utilities, and Vermont Electric Power Company (VELCO).
- Scale of Implementation: Local and state.

ii. Policy Description

Vermonters want approval processes for energy siting and permitting (for all energy resources) and for grid interconnection for electric generation that create public trust, address potentially competing interests, and consider all relevant economic and environmental costs and benefits. Fully encompassing siting and related permitting rules must consider all legitimate interests, allow for decisions to be made in a reasonable amount of time, and create the opportunity for stakeholder confidence. All appropriate siting and permitting criteria, including those related to grid interconnection of electric generation, should be employed in regulatory deliberations.

While Vermont's existing approach works well given the present volume of requests, a significant increase in future renewable energy projects, including electric generation and related interconnection requests, has the potential to overburden the administrative capability of utilities and regulatory agencies and may compromise reliability on elements of the existing electric distribution and transmission systems of Vermont electric utilities.[118]

iii. Siting and Permitting

State level authority, such as Public Service Board Section 248 permitting and Act 250, addresses a variety of energy-related issues, but regional planning and local zoning also play roles for various energy infrastructures. The areas to be considered include electrical generation siting, permitting of biomass and biofuels processing facilities, energy-related building codes, and local zoning ordinances. The use of local renewable resources for energy production must continue to be balanced with other, competing public interests.

Existing siting and permitting rules are in place at all levels and many currently are being reviewed to assess how well they function in light of present day considerations and interests.

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[118] See Vermont Public Service Board Rule 5.500 and 30 VSA, Section 248.

The Governor's Energy Generation Siting Policy Commission's report, issued on April 30, 2013, suggests more emphasis should be placed on planning at state, regional, and municipal levels, with simpler siting process for small projects and relatively more effort for larger ones. More community-led projects are encouraged, as is enhanced public participation. The Commission's report also suggests state agencies develop guidelines and checklists to enhance the protection of the state's natural resources; address public concerns; and provide clarity, accessibility, transparency, and predictability to the siting and permitting process.[119]

Efforts to maintain a clear and unambiguous pathway for the presentation and evaluation of renewable energy project proposals will reduce the time required and improve the process for permitting a renewable energy site. Strong siting and permitting guidelines and rules established at the state level may provide for state and local entities (including regional planning commissions) to operate under the same imperatives to consider all views without compromising the benefits of renewable energy to the state. Such rules, established with a long-term scope in mind and consistently applied across all jurisdictions, potentially affect all proposed renewable energy infrastructures and their developers, stakeholders, regulators, and local permitting entities. There may be value to this review and evaluation process if relevant state agencies prepare generic siting guidelines for developers of renewable energy projects, especially for permitting under Act 250 (buildings and industrial development) and Public Service Board Section 248 (electricity and natural gas).

iv. Facilitate Grid Interconnection for Distributed Generation and Net Metering Facilities

Vermont has effective grid interconnection rules, processes, and procedures for distributed generation and net metering developments. However, the anticipated future growth of interconnection requests to meet Vermont's goal of 90 percent renewable energy may overtax the present arrangement.

Vermont legislation in 2005 called for a statewide renewable portfolio goal and for the Public Service Board to set interconnection standards for up to 50 MW of distributed generation. The Public Service Board adopted Rule 5.500 in 2006 to establish a standard application form and mandate that utilities provide information to developers about applying for interconnection.[120]

[119] Vermont Energy Generation Siting Policy Commission (2013).

[120] Rule 5.500 set standards for distributed generation interconnection if generators were not covered under federally-approved (FERC) rules administered by the Independent System Operator of New England (ISO-NE). These rules also apply to net-metered systems larger than 150 kW but smaller than 500 kW.

An assertive approach is advisable, in advance, to address methods for handling the likely utility and regulatory resource needs (administrative, process, and technical) that are expected in coming years. Stakeholders may find it useful to assess the nature of utility support for interconnection requests and objectively assess future needs in terms of timeliness of response, information flows, and overall effectiveness of the process if there are significant increases in volume. Likewise, determination of an effective regulatory process to address substantial growth in the volume of requests for interconnection under Vermont rules may be useful.

The Vermont Public Service Board entered orders on March 1 and May 30, 2013 in Docket No. 7873, in which it established a Screening Framework and Guidelines "regarding transmission-constrained areas in which renewable generation having particular characteristics may provide sufficient benefit to the operation and management of the electric grid." While finding that there are no such transmission constrained areas at this time, the Public Service Board ordered "affected utilities to continue to analyze any identified constraints and to submit Reliability Plans next year consistent with the requirements of the Screening Framework and Guidelines."[121]

Continued support for enacting a distributed utility planning approach is consistent with this policy and the Public Service Board Screening Framework and Guidelines obligations, including related matters of performance-based ratemaking and reliability benchmarking. This approach may be consistent with electric utility distribution system planning to assess and identify the most receptive and most restrictive circuits (at least at the sub-station level) and propose priority for improvements to ease restrictions to accommodate distributed generation and net metering development activity. California currently conducts a process to acquire renewable generation projects between 3 and 20 MW (the Renewable Auction Mechanism or RAM). Related to the RAM, certain California utilities offer interactive on-line maps of their transmission and distribution systems providing information regarding capability to interconnect distributed generation to the distribution substations and transfer power onto the transmission system.[122] Such an approach, with oversight by the Public Service Board, would be useful in Vermont.

v. Select Resources

California ISO. (2013). *Integration of Renewable Resources*. Retrieved from http://www.caiso.com/informed/Pages/StakeholderProcesses/IntegrationRenewableResources.aspx.

[121] Vermont Public Service Board (2013).
[122] California Public Utilities Commission (2013).

Vermont Department of Public Service. (2011). *Comprehensive Energy Plan*. Montpelier, VT: Vermont Department of Public Service. Retrieved from http://publicservice.vermont.gov/publications/energy_plan/2011_plan.

Vermont Energy Generation Siting Policy Commission. (2013). *Energy Generation Siting Policy Commission Final Report*. Montpelier, VT: Vermont Energy Generation Siting Policy Commission. Retrieved from http://sitingcommission.vermont.gov/sites/cep/files/Siting_Commission/Publications/FinalReport/Final%20Report%20-%20Energy%20Generation%20Siting%20Policy%20Commission%2004-30-13.pdf.

c. Implementation Policies[123]

Once Vermont decides which of the aforementioned key policies it wishes to employ, it must make important decisions regarding how the policies will be implemented. These implementation decisions can have as strong effect on the policies' ultimate success as do the decisions regarding the key policies themselves. Therefore, it is critical that for each policy selected three key questions be considered and answered:

1. What entity will be responsible for overseeing and delivering the services associated with the policy?
2. How will the services associated with the policy be funded?
3. How will accountability be ensured?

Each of these questions is considered further in the sections that follow.

1. Administration

Identify the entity responsible for overseeing and delivering the services associated with a policy.

While both private and public entities can have an appropriate role to play in ensuring the successful delivery of programs to increase the use of renewable energy and decrease emissions of greenhouse gases, in order to ensure the success of programs it is important to decide which entity is the right one to charge with the overall responsibility for administering the program.

There are a number of potential administrating entities from which to choose, each with certain strengths and weaknesses: an end-user, the utility, a governmental entity, a quasi-governmental entity, or a third party (non-profit or for-profit). Furthermore, whether an entity is appropriate as an administrator may depend on the particular policy. For example, a government administrator may be appropriate for Policy A, but less so for Policy B. These decisions will depend on the details of the situation and of the policy.

When determining which entity is most appropriate to administer the program or service, it is advisable to consider the following factors:[124]

- **Trusted relationships with the market**: The administrative entity must already possess or be able to quickly develop relationships with existing market participants. The entity needs to understand the end use customers, their investment considerations, and how

[123] This discussion of implementation policies relies heavily on Wasserman & Neme (2012).
[124] Wasserman & Neme (2012).

best to motivate them to adopt the desired behavior. All of the respective players need to trust the entity and its ability to deliver programs and recommendations without bias.

- **Access to appropriate data**: The administrative entity should already possess or be able to gain access to appropriate energy use data to effectively design programs and measure progress toward goals.
- **Strong data tracking systems**: The administrative entity should already possess or be able to acquire easily the technological equipment and know-how to track relevant energy and customer data, program data, and outcomes. In addition, the entity must demonstrate the willingness and ability to keep this information safe and confidential.
- **Strong evaluation, measurement, and verification (EM&V) systems and expertise**: The administrative entity must be able to demonstrate the ability to credibly track, verify, and report on program outcomes. The entity must be able quickly to establish transparent mechanisms and processes so that participants rely on the accuracy of the administrative entity's findings. This is particularly true where a financial outcome hinges on the administrator's decision (i.e., if a payment is going to be made for attainment of an energy savings goal).
- **Regional coordination:** The administrative entity should be well positioned to engage in regional coordination with other obligated entities and with adjoining or overlapping service territories. This ability allows for a wider, more uniform message to be communicated to end-users. It also allows for broader program reach, with potentially deeper impacts.
- **Incentives and penalties**: The administrative entity must be empowered and able to implement incentives and penalties with end users to improve the outcomes of programs.

Vermont is fortunate to be home to the Vermont Energy Investment Corporation, a third-party, non-profit organization that administers many of Vermont's energy efficiency and renewable energy programs. VEIC is an excellent example of how a third-party administrator can administer programs successfully to increase renewables and decrease greenhouse gas emissions. California also has excellent program administration by using its investor-owned utilities to fund and carry out efficiency programs. The California utilities also hire out 20 percent of their efficiency work to third-party entities.[125]

[125] Wasserman & Neme (2012).

i. Select Resources

Sedano, R. (2011). *Who Should Deliver Ratepayer Funded Energy Efficiency? A 2011 Update*. Montpelier, VT: Regulatory Assistance Project. Retrieved from http://www.raponline.org/document/download/id/4707.

Wasserman, N. & Neme, C. (2012). *Policies to Achieve Greater Energy Efficiency*. Montpelier, VT: Regulatory Assistance Project. Retrieved from www.raponline.org/document/download/id/6161.

York, D., Kushler, M. & Witt, P. (2008). *Compendium of Champions: Chronicling Exemplary Energy Efficiency Programs from Across the U.S.* Washington, DC: American Council for an Energy-Efficient Economy. Retrieved from http://www.aceee.org/node/3078?id=100.

2. Funding

Identify a clear, secure, long-term source of funding for the services associated with a policy.

Ensuring a reliable, long-term source of funding for programs may be the single most important thing to "get right" when establishing new policies and programs.[126] It is important that once funding is committed, it continues uninterrupted so that programs can be implemented, the workforce can be trained, the public can be educated, and the market can mature. Swings in funding levels will frustrate these efforts and reduce the chances of meeting the state's targets.

It is important to ensure that those who pay for a program receive as many of the benefits of that program as is possible. Driving program participation is one way to ensure that consumers can benefit from programs. Care also must be given to more vulnerable segments of the population who may not be able to participate in programs absent some form of subsidization from the larger populace. There are a number of different funding mechanisms that can be considered, depending on the policy options that are chosen:

- **Public benefits charge**: A public benefits charge is a mandatory charge imposed by the government or one of its agents, which is collected from all energy users for a purpose that benefits the public. A typical example is an additional charge on an electric bill beyond the cost of fuel and service to fund energy efficiency programs.
- **Direct government investment**: Direct government investment involves allocating a portion of the state's general revenue to the operation of energy efficiency and renewable energy programs. This investment can take a variety of forms, such as a direct allocation of funds in the form of grants or rebates, establishment of loan/loss reserve funds, subsidized loans, etc.
- **Cap-and-trade proceeds:** This mechanism takes revenues from the regional cap and trade program (RGGI) and reinvests all or a portion of those revenues into energy efficiency and renewable energy programs. Vermont currently employs this technique, reinvesting nearly all of its RGGI revenues back into non-regulated fuel efficiency programs.
- **Carbon tax proceeds:** This mechanism is essentially the same as the cap-and-trade mechanisms discussed above, except the source of the funds derives from a carbon tax, not from the cap-and-trade program.
- **Public-private partnerships**: This mechanism involves the government working directly with private-entities by providing financing of loans and credit arrangements where the financing is invested into energy efficiency and renewable energy projects. The practice

[126] International Energy Agency (2010).

helps to jump start the market and is designed to encourage private financing, which will eventually supplant the need for government backed financing. The Property Assessed Clean Energy (PACE) program is a variation on this theme.[127]

- **Market based mechanisms**: Market mechanisms, as the name suggests, are funding tools that rely upon markets to generate funds to support efficiency and renewable programs. Two examples include: (a) allowing energy efficiency and demand side programs to bid their energy saved into energy and capacity markets operated by ISO-New England, thereby earning a revenue stream; or (b) employing tradable white certificates, which are documents that certify a certain amount of energy has been saved and can be bought and sold in a marketplace.

i. Select Resources

Allen, R. and Rao, A. (2011). *Affordable Heat: Whole-Building Efficiency Services for Vermont Families and Businesses*. Montpelier, VT: Regulatory Assistance Project. Retrieved from http://www.raponline.org/document/download/id/4439.

International Energy Agency. (2010) *Energy Efficiency Governance*. Paris, France: OECD/IEA. Retrieved from http://www.iea.org/publications/freepublications/publication/eeg.pdf.

Taylor, R. P., Govindarajalu, C., Levin , J., Meyer, A. S., & Ward, W. A. (2008). *Financing energy efficiency: Lessons from Brazil, China, India and Beyond*. Washington, DC: The World Bank. Retrieved from http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2008/02/18/000333037_20080218015226/Rendered/PDF/425290PUB0ISBN11OFFICIAL0USE0ONLY10.pdf.

[127] PACE generally involves municipal governments offering a bond to investors. The proceeds of the bond sale are loaned to residents and businesses to put towards energy retrofits. The loans are repaid through an annual assessment on the property tax bill.

3. Accountability

Establish a transparent, independently-administered system to ensure that energy savings and emissions reductions are truly being achieved and appropriately accounted for.

Accountability refers to the processes and policies that ensure energy efficiency and renewable energy programs are being operated with integrity and transparency and that energy savings and energy production can be tracked, counted, and confirmed. Accountability gives policymakers, market participants, and others confidence that Vermont's policy goals are being achieved in an efficient and cost-effective manner. Two key methods of building accountability are listed below:

- **Evaluation, measurement, and verification (EM&V):** EM&V are the rules and practices by which energy efficiency and renewable energy programs are evaluated, measured, and verified. The process involves clearly establishing rules and methods for calculating energy usage, energy savings, the source of energy production, and the level of and reductions in emissions. These rules must be established and regularly updated to remain valid. Further, consideration must be given to how much of a program budget should be dedicated to EM&V; it must be enough to satisfactorily perform the job but not so great as to unnecessarily draw funds from actual program activities.
- **Performance incentives or penalties:** This mechanism relies on a robust EM&V process that will unequivocally determine whether obligated entities have or have not achieved the targets for which they were aiming. For those entities that hit their goal, a performance incentive can be awarded. For those entities failing to hit their targets, a performance penalty can be assessed.

i. Select Resources

ISO-New England. (2012). *ISO New England Manual for Measurement and Verification of Demand Reduction Value from Demand Resources - Manual M-MVDR*. Holyoke, MA: ISO-NE, Inc. Retrieved from http://www.iso-ne.com/rules_proceds/isone_mnls/m_mvdr_measurement_and_verification_demand_reduction_revision_4_06_01_12.doc.

Schiller, S.R., Goldman, C.A., & Galawish, E. (2011). *National Energy Efficiency Evaluation, Measurement And Verification (EM&V) Standard: Scoping Study Of Issues And Implementation Requirements*. (No. LBNL-4265E). Berkeley, CA, US: Lawrence Berkeley National Laboratory. Retrieved from http://eetd.lbl.gov/EA/EMP/reports/lbnl-4265e.pdf.

IV. Resources and Experience

a. Introduction

Vermont is not alone in charting a path towards renewable and sustainable energy. Other states and national organizations are considering similar issues, and Vermont can learn from their efforts. The following resources include relevant, earlier Vermont studies and similar efforts outside the state. This section provides a brief summary of the major efforts to date and how they can be used to inform Vermont's choices. Recent studies demonstrate that technology exists that can enable us to achieve targets for renewables and carbon reduction without significant cost-impacts, even given modest expectations for commercialization of technology and technology cost improvements.

b. State and National Policy Resources[128]

i. **Vermont Governor's Commission on Climate Change:** The Commission considered the greenhouse gas situation in Vermont and developed a comprehensive set of 38 policy recommendations to reduce greenhouse gas emissions from all sectors, including energy supply and demand; transportation and land use; agriculture, forestry, and waste management; and included 7 recommended policies that cut across multiple sectors.

ii. **U.S. Environmental Protection Agency**: Web site linking to 32 state initiatives on climate action planning. This website provides information, strategy, and policy recommendations for a state climate change action plan to reduce greenhouse gas emissions. EPA offers technical assistance, analytical tools, and outreach support.

iii. **Vermont Comprehensive Energy Plan (CEP):** This statewide energy plan covers electricity, heating, and process fuels; energy in transportation; and land use decisions. It recommends the state goal of 90 percent of total energy from renewable sources by 2050. The CEP promotes efficiency and conservation as first priorities in all energy sectors and recommends a renewable portfolio standard of 75 percent renewable electricity within 20 years. In addition, it encourages planning for the integration of electric and alternative fuel vehicles and recommends aggressive goals for energy efficiency, bio-blended fuels, and renewable energy technologies for building heat in new construction. It endorses state government "leading by example" with prudent investment in energy efficient buildings and deploying renewable energy systems.

[128] Clicking on the title of the reports in the following sections will take you directly to the report's location in the Appendix A.

iv. **Biomass Energy Development Working Group Final Report ("BioE Report"):** The Working Group met over the course of three years to address the promotion, development, and growth of the Vermont woody biomass industry while maintaining forest health. It produced 47 recommendations in areas of modeling (6), enhancement and development of woody biomass industry (22), and forest health (19). Recommendations involved fiscal and regulatory incentives for sustainable biomass energy, standards, and policies for the design of new, sustainable renewable energy from biomass, guidelines for maintaining forest health, and suggestions for additional research and analysis.

v. **Energy Generation Siting Policy Commission Final Report:** The Commission was asked to provide guidance and recommendations on siting of electric generation projects, to identify best practices (including research of approaches of other New England states) for siting, and public participation and representation in the siting process. The Commission held informational sessions, public hearings, and deliberative meetings and received testimony. The result of this work is 28 recommendations in five main areas, which include 1) emphasis on planning at all levels of government; 2) create a tier system to classify generating projects by nameplate capacity, with Public Service Board resources focused more on large or more complex proposals; 3) increased opportunity for public participation in the siting and permitting process; 4) increased transparency, efficiency, and coordination; and 5) creating a standardized, accessible, and comprehensible system of environmental and other relevant guidelines.

vi. **Integration of Renewable Resources:** California has a renewable portfolio standard of 33 percent renewable generation by 2020. In support of this goal, the California ISO is working with a variety of electric industry stakeholders, including utilities, asset owners, regulators, and other control areas, to identify and solve issues related to integrating large quantities of renewable resources, including variable resources like solar and wind, into the California grid.

vii. **U.S. State Policies for Renewable Energy: Context and Effectiveness:** This UCLA study looks at how effective state renewable policies are at encouraging investments in renewable capacity. The researchers conclude that a renewable portfolio standard (RPS) is ineffective, but a mandatory green power option is effective. They also report that the RPS is more effective with investor-owned utilities than with publicly owned utilities.

viii. **Final Report to the Governor and Maryland General Assembly by the Electric Vehicle Infrastructure Council:** The Council met sixteen times in 2011 and 2012 and produced plans to 1) expand the adoption of plug-in electric vehicles; 2) support the creation of a statewide charging infrastructure network; and 3) make recommendations for a number of state policies and programs for actions at the state and local levels of government to promote owning an electric vehicle in Maryland.

ix. **Designing the Right RPS: A guide for Selecting Goals and Program Options for a Renewable Portfolio Standard:** This paper addresses issues surrounding design and goal setting for state RPS programs. It also considers experience thus far in several states and discusses features that contribute toward efficiently meeting cost effective RPS goals.

x. **New England Governors' Renewable Energy Blueprint:** New England has a large renewable energy resource potential. This report identifies both challenges and solutions to them to help bring these resources to market. New England has the ability to address economic and environmental issues, perform regional cooperation, and has considerable recent experience successfully siting significant transmission facilities. These and other skills and resources can increase New England's ability to develop and market renewable energy resources within the existing energy markets.

c. Relevant State and National Technology Studies

i. **Renewable Electricity Futures Study:** This paper reviews the ability of commercially available renewable electricity generation technologies to supply, and the U.S. electric grid to absorb, varying levels of renewable generation. It concludes that high levels (80 percent renewables) are possible by 2050, despite challenges for grid operation that must and can be solved. The study concludes that the cost of an 80 percent renewable scenario is comparable to published costs of other clean energy scenarios.

ii. **California's Energy Future Project:** This project researches ways to meet California's admirable and achievable goals for reducing greenhouse gas emissions. Separate reports have been produced on a variety of topics including biofuels, building and industrial efficiency, transportation, electric generation (both fossil fuel with carbon capture and sequestration and renewables), nuclear power options, and an overall summary report.

iii. **Roadmap 2050: A Practical Guide to a Prosperous, Low-Carbon Europe:** In 2009 European leaders set an objective to reduce greenhouse gas emissions by at least 80 percent below 1990 levels by 2050. This study was prepared to create an underlying source of information on what the technical and economic impacts of this goal might be, including consequences in the electricity sector. It discusses needed policies and regulations in the coming years, as well as broad changes necessary in society to accomplish the goal.

iv. **Cost-Minimized Combinations of Wind Power, Solar Power, and Electrochemical Storage, Powering the Grid Up to 99.9 Percent of the Time:** This report models renewable power (wind, solar, and storage) to meet demand for a large grid system that is 20 percent the size of the U.S. grid. Multitudes (28 billion) of combinations were run to determine least cost scenarios. Results show that nearly all hours of the year can be met by renewables using storage about 11 percent of the time (972 hours/year). Although least-cost combinations have large amounts of excess generation compared to load (3 times), the study concluded that 90 percent of the hours of the year electric load could be served at costs below today's when assuming 2030 technology costs.

v. **Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions:** This study considers impacts on greenhouse gas reductions from about 50 actions and strategies intended to either reduce the amount of vehicle travel or alter transportation services in ways that improve fuel efficiency. The study looks at costs and usefulness of reducing vehicle miles and increasing the efficiency of vehicles and the transportation network in which they perform.

vi. **Moving Cooler: Technical Appendix:** Emission reduction strategies and actions are organized into nine strategy categories each of which is assessed at three increasingly aggressive levels of speed of implementation.

vii. **A Policymaker's Guide to FIT Policy Design:** This guide provides an analysis of design and implementation of policies for a successful feed-in-tariff (FIT), as well as provides proven FIT design best practices for stimulating development of renewable generation. The study draws on experience from Europe (with nearly 20 years of FIT experience) and current examples in the U.S. and Canada where FITs also have been used.

viii. **California Feed-In Tariff Design and Policy Options:** This report discusses the possibilities of using various feed-in tariff designs to help meet California's renewable generation goals. The report assesses a number of FIT policy design options including tariff structure, pricing, and eligible resources. It evaluates and compares six policy paths to be considered further and reviews interaction of the FIT with other policies. The conclusion is a recommendation for a California FIT for renewable technologies of 20 MW or less in capacity. Numerous issues on design, pricing, planning, regulation, and implementation are considered as well.

ix. **Strategies for Decarbonizing the Electric Power Supply:** Decarbonization policies are reviewed and highlighted, including carbon pricing, carbon intensity measures, resource planning, portfolio and contract standards, and complementary environmental standards. In addition, the report discusses technology strategies such as carbon capture and storage and renewable resources. Policies to discourage the use of fossil fuel resources and encourage the use of low-carbon resources are also explored.

x. **Vermont Wood Fuel Supply Study 2010 Update:** This report calculates the potential supply of low-grade wood available for energy purposes above and beyond current levels of harvesting in Vermont and 10 adjoining counties in surrounding states.

xi. **The Future of Natural Gas: An Interdisciplinary MIT Study:** The paper provides research and insight into natural gas availability, price, and future utilization potential. The authors also state it "seeks to inform discussion about the future of natural gas…addressing a fundamental question: what is the role of natural gas in a carbon-constrained economy?"

V. Summary and Conclusion

Vermont has visionary renewable energy and climate goals. Significant effort is needed to design and implement the policies to reach them. The 19 policies featured in this report have the potential to be substantive, practical, and cost-effective means toward Vermont's goals. They warrant considered discussion and feedback from stakeholder groups. Importantly, the featured policies are both specific and actionable. Some represent policies the state is already implementing and should continue or expand, while others represent new or different approaches. Combined with the supplemental list of policies, the state has a multitude of options as it considers how best to meet its climate and renewable energy goals.

One of Vermont's greatest challenges, its size, also serves to its advantage. With its small area and population, Vermont has the advantage of local engagement, organization, and enthusiasm around energy and environmental concerns. Vermont is also fairly limited in it resource commitments: it relies heavily on outside contracts for power and relatively expensive outside sources of liquid fossil fuels for heating. With its reasonably close proximity to clean resources outside the state, the resource and technology pathways forward look even more promising for the development of distributed resources and those that can be developed locally. As a result, Vermont can be somewhat nimble in its approach to the resource and policy path forward and can act relatively quickly.

Vermont historically has relied on clean energy resources in the power sector, and the Comprehensive Energy Plan and statutes set clean energy targets across all sectors. Vermont can now translate these goals into actionable policies that put us on a path toward their achievement. In doing so, Vermont can play its part in providing solutions and can also provide some measure of leadership. Vermonters have already demonstrated their support for renewable energy and their desire to mitigate climate change. In such an atmosphere, Vermont can demonstrate to the rest of the country the level of effort and commitment it will take to turn the tide of climate change.

The featured policies are intended to inform, guide, and focus a series of stakeholder meetings occurring over the coming months. These meetings are part of a process to refine a list of resources and policy pathways the state should pursue to meet its goals. The process will also quantify, to the extent possible, the impacts that can be expected from their implementation.

Vermont has an opportunity to combine the enthusiasm and resourcefulness of its communities with the guidance and expertise of its policymakers and energy regulators to establish a plan of action appropriate to tackle the pressing climate and energy issues of the day. The policies outlined here, refined and edited by the process envisioned can create that action pathway.

VI. Appendix A: References

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VII. Appendix B: Inventory of Available Policies

The following list contains policies that, while important in their own right, do not rise to the level of key policies required to achieve the state's carbon and energy goals. Often, these individual policies will be coupled with a key policy to improve that key policy's performance. Policies are listed in alphabetical order.

Policy	Description
Administration of energy efficiency programs	These policies ensure the administration of energy efficiency programs is optimally conducted by providing guidelines for how to best oversee and deliver energy efficiency programs.
Appliance and equipment standards	These policies prohibit the production and sale of appliances and electronic products that do not meet certain minimum thresholds for efficient energy performance. Typical products covered by these standards include air conditioners, water heaters, refrigerators, and televisions. The standards can be "ratcheted up" so that, over time, products become steadily more and more efficient.
Bonding	Bonds can be sold, with the proceeds directed to fund renewable energy or energy efficiency projects.
Contractor licensing requirements for renewable energy	The state can require renewable energy contractors to be licensed and certified, ensuring that they are credible, insured, and capable of building projects to Vermont's standards.
Corporate tax	Vermont can impose a tax on corporations and direct the proceeds to fund renewable energy or energy efficiency projects.
Decoupling	This policy separate's a regulated utility's ability to profit from the volume of energy it sells to its customers. It is intended to remove the disincentive to cooperate with energy efficiency efforts. Vermont already successfully employs decoupling.

Policy	Description
Demand response programs	These policies encourage electricity consumers to reduce their normal energy consumption based on the price of electricity or in response to incentive payments intended to induce lower electricity use at times of high prices or system instability.
Electric grid infrastructure	The Public Service Board could require electric companies to conduct a reliability analysis of the power system on a regular basis. The analysis should include a review of the distribution system's requirements.
Energy efficiency information centers	Vermont could fund the operation of informational clearinghouses to provide information about the benefits of and availability of energy efficiency.
Energy efficiency resource standards	An energy efficiency resource standard or obligation reduces or flattens electric load growth by setting certain energy efficiency targets statewide. Local distribution utilities are charged with achieving specific reductions in energy use (MWh), peak demand (MW), or both. Efficiency programs are designed and implemented with the goal of achieving the prescribed targets.
Energy pricing	This policy is based on the notion that energy consumers should see the "real" price of the energy they use in as close to real time as possible, so that the consumer can make an economically informed and efficient choice. Real time pricing of electricity is an excellent example of this policy.
Energy savings performance contracting	Government agencies can enter into contracts with energy services companies (ESCOs) to install energy-efficient systems in government owned buildings. The contracts generally require ESCOs to audit the building, design an efficiency project, and install the new equipment. The renovation must accrue enough cost savings from forgone energy usage that the project can pay for itself within a set time period. Any savings in excess of the cost of the project are paid to the ESCO.

Policy	Description
Energy standards for public buildings	These policies set strict efficiency and renewable energy standards for the construction of new governmental buildings. These policies can create markets for advanced energy savings and renewable energy projects.
Equipment certification requirements for renewable energy	The state can require the mechanical systems used in renewable energy projects to be certified as qualifying as renewable energy systems.
Grants	Vermont can consider offering grants to citizens who elect to purchase and install renewable energy or energy efficiency projects in their home or business.
Green building incentives	Vermont can encourage the construction of new buildings with the highest levels of energy efficiency and use of renewable energy systems by reducing permitting costs, streamlining approval processes, offering tax incentives, and providing other benefits. These policies can take several forms and can occur at all levels of government.
Green power purchasing	The Public Service Board may require local electric distribution companies to offer ratepayers the option of purchasing energy generated from renewable sources.
Investment tax credits	The state can offer tax credits to taxpayers who invest in renewable energy or energy efficiency projects.
Land use and smart growth	Local and state zoning entities can adopt zoning and planning standards that discourage reliance upon motorized transportation, encourage transportation savings, and encourage increased population densities and pedestrian-friendly and transit-oriented development designs.
Loan guarantees	This policy involves offering loan guarantees to people who take out loans to finance the construction of renewable energy or energy efficiency projects.

Policy	Description
Loan programs	The state may offer loans, at discounted interest rates, to finance the construction of renewable energy or energy efficiency projects.
Low Emission Vehicle (LEV) program	Adopting California's Low Emission Vehicle and Greenhouse Gas Standards ensures that new vehicles sold within the state meet the most stringent emissions standards and helps foster development of advanced vehicle technologies such as plug-in hybrid electric, full battery electric, and fuel cell electric vehicles.
Mandatory energy audits and use disclosure	Vermont may require homeowners to engage a professional to conduct an energy audit of their homes. The information from this audit would then be required to be disclosed to future potential buyers of the home.
Mandatory energy labels	The state may require manufacturers to include the relative energy consumption and efficiency level of certain electronic devices on the item's packaging.
Net metering	The Public Service Board may direct electric distribution companies to develop and publicize clear standards for the interconnection of and payment for small-scale, distributed, renewable energy generation projects (i.e. home solar panels or wind turbines).
Non-public transportation improvements	Encourage individuals who do not use or have access to public transportation to employ other methods to encourage more efficient commuting strategies. Examples include ride-sharing or car-sharing, vanpooling, ride matching services, intercity passenger rail promotion, and mega buses.
Nontraditional rate structures: inclining block	This policy requires electric distribution companies to implement a rate in which electricity become more expensive the more of the commodity that is used. Usually, this is accomplished by set blocks of usage that increase in price.

Policy	Description
Nontraditional rate structures: time of use	This policy requires electric distribution companies to implement a rate in which electricity is more expensive at a particular time of day or time of the year. For example, power purchased during the peak times of the day or year is more expensive than power purchased at other times.
Output–based environmental regulations (OBR)	OBR encourages the use of efficient technology by measuring emissions per unit of energy output (i.e., electricity or thermal energy). These are policies that recognize conversion efficiency of the electric generation or industrial processes and rewards use of more efficient machinery.
Personal tax	Vermont may impose a personal tax and direct the proceeds to fund renewable energy or energy efficiency projects.
Production tax credits	This policy offers a tax credit to renewable energy projects that produce energy, usually on a per kWh basis.
Property tax exemption	The state may exempt from the property tax certain renewable energy property or energy efficiency investments as an inducement to undertake these projects.
Property tax	Vermont may impose a property tax on real property and direct the proceeds to fund renewable energy or energy efficiency projects.
Public benefit funds	These policies require electric distribution companies to place a surcharge on ratepayers' bills, and invest the funds in activities designed to increase public welfare, such as using the funds to support low-income assistance programs or to fund renewable energy projects.
Public transportation improvements	These policies support the operation of and encourage the increased use of public transportation services, such as light rail, bus, and taxi service.

Policy	Description
Renewable energy certificate (RECs) creation and purchase	Renewable energy credits (RECs) are certificates that verify that a unit of energy was generated from a renewable source. The REC (which represents the attributes of energy) can be separated and sold apart from the energy itself. This can create an additional revenue stream for renewable energy projects. According to the EPA, "a REC represents the property rights to the environmental, social, and other non-power qualities of renewable electricity generation. A REC, and its associated attributes and benefits, can be sold separately from the underlying physical electricity associated with a renewable-based generation source."
Renewable energy rebates	Vermont may require electric distribution companies or other entities to establish a funding mechanism to provide rebates to ratepayers that choose to purchase and install renewable energy systems for their homes or businesses.
Require certain fuel blends or types at the pump	These policies require gas stations to carry and sell fuels that produce fewer carbon emissions, including, cellulosic ethanol and corn based ethanol blends, biodiesel, or natural gas.
Require green power	The state may require entities, usually government entities, to acquire a set portion of their energy purchases from renewable sources.
Research, development, and demonstration	Vermont may fund research, development, and demonstration projects associated with energy efficiency, renewable energy, and alternate fuels. This investment can move the market forward more quickly than waiting for private investment in these areas.
Sales tax exemptions	This policy exempts certain renewable energy and energy efficiency products and services from state sales tax in order to incentivize their purchase.

Policy	Description
Tax incentives	Tax incentives encourage investment in and operation of certain types of businesses–in this case, companies related to renewable energy and energy efficiency—by reducing the tax burden these companies face. For example, Vermont may create tax incentives to reward companies that develop alternative fuels for transportation, or that build and install small-scale distributed generation apparatus, or that design and build better batteries to support economy wide electrification.
Transportation efficiency, land use, and smart growth	These policies create more transportation-efficient land use patterns, which allow walking and biking to supplant motor vehicle trips and reduce the length of the remaining motor vehicle trips. Smart growth policies focus development along transportation corridors and include zoning and planning standards that allow and support increased population densities.
Transportation pricing	These transportation-related policies are intended to increase the cost of driving, particularly in urban centers, and thereby dissuade individuals from driving personal automobiles. An example of one such policy is congestion pricing, which imposes a charge on privately owned vehicles driven in particularly congested portions of an urban center. Another example is increasing the cost of parking in urban centers.
Vehicles participate in electricity markets	These policies establish rules to allow electric vehicles to participate in ISO-New England's wholesale electricity markets. For example, Vermont could require its regulated utilities to implement programs to use electric vehicles as storage when there is excess renewable energy on the electric system.

Total Energy Study:
Report to the Vermont General Assembly on Progress Toward a Total Energy Approach to Meeting the State's Greenhouse Gas and Renewable Energy Goals

December 15, 2013

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Executive Summary

The purpose of this report is to inform the Legislature and the public of progress to date in carrying out the Total Energy Study (TES). The goal of the TES is to identify the most promising policy and technology pathways to employ in order to reach Vermont's energy and greenhouse gas goals. These goals are to: 1) meet 90% of Vermont's overall energy needs from renewable sources by 2050 and 2) reduce Vermont's greenhouse gas (GHG) emissions by 50% from the 1990 baseline level by 2028 and 75% from the 1990 level by 2050. Vermont's greenhouse gas emissions in 2011 were almost unchanged from the state's emissions in 1990. Vermont meets about 16% of its energy needs with renewable energy.

The Public Service Department expects to release, and submit to the Legislature, the Total Energy Study Final Report in the summer of 2014. While the Total Energy Study describes several policy and technology scenarios that are expected to achieve the State's goals, these reports are not intended to be or replace the Comprehensive Energy Plan. Neither this report nor the TES Final Report will articulate or recommend a definitive pathway forward.

The Department has structured its analysis around the development and evaluation of sets of policies and technology pathways. Technology pathways define different ways that the state could meet its objectives in terms of technology or hardware deployed (for example, how much electric power, and from which sources, how many cars powered by what fuels by what date, how many homes weatherized, etc.). Technology pathways generally determine overall cost and economic impacts. Policy sets are the tools deployed by the State government (in concert with policies adopted at the National, regional, and local level) to shape deployment of technologies.

The TES analysis evaluates technology pathways on criteria including: ability to meet the state's GHG and renewable energy goals; total economic impacts; impact on capital flows; and risks such as technology performance risk. The TES analysis of policy sets evaluates them based on: impact (both scope and leverage); responsiveness to external changes; and independence from polices adopted by others. Combining policy sets with technologies pathways, analysis will indicate potential compatibility or incompatibility between policy and technology directions, as well as overall impacts on the pace of State goal achievement.

The effects of a particular policy/technology pathway with regard to most other state policies depend on the details of policy implementation. If energy policy is implemented poorly, it could conflict with other state policy goals. This report summarizes the areas of greatest interaction between comprehensive energy policies and non-energy policies in the areas of economic development, land use, transportation, forestry, agriculture, heath, and natural resources. The policy sets analyzed in this report have been formulated so as to minimize conflicts between energy policy and other state objectives. In many cases, there is the potential for mutually-reinforcing benefits between these policy areas.

Comprehensive and integrated energy policy sets should be constructed with recognition for the structure of the energy sector and energy markets. In particular, the energy sector is rife with market failures; policy structures that have been developed to address those failures. Market failures include prices that do not reflect costs, lack of information, lack of access to capital, and split incentives. Government action can use four leverage points (identified and discussed in the 2011 Comprehensive Energy Plan (CEP)) to shape the adoption of technologies: education and outreach; finance and funding; regulatory reform; and technology and innovation. Because the clean energy transition involves many cases in which upfront costs are increased while savings are accumulated over time through reduced operating costs, financing tools and access to capital will be essential.

This study has identified and constructed five policy sets that represent different comprehensive and integrated approaches to energy and greenhouse gas policy. These are:

- Total Renewable Energy and Efficiency Standard (TREES): Require all providers of energy in Vermont to meet a fraction of their sales with renewable energy or energy efficiency. The required clean energy fraction would be the same for all fuels, and would rise over time. Obligations would be met by "retiring" tradable certificates corresponding to a certain amount of renewable energy or efficiency.
- Carbon tax shift: Creation of an economy-wide carbon tax in the context of tax reform, maintaining at or near revenue neutrality for the State. In this option, other taxes are cut by an amount equal to or close to the amount of revenue raised by the carbon tax. This carbon tax has the effect of sending a price signal much closer to the societal cost of emissions incurred, addressing the market failure of the mismatch between prices and costs.
- Renewable targets with carbon revenue: Draws from the previous two policy sets; here, the state would set a target for the renewable energy content of all fuels, placing a non-binding obligation on energy suppliers. If the target were not met within a given sector, however, the obligation would become mandatory within that sector or that sector's carbon tax would be increased. This obligation structure would be paired with a small economy-wide carbon tax used to raise revenue applied to programs directed at making it easier for obligated parties to meet their target obligations.
- Sector-specific policies: Consists of sector-specific policies, each tailored to address a known challenge or market failure within a given portion of the state's energy economy. The policies within this set could work in an integrated and comprehensive manner to drive the clean energy transition, but there would be no single, overarching policy structure as in the previous three policy sets.
- New England regional policy focus: Policies adopted at the regional level or coordinated with our neighboring states may be more effective than policies adopted by a single state. This reflects understanding that the six New England states are served by an electric grid with a single regional operator and markets, and that biomass is commonly used in a state different from the state in which it is harvested. There is also a potential that the combined market power of New England or Northeast states (and potentially including neighboring Canadian provinces) can move markets and bring new technologies to scale in a way that no single state can do.

Each of these policy sets raises a number of questions regarding implementation and impacts. Ongoing analysis will identify aspects of each policy set that could be combined to a smaller number of policy sets for quantitative analysis to follow publication of this report. Readers are encouraged to address the open questions associated with each policy set in written comments.

Technology pathway analysis conducted for the TES has highlighted the potential and open questions regarding both energy demand and energy supply. Reduction in total energy demand has been reaffirmed as essential to meeting the state's energy targets while maintaining compatibility with other state policy objectives. Energy demand can be managed through efficiency and conservation; demand shifting and load management; and fuel and mode switching. The discussion of fuel and mode switching, in particular, represents a new direction for analysis since the publication of the 2011 CEP.

The five renewable primary energy supply resources available to Vermont are solar, wind, hydropower, methane capture, and biomass. Each has strengths and weakness, described in detail in the 2011 CEP. Assessment of the use of each of these resources depends on their efficiency of utilization, especially for combustible resources, and the scale and location of energy generation infrastructure. This report identifies several areas where non-renewable resources may most productively remain in use, making up the 10% of the state's total energy that is not renewable in 2050. These include flexible electric generators for grid stability; heavy duty transportation and machinery; and some industrial processes.

The Department, working closely with the staff of the Governor's Climate Cabinet, structured the TES process to facilitate significant stakeholder and public engagement that would inform development of a wide set of scenarios that might meet the State's goals, then narrow those scenarios down based on a set of qualitative criteria to result in a manageable number of potential scenarios for further quantitative analysis. To that end, the Department published and solicited comments on a Framing Report and held a number of stakeholder focus groups during the summer and fall of 2013. The Department also hosted a public meeting to share the status of our policy analysis at the State House and via webinar on November 14. The Department continues to welcome public input, and has opened a formal comment period extending until January 22, 2014. Please refer to the Total Energy Study webpage for more information.

1 Introduction

The Public Service Department (Department) is undertaking this "Total Energy Study" (TES) to identify the most promising policy and technology pathways to employ in order to reach Vermont's energy and greenhouse gas goals. Act 170 of 2012, modified by the General Assembly through Act 89 of 2013, initiated this study to address the State goals to 1) meet 90% of Vermont's overall energy needs from renewable sources by 2050 and 2) reduce Vermont's greenhouse gas emissions by 50% from the 1990 baseline level by 2028 and 75% from the 1990 level by 2050.

Vermont's greenhouse gas emissions in 2011 were almost unchanged from the state's emissions in 1990: approximately 8.11 million metric tons[1]. 46% of these emissions were due to transportation; 32% from residential, commercial, or industrial fuel use, and 5% from electricity consumption. The remaining 17% were due to non-energy sources, such as agriculture, industrial processes, and waste. Vermont meets about 16% of its energy needs with renewable energy. This includes approximately 5% of transportation energy, 25% of energy used in residential buildings, 23% of energy used in commercial buildings, and 19% of industrial energy use.

The State's energy and greenhouse gas goals are guided by the statutory foundation of the State's energy policy as stated in 30 V.S.A § 202a(1):

> To assure, to the greatest extent practicable, that Vermont can meet its energy service needs in a manner that is adequate, reliable, secure and sustainable; that assures affordability and encourages the state's economic vitality, the efficient use of energy resources and cost effective demand side management; and that is environmentally sound.

Vermont's renewable energy and greenhouse gas goals are articulated in the 2011 Comprehensive Energy Plan and 10 V.S.A. §578, respectively. These broad targets set the direction, however more detailed pathways to reach the targets have not been defined. The Total Energy Study seeks to provide a more detailed analysis of several policy and technology roadmaps that will move the state from our current renewable energy and greenhouse gas trajectory that falls short of the above goals to a course that achieves them. The study is not intended to provide a definitive pathway forward, but rather to:

- Focus state, legislative, stakeholder, and general public conversation on actions with a high probability of meeting State goals.
- Clearly identify policies that the State should or should not pursue.
- Identify areas where federal or multi-state policies may be required in order to meet State goals (or make desired outcomes more achievable).
- Identify high-level economic and societal impacts from analyzed policy and technology roadmaps.
- Identify challenges and opportunities associated with several possible implementation scenarios that would meet the State goals.

[1] http://www.anr.state.vt.us/anr/climatechange/Vermont_Emissions.html

1.1 Legislative charge

Vermont's greenhouse gas targets were articulated in 2006 through the enactment of 10 V.S.A. §578(a):

> General goal of greenhouse gas reduction. It is the goal of the state to reduce emissions of greenhouse gases from within the geographical boundaries of the state and those emissions outside the boundaries of the state that are caused by the use of energy in Vermont in order to make an appropriate contribution to achieving the regional goals of reducing emissions of greenhouse gases from the 1990 baseline by:
>
> > (1) 25 percent by January 1, 2012;
> >
> > (2) 50 percent by January 1, 2028;
> >
> > (3) if practicable using reasonable efforts, 75 percent by January 1, 2050.

In 2011, Vermont adopted its first Comprehensive Energy Plan in over a decade. The Plan's intention is clearly articulated:

> [T]o set Vermont on a path to attain 90% of its energy from renewable sources by mid-century. . . . The goal is underpinned by this strategy: to virtually eliminate Vermont's reliance upon oil by mid-century by moving toward enhanced efficiency measures, greater use of clean, renewable sources for electricity, heating and transportation, and electric vehicle adoption, while increasing our use of natural gas and biofuel blends...

Following the release of the Comprehensive Energy Plan the General Assembly sought more detail on the policy and technology pathways that would allow Vermont to reach its goals. The Total Energy Study is required by Act 170 of 2012as modified in Act 89 of 2013:

> (a) The General Assembly finds that, in the comprehensive energy plan issued in December 2011, the Department of Public Service recommends that Vermont achieve, by 2050, a goal that 90 percent of the energy consumed in the State be renewable energy. This goal would apply across all energy sectors in Vermont, including electricity consumption, thermal energy, and transportation (total energy).
>
> (b) The Commissioner of Public Service shall convene an interagency working group to study and report to the General Assembly on policies and funding mechanisms that would be designed to achieve the goal described in subsection (a) of this section and the goals of 10 V.S.A. § 578(a) (greenhouse gas emissions) in an integrated and comprehensive manner.
>
> > (1) The study and report shall include consideration of a total energy standard that would work with and complement the mechanisms enacted in Secs. 3 (SPEED; total renewables targets) and 4 (SPEED; standard offer program) of this act.
> >
> > (2) The group's study and report shall consider currently available information on the economic impacts to the state economy of implementing the policies and funding mechanisms described in this subsection.

(3) The group's report shall identify those policies and funding mechanisms described in this subsection that do and do not warrant serious consideration and any areas requiring further analysis and shall include any proposals for legislative action. The report shall be submitted to the General Assembly by December 15, 2013.

(c) Prior to submitting the report to the General Assembly, the group shall offer multiple opportunities to submit information and comment to affected and interested persons such as chambers of commerce or other groups representing business interests, consumer advocates, energy efficiency entities appointed under Title 30, energy and environmental advocates, fuel dealers, educational institutions, relevant state agencies, transportation-related organizations, and Vermont electric and gas utilities.

1.2 Process to date

The Department, working closely with the staff of the Governor's Climate Cabinet, structured the TES process to facilitate significant stakeholder and public engagement that would inform development of a wide set of scenarios that might meet the State's goals, then narrow those scenarios down based on a set of qualitative criteria to result in a manageable number of potential scenarios for further quantitative analysis. The Process generally follows the structure outlined in the following figure:

1.2.1 Framing report and initial public comments

The initial step in the Total Energy Study was to develop a Framing Report intended to facilitate public and stakeholder feedback and discussion. The Department commissioned the Regulatory Assistance Project to identify and provide an overview of the most promising technologies (e.g. electric vehicles, heat pumps, biomass heat, solar power, etc.) and policies (e.g. carbon based fees, renewable portfolio standards, smart growth policies, etc.) available to Vermont to meet its goals.

A request for public comment was issued on June 21, 2013 to receive feedback on the Framing Report and general comments regarding the Total Energy Study. The request solicited comments from the public and stakeholders regarding:

- Whether there are "key policies" or "key technologies" that should be considered that weren't identified by the Framing Report.
- What are the most promising policies and technologies, or combinations of policies and technologies available to the state.
- What are the most important considerations for determining which policies or technologies are worthy of further consideration and study.
- Whether the study should analyze potential pathways possible only with regional coordination or Federal action, or just what Vermont could implement alone.
- What principles should guide the development of the baseline case – i.e. the business-as-usual projection to which possible policy and technology pathways will be compared.

The Department received 19 sets of comments addressing some or all of the above questions. The comments are summarized in Appendix A.

1.2.2 Stakeholder focus groups

Following receipt and consideration of the initial public and stakeholder comments, the Department convened 11 stakeholder focus group meetings to solicit specific feedback on what participants thought were the most promising policies and technology pathways, what principles should guide the choice of policies and technologies, and limitations or constraints that would diminish their potential effectiveness. Participants were also asked to develop their own policy and technology scenarios.. The focus group topics ranged from being technology or sector specific (e.g. residential buildings, electric biomass) to explicitly cross-sectoral concerns (e.g. local/diversified infrastructure; costs and benefits across sectors).

One hundred and thirty-two people representing 79 organizations attended the focus group sessions. Focus group discussions included a wide range of participants from all varieties of businesses and their associations, local and national energy businesses and consulting firms, energy utilities, environmental and citizens advocacy groups, academics, financial institutions, philanthropists, transportation authorities, law firms, town energy committees, planners and other local, state, and federal governmental agencies. The participants are listed in Appendix B.

The Department structured the focus groups to encourage participants to freely express their opinions in frank and respectful discussion, without attribution, through the use of a modified Chatham House Rule[2]. These discussions informed the narrowing of the wide range of policies and technologies

[2] "When a meeting, or part thereof, is held under the Chatham House Rule, participants are free to use the information received, but neither the identity nor the affiliation of the speaker(s), nor that of any other participant, may be revealed." (http://www.chathamhouse.org/about-us/chathamhouserule) In the TES case, we have revealed the names of the participants, but no attribution for any statement or idea may be revealed.

presented in the Framing Report to five policy sets and four technology pathways that might guide or inform decisions regarding the targeted energy transition. These policy sets and technology pathways are described in Sections 5 and 6 of this report. The focus group discussions also informed the development of the qualitative evaluation criteria (described in Section 2 of this report) that will be used to narrow 20 possible scenarios (five policy sets times four technology pathways) down to three promising scenarios for detailed, quantitative analysis taking place through mid-2014.

As required by Section 29 of Act 89 of 2013, the Department has coordinated with the Public Service Board in the Board's production of a report on the market for unregulated fuels and thermal building efficiency. Board staff attended the most relevant stakeholder focus group, and the Department has participated in the Board's process in developing its report. The TES and the Board's process drew upon the work already completed by the Thermal Efficiency Task Force, informed by subsequent developments in the sector.

1.2.3 Additional public meeting and comments

On November 14th, 2013 the Public Service Department held a public meeting and webinar at the Vermont State House. Twenty-five Vermonters attended the meeting in person and 26 connected via webinar. Between November 14 and December 2nd, the public and energy stakeholders submitted eleven sets of written comments in response to the meeting. The presentation for the public meeting can be viewed on the Total Energy Study webpage.

Appendix A summarizes all written comments received throughout the TES process to date, the focus group discussions, and the public meeting discussion.

1.3 Process in-progress and the future

Following a competitive solicitation, the Department hired Dunsky Energy Consulting (Dunsky) to assist with the analysis of technology pathways, policy sets, and scenarios combining them. Dunsky will also undertake detailed quantitative analysis of at least three unique scenarios to be defined in early 2014.

In the past months, the Department and Dunsky have defined technology and policy test scenarios, along with a baseline scenario to which each alternate scenario may be compared. The baseline scenario (known also as the business-as-usual case) is a quantitative description of the entire Vermont energy system up to 2050. The baseline scenario is being constructed with a various data sets and industry forecasts and takes account of existing State programs and policies.

At the time of this report, the Department and Dunsky are completing their qualitative analysis of the 20 test scenarios defined by the combinations of each of five policy sets and four technology pathways. This is being done using the evaluation criteria articulated in Section 2. The next step is to define three scenarios for continued quantitative analysis. These scenarios will likely be combinations of the most promising aspects of the 20 test scenarios. The Department expects to finalize the descriptions of these three scenarios in early 2014, following input from the Governor's Climate Cabinet, the public, and members of the Legislature as appropriate.

The modeling tool utilized by Dunsky and the Department is designed to optimize an energy system's resources for a given set of constraints, the most important of which are the renewable energy and greenhouse gas targets. Given the constraints defined, the model optimization identifies the least cost energy supply resources for each scenario. The model has the ability to account for complex interactions between the many variables representing the energy economy of Vermont and the New England region. The analysis will produce quantitative estimates of the pacing of each scenario through 2050 and describing their impacts on Vermont. The analysis includes predicting the economic impact of each scenario. Each scenario's quantitative output, including the economic impact (analyzed using a tool such as REMI PI+[3]), will be compared to the baseline scenario.

The Department and Dunsky expect to complete this quantitative analysis in the spring of 2014. Following its completion, the Department will publish the results and provide additional opportunities for public input, both in-person and in writing, to weigh in on and inform paths forward for state energy policy. The Total Energy Study Final Report is expected to be released in the early summer of 2014.

1.4 What this report is not

While the Total Energy Study describes several policy and technology scenarios that are expected to achieve the State's goals, these reports are not intended to be or replace the Comprehensive Energy Plan. Neither this report nor the TES Final Report will articulate or recommend a definitive pathway forward.

The Total Energy Study does not directly address non-energy greenhouse gas emissions (e.g. those from agriculture, waste, or chemicals). For energy greenhouse gas emissions, the Total Energy Study uses the same definitions used by the Agency of Natural Resources (ANR) in developing the State greenhouse gas emissions inventory, based on emissions at the point of combustion (including in electrical generation), not full life-cycle emissions.

This report does provide high level qualitative insights with regard to the economic and environmental impacts of choosing one scenario over another or relative to the baseline pathway. The report does not provide a detailed quantitative analysis of these impacts. Further quantitative analysis will be available in the TES Final Report to be published in the summer of 2014.

Along with subsequent analysis and work products through summer 2014, the TES Final Report will inform the next Comprehensive Energy Plan. Because these efforts address State policy goals with long timeframes (2028, 2050), an iterative energy planning process will continue to be necessary as technology, markets, and State policies evolve.

1.5 The structure of this report

Section 2 of this Report summarizes the Department's conclusions regarding appropriate criteria to use when evaluating future energy policy and technology scenarios. Section 3 discusses the overlap between policies designed to meet the state's energy and climate goals and policies designed to meet other state

[3] REMI PI+, a software product developed by Regional Economic Models, Inc., is the most commonly used tool for analysis of the economic impacts of policy choices in Vermont.

objectives in areas such as economic development, land use, transportation, forestry, agriculture, health, and natural resources. Section 4 outlines principles used in the design of energy policy sets, five of which are then defined and summarized in Section 5. Section 6 identifies technology pathways, including discussion of both energy demand and supply-side technologies, and the breadth of technology pathway choice available to the state while still achieving both renewable energy and climate change objectives. Section 7 concludes the report with a discussion of the ongoing study process.

Appendices to this report include a list of stakeholder focus group participants and a report summarizing all public comments received to this point in the TES process.

2 Criteria for the evaluation of policy and technology scenarios

In order to narrow the breadth of possible policy and technology scenarios and to choose a reasonable number of scenarios for detailed quantitative analysis, the Department and Dunsky developed qualitative evaluation criteria. The set of criteria developed was informed by the stakeholder focus groups and comments from the general public. These evaluation criteria are intended to support understanding of various advantages and trade-offs. Thus the criteria allow each scenario to be measured and compared against all other scenarios. The evaluation of policy and technology scenarios against these criteria is ongoing. Some initial results are reflected in the discussion contained in this Report; a more complete and quantitative analysis will be available in 2014.

2.1 Evaluating technology options

2.1.1 Ability to meet greenhouse gas and renewable energy goals

Each scenario that will be analyzed is constructed to meet the State's 2028 and 2050 greenhouse gas targets, and the State's 2050 renewable energy target. While there is likely to be some overlap among scenarios, reaching the climate and renewable energy goals does not necessarily require the same technologies in every case.

As described above, a baseline estimation of Vermont's energy system, which falls short of the State's targets, is being developed to compare with the test scenarios. In addition, for the initial narrowing of test scenarios the technology options will be qualitatively evaluated against a scenario developed using the software model. This initial quantified scenario will be constructed to identify the one set of energy supply technologies, and their pacing, to meet the renewable energy and climate goals at low overall estimated energy cost. Each test scenario will be evaluated against this initial scenario to determine how likely the test scenario is to achieve the State's targets at reasonable cost.

The Department recognizes there is diversity of opinion on how to define the "optimum" technology pathway. The initial quantified scenario will be based on optimizing a simple net-present-value of overall energy costs. We are analyzing a diversity of technology pathways to capture the varying benefits and costs of different scenarios.

2.1.2 Total economic impact

Perhaps the next most obvious of evaluation criteria is to consider the overall impact of the policy and technology scenarios on the Vermont economy. The total net direct and indirect impacts to the Vermont economy will be measured in two ways, one of which places a value on reductions in greenhouse gas emissions, the other of which does not. The direct impacts will consider changes in actual expenditures on energy, while the indirect impacts will additionally consider how those changes flow through the Vermont economy. For example, energy efficiency savings were recently shown to have a "multiplier" effect, as the customer savings on fuel costs were re-spent in the Vermont economy, leading to an increased benefit[4]. Other harder-to-quantify costs and benefits, such as impacts on public health, will be considered to the extent possible.

Analysis of economic impact to be conducted in 2014 should provide information about consequences for costs, prices, and manufacturing competitiveness in Vermont. The quantitative analysis will be completed in a format that facilitates input into state economic models such as REMI PI+.

2.1.3 Capital flows

Dunsky and the Department will also identify the capital flows associated with each scenario in order to determine the extent that the benefits and costs of the scenarios remain in-state or are exported out-of-state. The initial qualitative analysis will provide a high level indication of the direction and magnitude of these flows. The detailed quantitative analysis of three scenarios will provide more detail and, to the extent possible, will identify cash flows between individual sectors within the economy so that impacts can be analyzed across different socioeconomic groups, geographic areas, and/or economic sectors.

2.1.4 Risk

The pace, timing, and impact of technological change is nearly impossible to predict. Thus, the ongoing TES will qualitatively evaluate technology options with regard to the impacts of potential variances in initial projections, such as technology implementation cost, availability, and acceptability. This criterion will consider the flexibility of each technology option with regard to the diversity of energy supply technologies.

2.2 Evaluating policy options

2.2.1 Responsiveness

Similar to the diversity of energy supply resources discussed under the "risk" technology criterion, this criterion considers the ability of a policy to take advantage of new opportunities and meet new challenges. For example, if the availability of a technology changes (e.g. due to changes in performance or cost), then the policy may or may not be able to take advantage of those changes. This criterion evaluates a policy's responsiveness and/or vulnerability to change.

[4] See, for example, Appendix 5 of the 2011 Comprehensive Energy Plan, available from http://publicservice.vermont.gov/sites/psd/files/Pubs_Plans_Reports/State_Plans/Comp_Energy_Plan/2011/2011%20CEP_Appendixes%5B1%5D.pdf.

2.2.2 Independence

As discussed in Section 4, Vermont is a small state that is impacted by changes in markets and by policies set in other jurisdictions. The "independence" criterion considers the extent to which a policy is dependent on other jurisdictions' energy policies. There is real value in having Vermont policies compatible with those in neighboring states; indeed the economic impacts (either positive or negative) or even the ability of a policy scenario to facilitate meeting Vermont's energy goals may crucially depend on how other jurisdictions act.

2.2.3 Impact

A policy choice could score well against the above criteria, but only apply to a limited portion of Vermont's energy system. Thus, it is important to consider the overall impact of a policy choice. This will be done in two ways. First, the scope of energy sources and emissions addressed by the policy choice will be evaluated. Second, the possible leverage of the policy to ensure the desired outcome will be considered, taking into account whether a policy is voluntary, prescriptive, or mandatory.

2.2.4 Complementarity

Finally, it is imperative that the policy and technology pathways not undermine other efforts and goals of the state; instead they must work in coordination. Thus, each scenario was also constructed to be complimentary to the State's other energy and non-energy policies. A description of the state policies with which the Total Energy Study must coordinate can be found in Section 3.

2.3 Evaluating technology plus policy scenarios

In addition to the analysis of each technology pathways and policy set against the criteria above, each combination scenario will be evaluated. Evaluation will weigh whether implementation of a policy set is particularly compatible or incompatible with the technology pathway under analysis. It is important to note that Vermont's greenhouse gas and renewable energy goals may be reached at different times under different combinations of policies and technologies. The Study will seek to the extent possible to analyze the pacing of how quickly we will meet our goals under each combination. In addition, analysis may identify the optimal sequence for deployment of technologies or policies within each combined scenario.

3 Coordination with other state policies

Most activities in the Vermont economy have implications for the state's energy use and result in some greenhouse gas emissions. As a result, Vermont's energy and greenhouse gas policies are intimately linked with the state's policies in other areas. The state has developed polices that reflect Vermonters' priorities and expectations across the economy, and the energy policies and technology pathways studied here must be evaluated based on how well or poorly they interact with other state policies.

Through this study process, it has become clear to the Department that because the proposed scenarios are general in nature, the effects of a particular policy/technology pathway with regard to most other state policies depend on the details of policy implementation. If energy policy is implemented poorly, it could conflict with other state policy goals. The Department has attempted to design the scenarios such that neither policy design nor its thoughtful implementation would directly conflict with other state policies.

However, it is important to maintain awareness of the key policy areas where poor energy policy implementation could have a negative effect on other state policy goals. This section addresses areas of policy interaction and how energy policy and technology might be shaped by consideration of each policy area.

3.1 Economic development and equity

One of the key messages the Department heard from stakeholders during this study process was the importance of energy to the state's economic vitality. To that end, the Department has participated in the Agency of Commerce and Community Development's (ACCD) ongoing development of a Comprehensive Economic Development Strategy (CEDS), and ACCD staff have participated in the interagency and stakeholder TES working and focus groups.

There are two primary ways in which energy policy impacts the state's economic development: the cost of energy and the development and growth of Vermont's "clean energy" economy. Regarding the cost of energy, energy policies must be aware of both the marginal cost of a unit of energy, delivered via various fuels, and a customer's total expenditure on energy. (In the electric context, for example, that means both rates and bills.) Both of these have impact on the cost of living and the cost of doing business in Vermont, with implications for regional, national, and global competitiveness. Policy analysis and design should be concerned with inter-sector equity (favoring policies which distribute benefits to the same sector which directly bears the policy's cost), and aware of the implications for shifting economic activity from emissions-intense to less-emissions-intense activities. Further, policy analysis and design should also be aware of the timing of any imposed costs or secured benefits.

Procuring a growing fraction of the state's clean energy resources in the state (both supply- and demand-side resources) serves to bolster local firms delivering those resources, and also provides a platform from which firms can develop products and services offered in global markets. Vermont policies can foster innovation in both business models and technologies.

The cost of energy is borne unequally across Vermont consumers, both commercial/industrial and residential. Therefore, polices that change the costs of energy, or the relative costs of different fuel choices, will have uneven effects. For example, rural Vermonters are more sensitive to the cost of transportation fuels. Energy is also a larger fraction of household expenditures for low-income Vermonters than for higher-income, so policies which increase the cost of energy relative to other goods and services should also be designed with compensating features that ensure that benefits flow back to those bearing greater relative costs, particularly to the state's low- and middle-income residents.

3.2 Land use

The built environment, including both buildings and roads, both shapes and is shaped by energy and climate policies. The state's long-term commitment to compact settlement patterns is highly compatible with efforts to reduce energy use and increase the efficiency of the transportation sector because it increases the ability for Vermonters to live close to where they work and play and makes alternative modes of transportation viable alternatives to single occupancy vehicles. The energy polices considered here, then, should respect and complement the state's progress on implementing smart growth principles. While historic preservation is a key component of maintaining this settlement pattern, energy policy implementation should also respect the need to balance the desire to improve the efficiency of buildings, and to develop or maintain energy resources such as hydroelectric resources, with such preservation.

Energy infrastructure, such as electric generators, transmission lines, district heating systems, and pipelines, also has significant land use impacts. The recommendations of the Vermont Energy Generation Siting Policy Commission directly address potential improvements to the siting process that can increase the potential for compatibility between land use aims and clean energy implementation. One key take-away from that process is the importance of planning, for both energy and land use, and the need for these two kinds of plans to inform each other.

Even as Vermont makes progress on reducing greenhouse gas emissions, previous emissions and emissions from other jurisdictions continue to change the global climate. To this end, technology and infrastructure deployment, including buildings, road, and energy infrastructure, should be pursued in a way that increases resilience in the face of extreme weather, while avoiding undue impact on the state's natural resources, which will likely face increased stresses as well. A dynamic and resilient energy system, fostered by appropriate policies, can lessen the negative impacts on the state from such events.

3.3 Transportation

More than one third of the state's energy consumption, and nearly half of its greenhouse gas emissions, are tied to the transportation sector. Transportation infrastructure choices are also in many cases land use choices, involving them with energy through the mechanisms discussed above regarding land use. Broad energy policies, such as those focused on modal choice or the cost of competing fuels, can also impact how transportation infrastructure is used, and which infrastructure is required. For example, a shift of heavy-duty transportation away from trucks and toward rail has implications for the necessary rail infrastructure; the cost of gasoline has a direct impact on utilization of transit services. Coordination of policies and planning between these two economic foundations – energy and mobility – can advance state goals in both arenas. In addition, a significant fraction of the state's revenue for transportation infrastructure and programs is raised via taxes on energy products (gasoline and diesel). Thus, policies which address either side of this coin impact the other. The state and our regional neighbors have a compelling long-term need for sustainable funding for transportation infrastructure, so long-term energy policy planning must take this need into account.

3.4 Forestry

Vermont has a limited biomass resource that can be harnessed sustainably for energy purposes. Policies which increase or decrease the use of different kinds of woody biomass for energy will impact the state's forests. The Department's analysis of the availability and utilization of biomass for energy is informed by the amount of biomass that can be harvested sustainably and in a way that maintains or improves the health of the state's forest resource. This effectively serves to put a cap on the amount of biomass energy that the state's policies should count on using for energy purposes.

There is also a potential for synergy between forest health, the forest products industry, and meeting the state's energy goals. Sustainably harvested low-grade wood for energy purposes provides an economic driver for maintaining forested land in wood production, and can increase the quality of the forest resource over time. This results in less low-grade wood available for energy uses, but a greater state resource for other, higher-value wood products, and a potential positive impact to the forest products industry. Maintaining forested land as forest also can be compatible with the compact settlement patterns discussed above, and with maintaining habitat connectivity, carbon sequestration, and other environmental services.

3.5 Agriculture

Similar to in the forestry discussion above, energy has potential to be a co-product from Vermont's agricultural sector. As a co-product, it can improve the economics of the state's farms (through monetizing what might otherwise be waste) and also advance natural resource objectives. Anaerobic digester technologies, such as those deployed at a number of Vermont dairy farms, can contribute to addressing the organic-waste-disposal needs created by Act 148. Processing wastes explicitly through digestion can also increase the ability to capture potential water pollutants and nutrients for appropriate disposal or reuse.

Agricultural land can be an appropriate place to site energy infrastructure, including electric generation by various technologies. However, energy facility siting can also have implications for the use of the state's prime agricultural soils, so deployment plans for different types of renewable energy generators should be designed to respect this state resource.

3.6 Health & natural resources

In addition to the forest and farm resources discussed above, energy polices have implications for the state's air and water quality and the vitality of other natural resources. Energy policy structures under consideration should be compatible with policies that promote the maintenance or improvement of natural resources.

Greenhouse gases are global air pollutants whose reduction is inherent in the policies considered in this study. Other air pollutants, however, such as those resulting from combustion of fossil or biomass fuels, can have local and regional impacts on human health (e.g. cardiovascular and respiratory diseases and illnesses, cancer, etc.). Energy policies that reduce combustion for electricity generation, transportation, or heating also reduce such emissions. In addition, policies should reflect the differing ability of different combustion technologies to reduce emissions and the potential (or lack thereof) for "scrubbers" or other technologies to remove pollutants from flue gases.

Energy-related impacts on Vermont's water quality include impacts from dams and hydroelectric generators, introduction of various waste streams (e.g. via run-off), and deposition of air pollutants into water (e.g., via acid rain). Clean energy pathways that the state might pursue are generally consistent with polices to improve water quality by addressing such concerns; one area of potential greater conflict is in Clean Water Act compliance and the use of hydroelectric generators in run-of-river vs. more controlled operation, as well as the expansion of hydroelectric generation to existing dams (rather than the dams' removal).

Siting and construction of energy facilities can have impacts on wildlife habitat and the state's other natural resources, as well as water and air quality. Public and regulatory acceptability of clean energy technology deployment depends on the ability of such developments to mitigate impacts on the state's natural resources, and ideally to improve them.

Policies that advance clean energy can also have direct impacts on human health. For example, land use policies and transportation infrastructure that support compact settlement patterns, with resulting energy savings, also provide a context for walking and biking, with resulting improvements in fitness. Climate change will also have increasing impacts on Vermonters' health, such as through extreme heat events, flooding events, or introduction of diseases or pests. The built environment can directly impact the ability of Vermonters to weather such changes. For example, more efficient buildings can be better able to maintain heat (in winter) and cold (in summer), increasing human comfort and health.

4 Developing "comprehensive and integrated" energy policy sets for analysis

4.1 Market structure and failures

Global, national, state and local energy markets are not free markets – they are strongly shaped by utility regulation, tax policies, incentives, and environmental regulation. Many of the policy sets described in Section 5 address known and identified market failures (such as utility regulation in the context of natural monopolies); others exacerbate such failures. In developing and analyzing energy policy options for Vermont, the Department has identified several market failures that could be addressed in order to increase the alignment between market forces and the public interest.

The market failures identified here exist to different degrees and in different guises in different parts of the energy economy. For example, the natural monopoly world of electricity and pipeline natural gas is shaped by utility regulation and rate-setting, while delivered fuels are subject to competition between suppliers. At the wholesale level, however, electricity and natural gas are traded commodities, similar to oil, gasoline, or propane, operating under a different set of market forces. Public policies (or other forces) that result in a shift of demand to or from price-regulated fuels will have impacts throughout the energy economy, changing the characteristics of different parts of relevant markets.

Market failures identified in the Department's research and raised by stakeholders include:

- **Prices that do not reflect costs:** In order for consumers to make economically efficient decisions that also reflect the public interest, the prices paid for goods and services should reflect the full cost of those goods. For example, the market prices of fossil fuels do not reflect the full environmental cost (both present and future) of the production and combustion of those fuels;

similarly the price of electricity generated by a renewable facility may not reflect the full societal cost of the construction and operation of the facility. Costs borne by someone other than the person paying the final price are called "externalities."

- **Lack of information:** If a consumer lacks complete information her purchasing decisions may fail to serve either her own personal interest or the public interest. For example, the lifetime cost of an appliance or automobile is a combination of the upfront cost and ongoing fuel and maintenance costs (among others). A more efficient appliance may cost more up front but save money in the long term. However, without complete information, the consumer may unintentionally choose the product with a higher overall cost, a phenomenon known as adverse selection.
- **Lack of access to capital:** The more economical long-term energy choice may require greater upfront expense, and if a consumer lacks access to the capital necessary to make that investment, she may not be able to make the choice she would like to optimize her well-being.
- **Split incentives:** In many cases, such as in a landlord-tenant relationship, the parties who make purchasing decisions are not those who pay for operating costs associated with those decisions. This situation is considered a principal-agent problem, a problem commonly observed within organizations where capital and operating costs are treated separately. The nature of a principal-agent problem is that the best collective choice (for the landlord and tenant together, or for the organization as a whole) is not in the best interest of the persons making the decision (the agent).

The policy sets the Department has developed for analysis, described in Section 5, address these market failures in a variety of ways. One way to think about each policy set, however, is that it uses some policy tools to encourage prices to approach the correct societal costs, and other complementary policy tools to reduce other market failures and allow these price signals to be more effective or otherwise shape consumer or producer behavior to address market failures.

4.2 What are the leverage points, and who can wield the levers?

As discussed in the 2011 Comprehensive Energy Plan, attempts by government and others to shape the energy sector or reduce greenhouse gas emissions can be categorized into four leverage points:

- education and outreach,
- finance and funding,
- regulatory reform, and
- technology and innovation.

These leverage points can address the market failures discussed in the previous section, although they also have other roles in meeting the state's energy and climate change goals. For example, education and outreach can address the lack of information; finance tools can address the lack of capital, and regulatory reform can address alignment of prices with costs. These leverage points must work in concert, however, in order to be truly effective.

Different levers, or different aspects of each lever, may also be best operated by different kinds of entities. Potential actors in Vermont include state agencies, political leaders, community leaders, educators, financial institutions, businesses, researchers, and non-profit organizations. Coordination among these different kinds of actors, each wielding the levers they can, can increase effectiveness of each contributor's actions. The state has long recognized this, and it is implicit in the logic behind the development of a regularly-updated Comprehensive Energy Plan and the generally collaborative nature of the energy policy process in the state. The policy sets described here are each constructed with the intent to provide an overall policy framework to facilitate a common understanding of the tradeoffs between the costs and benefits of various policy choices, with which Vermont's broad cast of actors can engage in meaningful debate.

An example, based on one of the underlying shifts the Department has identified as key to the clean energy transition, may be illustrative. Across almost all sectors and energy uses, both efficiency and renewable energy technologies have a greater up-front cost but lower ongoing or operating costs than is the case for existing technologies they might displace. For example:

- Home weatherization increases the capital invested in the building while reducing the home's operating costs.
- Pellet boiler systems are more expensive than fuel oil boilers, but pellet fuel is less expensive than fuel oil.
- Solar PV, wind, and hydroelectric generators incur almost all of their lifetime costs at their time of installation, with no cost for the sun, wind, or water used to generate energy. Fossil fuel generators are relatively inexpensive to construct, but retain significant fuel costs throughout their operation.
- Electric vehicles are generally more expensive than an equivalent gasoline-powered vehicle, but have significantly lower cost per mile of operation.
- Transit vehicles and infrastructure have significant upfront capital cost, but reduce the cost of mobility for their riders as they have lower operating costs than the total costs of all the single-occupancy vehicles they displace.

Given this aspect of the clean energy transition, how can different actors use their leverage in a coordinated fashion to accelerate change and overcome time preferences biased toward the present?

Financial levers, generally wielded by the private financial sector, have a lead role to play in this circumstance because of the ability of financial tools to amortize high upfront costs over time. For cost-effective investments, lower operating costs combined with repayment over time can result in reduced overall recurring costs. This allows the customer to see immediate and ongoing benefit from making a clean energy investment. Where investments are not yet cost-effective, or where financial tools do not yet correctly reflect the risk profile of the investment, funding tools, generally wielded by or under the direction of government agencies, can step in to help bring down the cost of new technologies through market growth or to enable demonstrations that develop data to document risk.

Even with cash-flow-positive financial structures, however, energy consumers need access to good information and encouragement – shared by political and community leaders, educators, non-profit organizations, and businesses – to develop the confidence to proceed in a clean energy investment. State agencies and financial and other regulated firms may need to work together to develop new regulatory structures that encourage cost-effective clean energy investments, rather than present barriers. And technology and business model innovators can develop new technologies, and businesses to deploy them, lowering overall costs while improving quality of life.

Coordination in this context requires, for example, that as new technologies are developed, the private financial sector, technology innovators, and government funders coordinate to provide necessary but not excessive support while demonstrating technical and economic performance, lowering risk, and enabling lower financing costs. In a capital-intensive clean energy context, "green" jobs are likely to be more in installation, rather than operations.[5] This highlights the benefits of coordination between technology innovators, business model innovators, and educators, as well as political and community leaders who can spread the word about these opportunities. The pace of clean energy infrastructure investments shapes the size and scope of the clean energy industry.

4.3 Recognizing the role of the State vs. private sector and other governments

When developing policy sets for analysis, the Department considered the question of the correct role for state government *vis a vis* both other governments (federal and other states) and the private sector. Energy demand, supply, and distribution are shaped by Federal and state government policies but are fundamentally functions of the private sector. The Department's consideration includes an understanding of Vermont's role in the national and global energy sector and economy, and in the context of global climate change.

Vermont is a small state. Vermonters could eliminate our greenhouse gas emissions, or double them, with only marginal direct impact on the climate. Similarly, our actions have only marginal effect on the price of global energy commodities, appliances, vehicles, or infrastructure. At the same time, however, the global climate and the regional, national, and global energy markets have profound impacts in Vermont. In this context, it is in the state's interest to impact the decisions of others, whose collective actions can materially impact the global climate and energy sector. Vermont can demonstrate a successful path forward and inspire broader action by recognizing the imperative to act on climate change and by developing policies that work for Vermont and advance the state's energy, economic, and environmental goals.[6]

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[5] This shift is not absolute, of course. For example, a growth in transit will result in more transit operators; they are displacing the unpaid role of "single occupancy vehicle driver" that might otherwise have been played by each of their passengers.

[6] An example: Vermont was an early leader in electric energy efficiency. While our average and overall electricity consumption was already low relative to the rest of New England, our commitment to energy efficiency and success delivering programs paved the way for most of our neighboring states to embrace electric energy efficiency. Vermont's investment in energy efficiency is small (in absolute terms) relative to other states, but the

One tension that the Department identified in analyzing the state's role is the potential tension between policies that may be easily generalized and exportable, but perhaps not well suited to Vermont, and polices that are designed to reflect Vermont's uniqueness, but are necessarily less immediately exportable. Our conversations with stakeholders convinced the Department that the latter path is preferable. We should not accept sub-optimal policies for Vermont that risk incurring unnecessary costs in achieving other state goals, including robust economic progress, in order to make our policies more easily exportable. As a rural northeastern state, the technology pathways available to Vermont are not necessarily those available to many other states or nations, and we also face unique challenges. By demonstrating the success of correctly-designed policies, we will inspire others to design the policies that achieve comparable energy and climate impacts elsewhere. Aspects of our policy solutions may be adapted to other jurisdictions facing similar challenges or with similar opportunities, and Vermont should share what we have learned.

Regional collaborations, with both our neighboring states and Canadian provinces, can carry weight beyond what Vermont alone can do. The Regional Greenhouse Gas Initiative (RGGI), for example, is reducing the greenhouse gas emissions from the electric power sector across 9 states. This reduces the GHG emissions of Vermont's electricity portfolio through regulation of power plants in other states. Energy-related infrastructures (such as road, rail, pipeline, and electric grid networks) are commonly addressed at the regional level, so polices that directly impact these networks may particularly benefit from regional consistency. The northeast is also a large enough potential energy market to exercise some "demand pull" if the region's states collectively act to shape markets (such as encouraging the availability of new products such as electric vehicles). Vermont has also played a role as a bridge between New England and Quebec in the flow of energy, goods, and services.

As Vermont looks to lead on energy and greenhouse gas emissions, we must be cognizant of current and emerging regional markets, trends, and policy structures. In particular a Vermont decision to rely on more constrained renewable resources like biomass and hydroelectricity could interfere or interact with choices made by other states or provinces.

The Federal government can take a wide range of actions that are unavailable to Vermont, for example, because Vermont may be preempted from acting in areas of Federal jurisdiction, or more simply due to scale of potential investment. More specifically, Vermont may be too small to sustain large-scale state-funded research and development activities given the potential for the fruits of those investments to flow to other states; the federal government has less concern than any state might about such interstate benefit flows. Vermont may, however, identify technologies particularly well suited to Vermont needs and focus our efforts there (as we have done historically, for example, with anaerobic digesters). Due to preemption, Federal policy-making could (in theory) upend most any policy structures Vermont might establish; in practice state policy innovation has also provided examples that the Federal government can adopt.

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state benefits from reduced market prices, transmission needs, and emissions saved by other states. Another example has to do with RGGI. Vermont was the first state to Vermont was the first state to call for auctions of the allowances and to dedicate 100% of the auction proceeds to clean energy investments, which have had the effect of lowering demand for, and therefore the price of, the allowances.

Within the state government, different kinds of actors can be most effective with different roles. For example, regulatory programs are the natural purview of long-standing (and stable) agency bureaucracies due to the importance of consistency and subject matter expertise. Technical assistance and funding or finance programs benefit from being more nimble and responsive to market changes and contain the flexibility to develop public-private partnerships. Political leaders more closely reflect the concerns and hopes of their constituents, and serve to both reflect those opinions into policy-making and exercise political leadership by shaping public opinion. There is a feedback loop between state policy-setting, political acceptability, and changes in the public understanding of and opinions toward the clean energy transition.

State actions and policies can also send signals to the marketplace and to citizens regarding the importance or impacts of the clean energy transition. (These signals can be discouraging or encouraging.) For example, state support for installation of electric vehicle charging equipment (EVCE) could have the combined results of increased range confidence among drivers of electric vehicles, increased visibility of electric vehicles as an option, and identification of Vermont as a state on the leading edge of new technology. State operational "lead by example" initiatives have the potential to shape public understanding and opinions by demonstrating, through the operations of government itself, the benefits of a clean energy economy. Political leaders can also use their opportunity to be heard in order to "lead by example" on changes in opinion and culture. State policy leadership itself enhances the Vermont brand and sends a "welcome" signal to clean energy investment and entrepreneurs.

5 Trial policy sets

The Department developed the five integrated and comprehensive sets of potential energy and greenhouse gas policies described in this section in order to evaluate the strengths and weaknesses of each in meeting the State's energy and greenhouse gas goals. The first sub-section describes the baseline of state policies, principles, and tools that will be incorporated into all scenarios being modeled and analyzed. Each of the following subsections describes one set of potential policies identified for further analysis and consideration.

5.1 Common policies across all scenarios

As discussed in Section 3, there are numerous interactions between the course that Vermont takes toward its clean energy goals and state policies and objectives not directly associated with energy. For the purposes of its analysis, the Department has assumed that the non-energy policies, programs, and objectives are maintained to the degree possible while pursuing each of the five policy sets described in greater detail in the remainder of Section 5. Policy sets may include strengthening existing non-energy policies or objectives (for example, land-use policies directed at creating compact development patterns).

Turning to policies or programs directly related to energy, the Department assumes that the general energy policy of the state, embodied in 30 V.S.A. §202a, is maintained:

(1) To assure, to the greatest extent practicable, that Vermont can meet its energy service needs in a manner that is adequate, reliable, secure and sustainable; that assures affordability and encourages the state's economic vitality, the efficient use of energy resources and cost effective demand side management; and that is environmentally sound.

(2) To identify and evaluate on an ongoing basis, resources that will meet Vermont's energy service needs in accordance with the principles of least cost integrated planning; including efficiency, conservation and load management alternatives, wise use of renewable resources and environmentally sound energy supply.

The similarity between the principles contained in §202a and the policy evaluation criteria used in this report is intentional. Section 202a(2) provides grounding for the assumption that cost-effective efficiency, conservation, and load management are to be the first resources utilized, consistent with the principles of least cost integrated planning, under all evaluated scenarios.

Consistent with this policy, the Department assumed continued use of policy levers aimed at addressing market failures due to lack of information and lack of access to capital. In particular, this includes robust and consistent education and outreach regarding clean energy opportunities. Similarly, the state is assumed to have a continuing interest in development and promotion of financial tools that allow Vermonters access to capital to make cost-effective clean energy investments.

5.2 Total Renewable Energy and Efficiency Standard (TREES)[7]

The first policy set the Department identified for analysis requires all providers of energy in Vermont to meet a fraction of their sales with renewable energy or energy efficiency. (A version of this policy was first proposed in the 2011 Comprehensive Energy Plan, under the title of a "Total Energy Standard." The Legislative charge for this study requires consideration of this policy option.) The required clean energy fraction would be the same for all fuels, and would rise over time (for example, to 90% by 2050). Obligations would be met by "retiring" certificates corresponding to a certain amount of renewable energy or efficiency. These certificates could be traded commodities, called "TREE certificates" or "TREE credits." For example, a weatherization contractor could sell TREE credits for home weatherization to an electric utility, or a solar PV developer could sell credits for PV generation to a heating fuel distributor. This is the economy-wide equivalent of a renewable portfolio standard (RPS; a policy tool used in 30 states to regulate electric energy supplies), with incorporated energy efficiency. For the electric supply sector, TREE certificates would be essentially identical to Renewable Energy Certificates (RECs).

Practical implications and open questions in the design and implementation of this policy set include:

- At current, it is much more obvious how to achieve validated credits for some activities than others. For example, the verified savings from Efficiency Vermont or the Renewable Energy Credits generated by a small hydroelectric plant are well established. In contrast, at low levels of blending the biofuel content of heating oil is difficult to track, and there are no established

[7] The Department welcomes comments regarding alternate names for this policy structure.

protocols for measuring and verifying efficiency savings from efforts such as the development of a new transit service.

- Should credits be awarded for generation or savings in the year of obligation or awarded at the time of implementation for an expected project lifetime? Renewable energy credits generally use the latter formulation; "white certificates" in European energy efficiency obligation programs generally use the former. Would the policy work well with both of these kinds of credits?
- If energy efficiency measures are awarded lifetime credits, it could mean that the overall obligation could rise above 100% (e.g. achieved through 30% lifetime efficiency – saving 2% annually for 15 years – and 75% renewable supply). The Department observes that energy efficiency is relatively less expensive than renewable energy supply across most energy sectors, so achievable energy efficiency would generally be obtained first; by the later years when obligations are high, most achievable waste may have been captured.
- Trade, marketing, and advertising guidelines have been developed over the past decade or so that describe green claims, renewable energy claims, etc. (For example, if a utility owns the energy, but not the RECs, from a generator, they can't claim to be providing renewable energy from that generator to their customers without running afoul of fraud guidelines.) In the TREES context, Vermont would need to develop ways to correctly characterize the attributes of delivered energy services that have been sold as a credit and retired to meet an energy provider's obligation.
- The TREES could be designed with carve-outs or other sub-obligations to help meet other policy goals. For example, a requirement on electric utilities that some fraction of their credits correspond to small-scale generation distributed across the electric grid could support grid resilience and control transmission and distribution costs, while reducing line losses. There could also be limits on the amount of energy efficiency able to be used in meeting obligations in order to ensure a minimal amount of renewable energy.

One possible structure that would address the uncertainty regarding the creation of TREE credits for sectors and activities without well-established accounting mechanisms is as follows: Begin the TREES program with requirements placed only on suppliers of energy in some sectors or fuels. For example, the policy could begin with just the electric utilities and heating fuel (regulated and unregulated) sales to residential customers. These are sectors in which at least some renewable supply is well characterized and countable, via RECs in the case of electric supply and bioheat, biogas, and pellets in the case of residential heating. Similarly, learning from the regulated energy efficiency structure, there are established ways to quantify credits for energy efficiency in these sectors.

To expand the TREES beyond its initial participants and obligated parties, the first step would be to accept credits from other sectors or fuels. For example, credits earned through industrial process improvements that reduce the use of process fuels could be sold to an electric utility. This would encourage experimentation and the establishment of protocols for the creation of credits in these other sectors. In order to ensure continued progress in the covered sectors, the TREES could include limits on the number of credits from "uncovered" sectors that could be used. This is compatible with expanding obligations to other sectors over time. Knowing that obligations will come, firms will develop ways to earn and quantify TREE credits in those sectors; this in turn eases the expansion of the TREES into those and other sectors.

5.3 Carbon tax shift

The second policy set the Department identified for analysis creates an economy-wide carbon tax as one leg of a tax reform package that maintains or comes close to maintaining revenue neutrality for the State. The Department's modeling simulations will assume that such a carbon tax would have the effect of aligning price signals with the external costs of emissions. A similar policy has been adopted in British Columbia, where a carbon tax on fossil fuel combustion has been in place since 2008. British Columbia maintained revenue neutrality by reducing personal income and business taxes, and by providing property tax relief to "rural and northern homeowners." The tax was ramped up over four years to $30/metric ton. A 2012 evaluation resulted in the continuing of the policy.[8]

Practical implications and open questions in the design and implementation of this policy set include:

- Determining the correct amount for the tax, and updating it over time. The economically efficient price to assign is the price that equals the social cost of carbon emissions. However, there is no state, national, or global consensus on that value. Some potential values include the values used for Federal rulemaking (expressed as a range between $12 and $116 per metric ton, and rising over time[9]) and the value derived to estimate the cost of carbon abatement, used by some energy efficiency program administrators across New England, including Vermont ($100/short ton[10]). Once set, the value of the tax serves two purposes: maintaining state revenues (which would fall if the tax is successful at reducing emissions) and causing decision-makers in the state to make choices that result in lower emissions. There is no inherent guarantee that the correct value for the purposes of state revenue and the correct value for the purposes of hitting state GHG emission targets are the same value, and both may change over time.
- Tax reform may benefit from being phased in over time. For example, the tax could be ramped up at a rate of $10/ton per year until the final value is achieved.
- There is no guarantee that a price on carbon will encourage greater usage of renewable energy, as opposed to switching between fossil fuel sources or using nuclear-generated electricity.

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[8] "After a review last year, B.C. confirmed it will keep its revenue-neutral carbon tax, the current carbon tax rates and tax base will be maintained, and revenues will continue to be returned through tax reductions…The review covered all aspects of the carbon tax, including revenue neutrality, and considered the impact on the competitiveness of B.C. businesses such as those in the agriculture sector, and in particular, B.C.'s food producers." http://www.fin.gov.bc.ca/tbs/tp/climate/carbon_tax.htm accessed November 19, 2013.

[9] http://www.epa.gov/climatechange/EPAactivities/economics/scc.html

[10] See chapter 4 of http://publicservice.vermont.gov/sites/psd/files/Topics/Energy_Efficiency/AESC%20Report%20-%20With%20Appendices%20Attached.pdf

Supplementary policies may be necessary to encourage enough use of renewable energy to achieve the 90% renewable energy goal and simultaneously cut emissions[11].

- What reduction in other taxes or fees is necessary and appropriate in order to remain revenue neutral? Adoption of a carbon tax of this sort invites a larger discussion about tax reform and provides an opportunity to better align costs with prices throughout the economy. It may be appropriate to reduce other taxes on the same fuels that are charged a carbon tax in order to mitigate net price effects and maintain equity among fuels on a carbon basis. Fuels for which there is already a small carbon payment (such as electricity via the RGGI cap and trade system), could have a reduced payment to avoid double-payment. The energy efficiency utilities (EEUs) exist to meet the obligation of the state's regulated energy providers to provide least cost service, so this policy would not immediately impact these programs, nor would the tax revenue obviate the energy efficiency charge levied to pay for these programs.
- Where are the most appropriate and implementable points to measure greenhouse gas emissions? Measuring fuel use at the point of import into Vermont may be the most straightforward to implement. (There are relatively few energy importers, so relatively few taxpayers, compared with energy consumers.) However, measuring at the state line neglects upstream emissions from fuel refining, drilling, extraction, transportation, etc. Electric utilities can track their emissions through the NEPOOL Generator Information System, which allows the calculation of emissions due to electric generation at facilities throughout New England, but again this does not include upstream emissions. Life-cycle emissions for biomass (woody biomass in particular) also depend on harvesting and replanting rates.

One concern raised by this policy set is that simply setting the "correct" price is unlikely to be sufficient to cause the necessary change in behavior, given other market failures. Therefore, it may be necessary to develop complementary programs, which will have associated costs, in order for the revenue neutral carbon tax to work effectively. These programs would change over time, but would likely include purchase incentives, financing tools including credit enhancements, technical assistance programs, and programs designed to mitigate the impacts of increased energy costs on low- and middle-income Vermonters. There are two primary options for revenue to support such programs. The first is to make the carbon tax not quite revenue neutral – that is, to offset the carbon tax by reduction in other taxes and fees that do not quite cancel the net revenue impact, thereby generating net revenue. The second is to capture some or all of the increase in state revenue that could come with increased economic activity associated with a more economically efficient tax structure. The former of these is more certain and is available immediately; the latter avoids increases in overall tax rates but is uncertain and takes time to develop.

A second concern to be addressed is the tax's impact on energy-intensive commercial and industrial activity. During a period in which Vermont levies a carbon price but other jurisdictions do not, Vermont firms may be at a disadvantage. The extent of this disadvantage depends on the taxes cut to balance the

[11] A recent report from the International Energy Agency, available at http://www.iea.org/publications/insights/insightpublications/name,43825,en.html, describes a framework for analyzing the interaction between carbon pricing and energy policies.

carbon tax, however particularly emission-intense firms are likely to see a net tax increase. One option to address this concern, developed based on stakeholder input, would be to exempt firms from the carbon tax if they make particular progress to increase their productivity per unit of emissions. Increases in productivity that would redound to Vermont's benefit could be measured in units such as the firm's payroll or state tax burden. So, for example, a firm could be exempted from all or part of the carbon tax if its payroll per ton of emissions increases at a certain rate, evaluated on an annual basis. Designing this tax incentive program would require a careful balance between state goals regarding economic development and state greenhouse gas reduction goals.

5.4 Renewable targets with carbon revenue

The third policy set the Department identified for analysis combines aspects of the previous two policy sets, while taking a somewhat different approach: In this policy set, the state would set a target for the renewable energy content of all fuels, placing a non-binding obligation on energy suppliers. If the target were not met within a given sector, however, the obligation would become mandatory within that sector. This obligation structure would be paired with a small economy-wide carbon tax, used to raise revenue applied to programs directed at making it easier for obligated parties to meet their target obligations. As an alternative to making the obligations mandatory in the case of failure to meet renewable energy targets, the carbon tax could be increased in such sectors.

Revenue raised with the carbon tax would be paired with regulatory reform to increase the pace of business model innovation throughout the clean energy economy. For example, funds or regulatory changes could be used to increase the pace of adoption of electric vehicles or alternative modes of transportation; adapt regulated utility business models to allow or incent them to make investments or utilize financing tools to make adoption of efficiency or renewable energy easier; or establish funding or financing programs that support fuel dealers expanding their business into becoming energy service providers, more broadly defined.

Practical implications and open questions in the design and implementation of this policy set include:

- How to structure the voluntary targets and trigger mechanism to provide the right amount of incentive to market actors while also achieving the state greenhouse gas and renewable energy goals.
- Voluntary carve-outs could be established with or across sectors, similar to the TREES structure. Whether failure to meet a carve-out target would force the trigger provisions is an open question.
- Allocation of limited carbon tax revenue to the correct programs to best address market challenges would require a flexible and informed priority-setting process that also respects the value of program stability and predictability.
- In the event that the targets are not met, many of the questions or implications of the TREES policy set could apply in the relevant sector.

5.5 Sector-specific policies

The fourth policy set the Department identified for analysis consists of sector-specific policies, each tailored to address a known challenge or market failure within a given portion of the state's energy economy. The policies within this set could work in an integrated and comprehensive manner to drive the clean energy transition, but there would be no single, overarching policy structure as in the previous three policy sets. This reflects the opinion, expressed by some stakeholders, that each sector is unique and may best be addressed by tailored policies. These policies might also be identified as complements to the three policy sets described above to address market failures not addressed by those overarching policy structures.

The set of polices the Department selected for analysis includes:

- Electric supply governed by a Renewable Portfolio Standard (or potentially by renewable energy planning targets of the sort currently established in 30 V.S.A. §8005).
- Continue energy efficiency utility structure for currently regulated fuels.
- Innovation in regulated utility revenue and rate making models to allow and incent utilities to invest in promotion of fuel switching, distributed generation, and development of financing tools.
- Establish energy efficiency obligations on all heating fuel suppliers, for which dealers could procure efficiency (in a manner similar to the TREES discussed above) or pay an alternative compliance payment. The compliance payment would be used to fund thermal efficiency programs. An open question is whether demonstrated use of renewable fuels could be used as a method of compliance (in which case this is a clean energy obligation, rather than an energy efficiency obligation).
- Transportation funding based on vehicle miles travelled (VMT) and vehicle weight, with increased funding support for modes other than single-occupancy motor vehicles in the light-duty market and other than trucks in the heavy-duty market. This funding mechanism preserves an incentive to drive less even in the face of the reduced marginal cost of driving that comes from the adoption of more efficient and electric vehicles. A "utility" model of transportation infrastructure funding, in which per-mile rates are set to meet known revenue requirements, could be deployed here.
- Shape the vehicle purchase decision through use of a "feebate" purchase and use tax structure that requires payment of more tax on less efficient vehicles; and serves as a rebate for purchase of more fuel efficient vehicles Alternatively, or in addition, adjust the gasoline and diesel tax structure to lower the relative price of liquid biofuels for transportation, compared with fossil fuels.
- Strengthen land use policy to drive growth in designated areas and restrict it elsewhere.

Practical implications and open questions in the design and implementation of this policy set include:

- Is the Vermont market of unregulated fuel dealers large and sophisticated enough to support the regulatory infrastructure surrounding energy efficiency obligations? If all firms would choose to pay the alternative compliance payment, it may be more straightforward to raise funds via an excise tax and directly fund independent efficiency programs.

- The Framing Report (pages 71-72) identifies a number of questions regarding the design of a renewable portfolio standard; each would need to be answered before such a policy was adopted.
- One additional idea raised by stakeholders was to cover only portions of the electric utility sales with an RPS (such as requiring that the electricity used for transportation be 100% renewable, or requiring only sales to particular end-use classes to meet the renewable percentage requirements). The benefits (price stability) and costs (potential increased energy costs) should flow through to the affected sectors.
- VMT-based transportation funding may be better adopted at a regional or national level than in a Vermont-only context, due to the large number of Vermonters who drive in other states (and pay those state's gas taxes), and the large number of out-of-state cars and trucks on Vermont roads.

5.6 New England regional focus

The fifth policy set the Department identified for analysis takes as its starting point the notion that policies adopted at the regional level or coordinated with our neighboring states may be more effective than policies adopted by a single state. It also reflects understanding that the six New England states are served by an electric grid with a single regional operator and markets, and that biomass is commonly used in a state different from the state in which it is harvested. There is also a potential that the combined market power of New England or Northeast states (and potentially including neighboring Canadian provinces) can move markets and bring new technologies to scale, in a way that no single state can do. Common policies across state lines would also level the playing field for many firms that compete in the regional market.

The set of polices the Department selected for analysis in this set includes:

- An electric supply renewable portfolio standard designed to match and pace with the rest of the region. Establish common regional definitions for eligibility of different kinds of renewable resources, including biomass.
- States have common and synchronous adoption of VMT-based transportation funding that encourages more efficient vehicle purchase and raises revenues for alternative modes.
- Establish and maintain synchronized regional standards for liquid biofuels/bioheat, as well as common programmatic promotion of pellets and/or heat pumps.
- Establish regional biomass harvesting and procurement standards, as well as pellet standards.
- Each state continues adoption of the California low-motor vehicle emission standards.
- Common vehicle purchase incentive structures, such as for electric light duty vehicles or natural gas heavy duty fleet vehicles.
- Establish a regional low carbon fuels standard, requiring increased availability and utilization of advanced biofuels, natural gas, and electricity for transportation.

- Plan and coordinate regional infrastructure for EVs (such as travel corridors and shared payment methods like EZ Pass), as well as for rail service and freight movement.
- Programmatic funding from a common regional tax or fee structure, such as through expansion of the Regional Greenhouse Gas Initiative (RGGI) to cover fossil fuel use outside of the electricity sector, and the associated revenue.

Practical implications and open questions in the design and implementation of this policy set include:

- How to establish and maintain a common regional framework and emission/renewable energy goals across multiple sectors in the face of political pressures that may vary over time and between states.
- Whether the policies adopted region-wide would be sufficient to reduce Vermont's emissions, and increase the use of renewable energy in Vermont, at the pace necessary to meet the State's goals.

6 Technology pathways

Technologies deployed as the state achieves its greenhouse gas and renewable energy goals can be broadly described as falling into demand-side and supply-side technologies. The electric grid serves as an intermediary between demand and supply and has its own potential for technological innovations; it is incorporated into both the demand and supply discussions below. This section describes the understanding of many of these technologies that the Department has constructed during the Total Energy Study process. It concludes with a short discussion of the analysis the Department is conducting to understand the breadth of the range of energy options (particularly energy supply options) available to the state that also allow the state to meet its targets.

The 2011 Comprehensive Energy Plan describes the context and opportunities in energy demand and supply in much greater depth than is included here. The reader is asked to refer back to that plan; this report tells only a small portion of the story, and focuses on new insights gleaned during this study process.

6.1 Energy demand

Reducing the state's total energy demand will be an essential component of all technology pathways that achieve the State's greenhouse gas and renewable energy goals. The Department assumes that Vermont will maintain its commitment, established in 30 V.S.A. §202a(2), to the principles of least-cost integrated planning, applied across the energy sector. Pursing least cost service requires ambitious and extensive efforts on reducing and controlling energy demand, as well as in capturing the potential to meet needs with new modes or fuels.

6.1.1 Efficiency & conservation

Energy efficiency is defined as actions taken to reduce the energy used to deliver a set amount of energy service. For example, an LED light bulb delivers the same service (light) at a fraction of the energy demand of an incandescent bulb. Energy conservation, on the other hand, denotes reductions in energy use that are related to reductions in the energy service provided. For example, turning down the thermostat in the winter saves energy but also reduces the service provided (in this case, comfort). Assigning any given action to be either 100% efficiency or 100% conservation, however, is often not possible. For example, using a bus to get to work instead of a personal vehicle uses less energy, but may also provide less service (in that the trip cannot be undertaken at the exact time of the rider's choosing, and may take a different amount of time). Reconceiving energy services can result in even greater savings – teleworking, for example, might eliminate the need for the trip to work at all.

The preliminary quantitative analysis conducted by the Department has shown that reducing the total amount energy consumed in Vermont (or in electric generators serving Vermont) will be key to achieving the State's goals. The more complete to be completed in the spring of 2014 will likely confirm this, and is expected to reveal a need to reduce the state's total energy use by factor of two or more by 2050. This would imply a dramatic increase in the energy productivity of the state's economy.

In this context, there is great potential to deploy a range of "technologies," very broadly defined, that can reduce energy use while maintaining or increasing quality of life. These technologies include those mentioned above, and also:

- Compact development of towns and growth centers
- Infrastructure for alternative transportation modes, including transit, walking, and biking
- Building weatherization, especially air sealing and insulation
- Development or adoption of new industrial processes that produce the same or increased output for a given amount of energy input

This list is by no means exhaustive; its intention is to incorporate disparate deployment decisions into the rubric of energy efficiency and conservation, so they contribute to the development of comprehensive and integrated solutions.

6.1.2 Load shifting and demand response

Energy flow and consumption depends on a number of shared infrastructures, including the electric grid, fuel pipelines, road and rail transportation networks, and many of the state's buildings themselves. Increasing the productivity of energy use can be accomplished in part by using these shared infrastructures more effectively and completely. Greater integration of data and information technology into the management and use of these infrastructures is a promising tool to create this increase in productivity, when accompanied by the technologies that allow utilization of data and control systems.

Grid modernization (the so-called "smart grid") provides a key example of the potential of this approach. The electric grid is designed to be able to provide a peak level of service for only a few hours per year, at times of greatest load. By better understanding the flows of energy on the grid, and then shifting and shaping those flows (even without using less energy), we can: put more energy through existing wires and transformers; avoid the need to pay for upgrades to the grid; and better integrate variable electric generators into the grid. Better control over electricity use will allow such use to be more elastic, in the economic sense – better able to respond to price signals. This, in turn, makes price signals (like those discussed in the context of market failures) more effective at shaping market decisions and driving societally-beneficial outcomes.

Regulatory flexibility and innovation will be necessary to harnessing and appropriately shaping these technological developments. Privacy concerns regarding energy use data and security concerns regarding control systems will need to be carefully and completely addressed. Where shared infrastructures result in rate-regulated monopolies, rate design will be a primary tool.

This same model of harnessing information technology could be expanded to the use of other shared infrastructure, or enable the sharing of current unshared infrastructure. This extends from telework enabling each of several firms to use the same physical office space, to car sharing networks, and pop-up stores.

6.1.3 Fuel and mode switching

One way to reduce energy use overall is to find new ways, potentially using different fuels, to provide similar energy services. These switches may not provide the same service, and so they are prime examples of the kind of actions that are neither perfectly described as efficiency or as conservation (such as the bus ridership discussed previously). The most common examples are:

- Use of alternative modes of transportation,
- Switching fuels for vehicles (e.g. to biofuels or electricity), and
- Switching fuels for heat (e.g. to electric heat pumps or wood pellets).

Transitions between modes and between fuels have historically been driven by changes in technology, by market prices, and by public policy. These three forces will also shape how these transitions are adopted to help Vermont meet its goals. Public policy innovation and flexibility will be required to adapt existing structures, including regulatory and tax structures, to new modes or fuels. Each of these transitions involves a broad array of interests. Transportation, in particular, involves an array of interests that have not historically been at the table regarding energy use. In contrast to the structure of the 2011 Comprehensive Energy Plan, in the future it will not make sense to think of "electric," "thermal," and "transportation" as three distinct fields.

The fuel transitions garnering the most attention in Vermont now are driven by advances in technology: cold-climate air-to-air heat pumps and electric vehicles. These technologies have the potential to dramatically lower the energy required to heat Vermont homes and move Vermonters around the state. Both are new technologies, rapidly evolving, and causing disruption in the marketplace. They offer the potential for dramatic reductions in the cost of heat and transportation without changes in the cost of the underlying fuel. If these two technologies are adopted at scale (tens to thousands to hundreds of thousands of units in the state), they will have impacts on the way the grid is operated and built. We do, however, have time to study and examine these technologies as their performance is proven and they are adopted at greater scale before they have large impacts on the grid (or, in the case of electric vehicles, on transportation funding). If either or both of these technologies deliver on their promise, Vermont will see a significant economic benefit due to reductions in expenditures on fuel, and environmental benefit due to the displacement of fossil fuel combustion with electricity (provided the electricity is supplied by predominantly renewable sources). At this time, public policy should be aware and supportive of these technologies, given their potential, however the extent of their current and potential impacts needs to be better understood. The example of these technologies is one of the reasons that the Department selected responsiveness to technology change as one of the criteria for policy evaluation.

The Department examined the extent of overall increased electric use if heat pumps and electric vehicles were adopted universally between now and 2050, and the resulting impacts on infrastructure. The approximate range of gross electric use increases in the context of these new end uses is between 20% and 50%. That is, the state is unlikely to use more than 50% more electricity in 2050 than we do today; a more likely figure would be an increase of 30%, even if the state's path forward skews heavily in the direction of electrification rather than utilization of biomass-derived fuels. The extent of increased electric use relative to current totals depends on several factors: the extent of electric efficiency implemented in other currently-electric end-uses; the extent of weatherization applied to buildings at the time of or following installation of heat pumps; and whether the low marginal cost of driving electric or other highly efficient vehicles hampers efforts to reduce VMT.

Given the state's current load shape and grid capacity utilization, and assuming that demand does not become elastic enough to entirely flatten the state's load profile, this would result in some moderate increase in the state's peak electric demand. It is likely, however, that the peak would increase by significantly less than the energy increase (that is, significantly less than 30%). That is because electric vehicles are likely to be a relatively elastic demand, predominantly charged late at night. It may mean, however, that Vermont returns to being a winter-peaking state, with heating load coinciding with the current winter peak. The same infrastructure can support a higher winter peak than summer (due to thermal load constraints), but it is likely that mass deployment of these two technologies would result in need for some new grid infrastructure -- not for a dramatic overhaul of the grid. Given the multi-decadal nature of this shift, careful planning could control this cost.

One additional kind of fuel or mode switch for discussion is the use of combined heat and power (CHP). (This technology also serves as a bridge between demand and supply.) In this case, what would have been a waste product (excess heat) is captured and utilized, increasing overall energy efficiency. In heat-led CHP, electricity is a by-product generated using the excess high-quality heat from a process that uses most of the energy as heat. In electric-led CHP, the waste heat from an electric generator is captured and utilized. Heat-led CHP is significantly more efficient than electric-led CHP, but it is harder to find 12-month-per-year heat-led applications in Vermont.

Combined heat and power could be implemented in concert with district heating systems, although the seasonality of building heat requirements may make the integration of electric generation impractical or uneconomic. Even without electric generation, however, district heat is another kind of mode switch for energy use. Rather than have each building in a downtown or campus provide its own heat, a centralized facility, taking advantage of economies of scale, can provide heat for the district. Biomass and biogas heat, which benefit from scale and centralized fuel handling, are particularly amenable to this mode/fuel switch.

6.2 Energy supply

Vermont's aspires to meet 90% of its energy demand in 2050 using renewable resources. This section addresses the potential sources of that energy, and includes some discussion of the likely composition of the 10% of energy use that is not renewable (and the 25% of 1990-level greenhouse gas emissions remaining).

The five renewable primary resources available to Vermont are solar, wind, hydropower, methane capture, and biomass. Each of these can be used to generate electricity; solar is also used for heat and light, while biomass and methane capture are also used to produce fuels for heat and/or transportation. These fuels are discussed in great detail in the 2011 Comprehensive Energy Plan.

Vermont's biomass resource is extensive, but also limited. Sustainably harvested low-grade wood for energy use has the potential to both improve the quality of the state's forests (thus increasing the forest resource for non-energy applications), and improve the economy. There is also significant, but less well understood, potential to harness the state's agricultural resources for energy crops (such as perennial grasses) or use agricultural wastes (such as manure) on a more extensive scale for both electricity and heat. Food and other organic wastes could also have energy implications in the context of Act 148's coming restrictions on organic materials in landfills.

When considering combustion of biological fuels in particular (but also fossil fuels), the efficiency of combustion and utilization is a key consideration. Greater efficiency is essential to make limited resources stretch to meet the state's needs (in the case of biomass); for fossil fuels greater efficiency minimizes the greenhouse gas emissions per unit of energy service delivered. Different types of application have different efficiency, and the state should prioritize use of combustible fuels in this order: heat-led combined heat and power (CHP); heating only; transportation; electricity-led CHP; and electricity only.

In considering future electric supply portfolios, in the context of meeting most of the state's non-electric energy use with biologically derived resources, the Department examined the question of the scale of resources appropriate to meet the need. Future electric portfolios will depend on extensive build-out of one or more types of resources, including likely increases in each of the kinds of renewable electric generation that currently serve Vermont. Given Vermont's resources, accessing necessary resources will require either import (especially if the state were to pursue extensive hydroelectric power) or the construction of some generation resources at what is commonly referred to as "utility scale" (generation in the tens of MW or larger per facility).

When Vermont achieves its goal of 90% renewable energy across all sectors, it will still get 10% of its energy from fossil fuel and/or nuclear sources. Stakeholders have assisted the Department in identifying areas for which renewable resources are more difficult to integrate. These are the most likely areas to draw upon this remaining portion.

- Natural gas or oil electric generators needed to maintain grid balance and stability on a moment-by-moment basis (as discussed above). The extent to which these generators are necessary depends on the extent to which biomass or hydroelectric resources can be controlled in a similar fashion, the availability of electric energy storage technologies, and the elasticity of electric demand.

- Heavy-duty transportation and machinery require energy densities beyond that available with existing battery energy storage technologies. Primary options beyond fossil diesel fuel are biodiesel and natural gas. Vermont does not have the market pull to direct this market toward one or the other of these options; at the moment it appears there is significant market interest in natural gas for long-distance trucking; natural gas is already in use by several heavy-duty fleets in Vermont.
- Liquid and solid biofuels require some amount of energy to produce. Some of this energy is likely to be fossil fuel energy, particularly for liquid fuels imported to Vermont from states that lag behind Vermont's renewable energy mix.
- Industrial process uses of natural gas (and other specialized fuels) can be substituted to some extent by biogas or renewable natural gas, but supply of such alternatives is unlikely to meet demand. The desire to maintain competitiveness in the state's manufacturing sector will likely drive expansion of natural gas accessibility (via pipeline or truck). Even if competing jurisdictions share Vermont's greenhouse gas and renewable energy trajectory, supply limitations of alternatives that can meet the demands of some industrial processes will restrict the sector's ability to meet 90% of its energy needs with renewable sources.

6.3 Variation among possible paths forward

Vermont's greenhouse gas and renewable energy targets are aggressive. Concerted effort will be required across all sectors in order to achieve them. It remains an open question, however, the breadth of the range of technology deployment pathways that remain available for Vermont to choose at reasonable cost. Reductions in energy demand will be essential to achieving the State's goals, and greater energy demand reductions will increase the flexibility to choose different energy supply options. Two primary axes of variation among energy supply pathways emerged in our research and stakeholder conversations:

1) Scale: small scale/local/distributed versus larger/perhaps out-of-state
2) Fuel mix: Electrification versus the direct use of biomass. Of the four primary sources of renewable energy (wind, water, sun, and biomass), only biomass can be used directly for heating and transportation. All can generate electricity.[12]

As part of its analysis, the Department will explore four technology pathways that span the two dimensions (scale and fuel mix) discussed above. Each pathway selects one answer to each of the two questions inherent in the two dimensions: 1) More local/small scale or more large/potentially imported? 2) More direct use of biomass, or more electrification? By evaluating both the costs and benefits of

[12] The question of biomass versus electrification also has feedback implications for the state's energy demand because electrical end-use technologies (particularly heat pumps and electric vehicles) can be much more efficient than their combustion-based alternatives. Overall energy demand implications also depend on how the electricity is generated.

these four pathways, the Department hopes to learn the size and scope of the remaining options facing Vermont that can be achieved with acceptable costs and benefits.

The technology pathway the state follows, with likely variation in the distribution along both of these axes over time, will have a significant impact on both the state's net cost of infrastructure and fuel and the economic benefits that flow to the state as a result of capital flows into and out of the state. For example, smaller-scale electric generators are likely to be more expensive than larger (due to the lack of economies of scale), and are also more likely to be in Vermont as opposed to out. Solid biomass is likely to be sourced in Vermont or close by, while liquid biomass (unless produced from in-state agricultural products) is more likely to come from out of state. The interaction of these two effects, in the context of increased efficiency reducing capital outflows for the purchase of fossil fuel, will shape the net economic benefit accruing to the state as a result of the clean energy transition. The Department's further analysis seeks to identify optimal pathways, recognizing that the definition of "optimal" may vary according to different perspectives, in terms of both total cost and benefit and net economic impact on the state.

7 Next steps

This report serves as a snapshot of the status and interim results of an ongoing research and analysis project, which will be completed in the summer of 2014. As such, it raises questions for which it does not provide answers. The Department will continue to work with its sister Agencies and Departments, as well as with the public, legislators, and other stakeholders, to expand and refine analysis of policies and technologies Vermont might pursue in service of greenhouse gas emissions reduction and increased use of renewable energy.

The Department welcomes comments on this report, or the TES process in general, through January 22, 2014. Comments may be submitted electronically to PSD.TotalEnergy@state.vt.us.

The Department plans to release the results of additional analysis during 2014, with additional opportunities for comment and public engagement. A Total Energy Study Final Report will be issued in the summer of 2014. Please refer to the Total Energy Study webpage throughout the spring for updates.

ENERGY POLICY OPTIONS FOR VERMONT

Technologies and Policies to Achieve Vermont's Greenhouse Gas and Renewable Energy Goals

PREPARED BY
DUNSKY ENERGY CONSULTING

with the collaboration of Sustainable Energy Economics, KanORS-EMR Consultants, Grasteu Associates Inc., and Forward Thinking Consultants LLC

PREPARED FOR
VERMONT PUBLIC SERVICE DEPARTMENT

June 23rd, 2014 – FINAL REPORT

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Dunsky Energy Consulting remains solely responsible for any errors or omissions in this report.

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EXECUTIVE SUMMARY

INTRODUCTION

Responding to the publication of the 2011 Comprehensive Energy Plan, which called for a Total Energy Study (TES), the Vermont Legislature passed Act 170 of 2012 (modified by Act 89 of 2013), requiring the Vermont Public Service Department (PSD) to conduct this study. The purpose of the TES is to identify the most promising policy and technology pathways to reach Vermont's renewable energy and greenhouse gas (GHG) reduction goals. The TES is a multi-phased process that began in January 2013 and has involved decision-makers, experts and the general public. The TES results will inform the next iteration of Vermont's Comprehensive Energy Plan, due to be released in late 2015.

THE TOTAL ENERGY STUDY: POLICY AND TECHNOLOGY MODELING

This report describes the energy modeling phase of the TES. It begins by describing the process by which the PSD, in close collaboration with the Dunsky Energy Consulting team, defined an array of twenty future technology and policy scenarios, and subsequently selected three scenarios for comprehensive analysis. Quantitative analysis was conducted using the Framework for Analysis of Climate-Energy-Technology Systems (FACETS) energy system optimization model. FACETS was used to construct a Business as Usual (BAU) scenario, projecting Vermont's energy production and consumption (and associated emissions) in the absence of additional climate and energy policies. It was then used to simulate how the energy system would evolve using different policy mechanisms designed to help achieve the State's long-term goals.

These models allow us to understand how each policy approach would impact the adoption of a broad array of technologies and practices – including heating and cooling equipment, vehicle types and usage, fuel types, and other energy-consuming technologies – across all sectors of the State's economy. The analysis accounts for Vermont's reasonably-available resources, as well as available technologies to meet consumers' needs.[1] This report discusses how these scenarios were built, the modeling results, and the conclusions that can be drawn from them.

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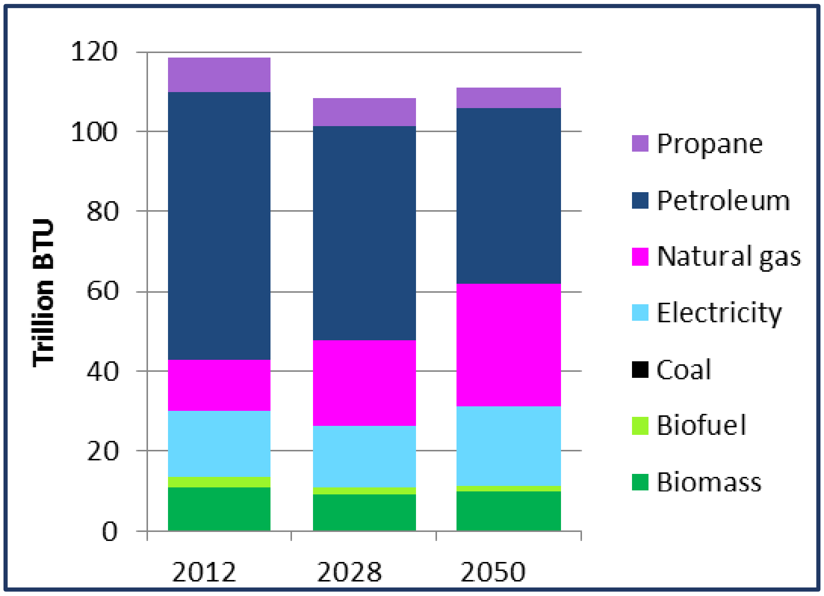
[1] We note that transportation modal switching and land use policies (e.g. smart growth) were not modeled; due to data limitations, analysis of the industrial sector – a very small portion of the state's energy use – was also limited.

BUSINESS-AS-USUAL (BAU)

The first step in the modeling process is to construct a Business as usual (BAU) scenario that represents the evolution of the current Vermont energy system, assuming no new policies directed at renewable energy or GHG emissions reductions. As shown in Fig. ES-1 below, the total amount of energy consumed annually in Vermont is projected to decrease slightly from 2012 to 2050, due to greater efficiency of home heating, lighting, and other devices, as well as the new federal light-duty vehicle CAFE standards, which require nearly a doubling of new vehicle efficiencies over the coming decades.

Fig. ES-1: Vermont Energy Consumption 2012-2050 – Business As Usual (BAU) Scenario



Along with this decrease in total energy consumption, Vermont's energy-related greenhouse gas emissions are projected to decrease by about 10% between 2012 and 2050.

Despite this slight reduction in energy usage and carbon emissions, achieving Vermont's long-term goals – a 75% reduction in GHG emissions and 90% renewable energy content – will require far more aggressive changes to the State's energy systems.

POLICY OPTIONS FOR MEETING VERMONT'S STATEWIDE GOALS

Vermont has established policy goals of reducing emissions of greenhouse gases from 1990 levels by 50% by 2028, and by 75% by 2050, in addition to obtaining 90% of all energy from renewable resources by that same year.[2,3] The Dunsky Team's analysis shows that these goals are technically achievable under each of the three potential policy approaches we modelled:

1. **Carbon Tax Shift:** a revenue-neutral tax[4] on greenhouse gases emitted from energy resources across all sectors, to be offset by a corresponding tax reduction in other areas of the economy (e.g. reductions in income, sales and use, corporate, and/or other taxes)

2. **TREES Basic:** The Total Renewable and Energy Efficiency Standard (TREES) applies a schedule, provided by the PSD, of mandatory shares of total energy consumption derived from either renewable energy or improved energy efficiency. Under this schedule, non-renewable energy ramps down linearly from current levels to 10% of Vermont's total energy needs by 2050. Energy distributors are required to demonstrate compliance with the standard, either by directly sourcing an escalating percentage of their supply from renewables or efficiency, or by purchasing renewable or efficiency "credits" from entities with amounts in excess of the standard.

3. **TREES Local:** The TREES Local policy begins with the TREES Basic described above, but further requires an increasing share of the renewable energy requirement to be sourced in-state.

As the reader can see, each of these policy options represents a different degree of flexibility – or inversely, of constraint – on how market actors can achieve the overall goals.

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[2] 10 V.S.A. § 578(a)

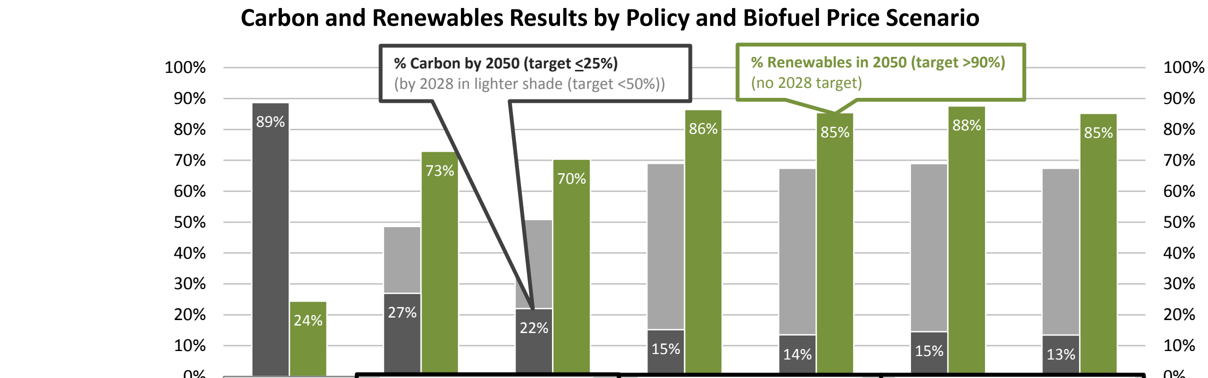
[3] State of Vermont, *2011 Comprehensive Energy Plan*.

[4] From Vermont Public Service Department, *Total Energy Study: Report to the Vermont General Assembly on Progress Toward a Total Energy Approach to Meeting the State's Greenhouse Gas and Renewable Energy Goals.* December 2013. "Creation of an economy-wide carbon tax in the context of tax reform, maintaining at or near revenue neutrality for the State. In this option, other taxes are cut by an amount equal to or close to the amount of revenue raised by the carbon tax. This carbon tax has the effect of sending a price signal much closer to the societal cost of emissions incurred, addressing the market failure of the mismatch between prices and costs."

RESULTS

Fig. ES-2, below, presents an overview of the anticipated impacts of each policy option ("TaxSHIFT" "TREES Basic", and "TREES Local"), for two scenarios regarding future biofuels prices ("LoBio$" and "HiBio$").

Fig. ES-2: Policy Options and Projected Results



	BAU	TaxSHIFT (LoBio$)	TaxSHIFT (HiBio$)	TREES Basic (LoBio$)	TREES Basic (HiBio)	TREES Local (LoBio$)	TREES Local (HiBio$)
2028 CO2 Emissions	87%	49%	51%	69%	67%	69%	67%
2050 Renewable content	24%	73%	70%	86%	85%	88%	85%
2050 CO2 Emissions	89%	27%	22%	15%	14%	15%	13%

The ability of the energy system to change is highly dependent upon the assumed evolution of liquid biofuel prices in the future. For this reason, we conducted a sensitivity analysis around two such price scenarios. As explained further in this report, the reader should note that in order to account for these sensitivities, we adjusted the level of the carbon tax under the TaxSHIFT policy according to the assumed price of biofuels. As such, the level of carbon tax increases far more rapidly under the "HiBio$" scenario than under the "LoBio$" one, in order to meet the State's carbon reduction goals.

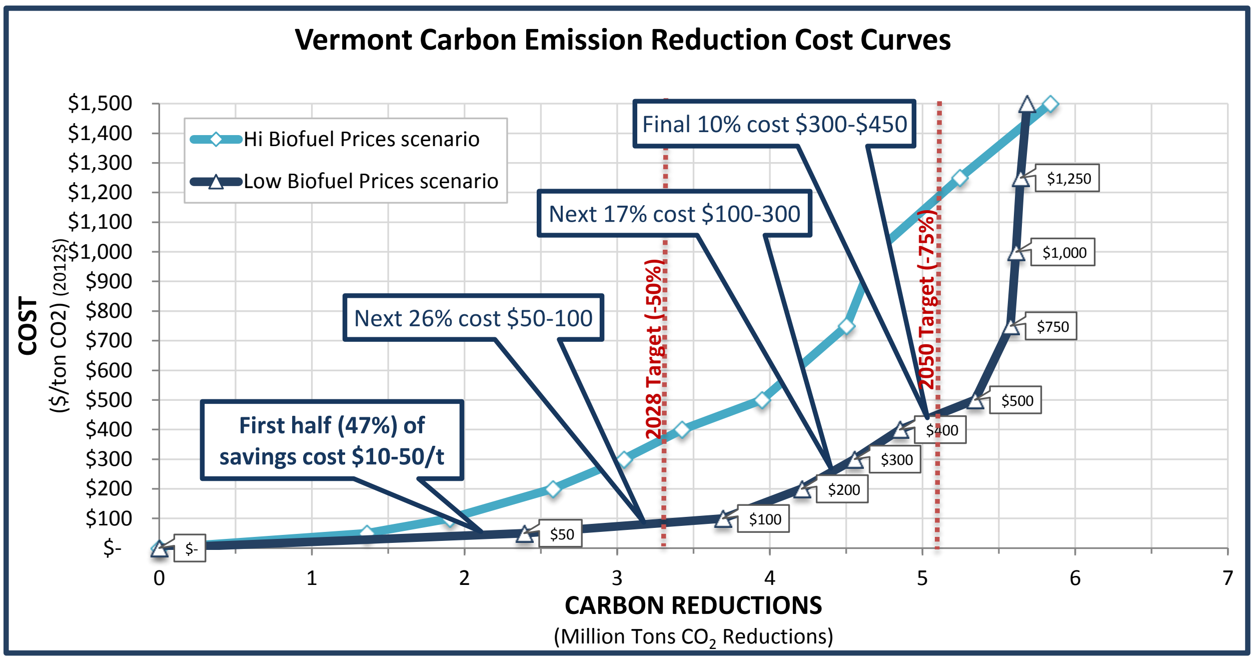
The Dunsky Team's analysis finds that achieving the goal of a 75% reduction in Vermont's greenhouse gas emissions by 2050 is achievable under all three policy options, and at a moderate cost. That said, each option evokes a trade-off regarding the other targets. For example, a Carbon Tax Shift also achieves the mid-term GHG target of 50% by 2028, but falls short of the 2050 renewable energy target. Inversely, both TREES policies achieve the long-term GHG target *and renewable energy* targets, but fall short of the mid-term (2028) GHG reductions target.

DISCUSSION OF COSTS

Results show that achieving these significant targets comes at a moderate cost: depending on the policy option as well as assumptions regarding future biofuel prices, achieving the targets will add between 2.2% and 5.5% to the direct cost of meeting Vermonters' energy needs. While assumptions around liquid biofuels prices are responsible for the bulk of the cost range, the choice of policy approach also plays a role, with a carbon tax being generally more economically efficient than either TREES standard.

Figure ES-3, below, provides a "cost curve" of emissions reductions. As the reader will see, assuming low biofuel costs, nearly half of the long-run goal can be achieved at costs of between \$10 and \$50 per ton of CO_2e. The marginal cost of emissions reductions increases thereafter, rising to approximately \$450 for the final ton needed to achieve the 2050 target. Given how much of the target is available at relatively low cost, the *average* cost of savings over the full 38-year period is limited to approx. \$40 per ton of CO_2.

Fig. ES-3: Cost Curves for Carbon Emissions Reductions in Vermont



Under the low biofuel price scenario, the first 3.7 MT, i.e. nearly three-quarters of the 2050 emissions reduction target, and all of the 2028 target, can be achieved at a cost of between \$10 and \$100 per ton.

Vermont currently imports most of the energy consumed in the state. An unassessed benefit of achieving the statewide goals will likely be to shift a significant share of the energy production and associated economic activity from imports to Vermont-based sources.[5] While The Dunsky team's analysis was limited to Vermont's energy system, accounting for the macroeconomic impacts of each option should be a consideration in choosing among policy options. We understand that the PSD will be using the results presented herein to assess their likely impact on key macroeconomic indices, such as employment and Gross State Product, as part of the broader Total Energy Study report package.

Finally, another benefit of these policies is a potential improvement in air quality, given a likely reduction in air emissions associated with the electrification of vehicles and buildings, and/or from a shift to cleaner-burning fuels and technologies. These improvements, and associated health and economic benefits, were not modelled as part of this report.

CONCLUSION

While each policy option – in addition to sensitivities around liquid biofuel prices – will generate different energy mixes, all cases revolve around three "pillars" upon which Vermont's energy transformation will be built:

1. *Efficiency*: increased energy efficiency and conservation, beyond current projections.
2. *Fuel Switching*: accelerated adoption of liquid biofuels and electricity in vehicles, and of woody biomass and electricity in buildings; and
3. *Clean Power*: growth in renewable power generation to support electrification.

The Dunsky Team's analysis suggests that the transformation needed to achieve Vermont's greenhouse gas emissions reduction and renewable energy goals are ambitious but, to a significant extent, achievable. The Carbon Tax Shift approach could be expected to hit the State's 2028 *and* 2050 GHG reduction targets, albeit falling short of the renewable energy goals. Meanwhile, the TREES policies would achieve Vermont's long-term GHG *and* renewable energy goals (significantly exceeding the former), while falling short of the 2028 GHG target.

Furthermore, the cost of achieving these goals appears moderate. Under the low biofuel price scenario, the cost of meeting the state's energy needs increases by a modest 2.2% to 3.3%. Under the high biofuel price scenario, costs increase by 4.5% to 5.5%. Under all cases, the added cost is lower than the assumed cost of inaction. Finally, this analysis does not account for other benefits to the state, including those associated with improved commercial balances from increased in-state economic

[5] Depending on the policies chosen, the share of in-state supply can be expected to supply up to 60% of all domestic consumption by the end of the period (under the TREES-Local option).

activity, as well as from potentially improved air quality and associated health and infrastructure benefits.

In choosing the preferred policy approach, policymakers may need to choose between the tradeoffs identified previously, namely which targets to prioritize (long-term renewable energy vs. mid-term carbon goals), and the extent to which the presumed macroeconomic benefits of increased in-state sourcing are worth the additional cost of the TREES policy options. Other considerations – around administrative burden, risks, cost, compliance, and even political feasibility – may be equally as important.

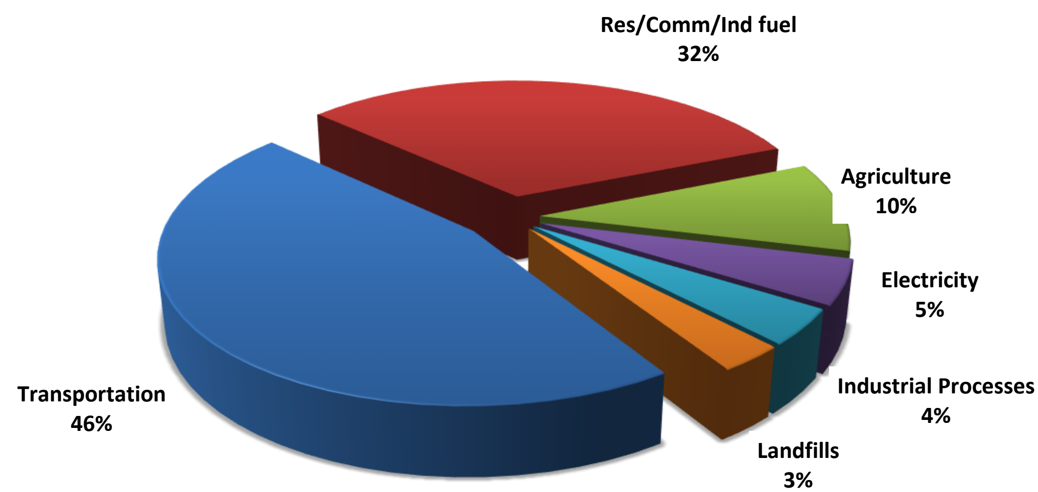
Regardless of which approach is pursued, achieving the goals will clearly require a bold – and sustained – policy commitment. While we provide recommendations regarding next steps to be undertaken, most critically is the need for a more detailed feasibility assessment of the two primary options: a tax shift from other areas of the economy toward carbon, or a renewable energy standard that applies to all fuels and sectors, including transportation.

INTRODUCTION

VERMONT'S CHALLENGE

Energy use accounts for 83% of Vermont's current greenhouse gas emissions. In fact, nearly half (46%) of Vermont's 2012 emissions came from energy used for transportation, and another third (32%) from fuels used to heat homes and businesses. By contrast, electricity generation is responsible for only 5% of emissions. Figure 1 below provides the full breakdown of greenhouse gas emissions by sector.

Figure 1: Vermont's 2012 Greenhouse Gas (GHG) Emissions Sources[6]



In response to the Comprehensive Energy Plan, in 2012 the Vermont State Legislature adopted Act 170 which, as later modified by Act 89 of 2013, requires the Public Service Department (PSD) to conduct a Total Energy Study of policies and funding mechanisms designed to achieve the state's greenhouse gas and renewable energy goals in an integrated and comprehensive manner.

Specifically, the Total Energy Study (TES) is designed to chart technically effective and economically feasible paths to an energy system that meets Vermont's energy goals:

- 50% reduction in greenhouse gas emissions (from 1990 levels) by 2028

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[6] Vermont Agency of Natural Resources, http://www.anr.state.vt.us/anr/climatechange/Vermont_Emissions.html

- 75% reductions in greenhouse gas emissions (from 1990 levels) by 2050, and
- 90% of all energy sourced from renewable resources by 2050.

Reducing Vermont's greenhouse gas emissions will require changes in the consumption patterns of multiple fuels across multiple sectors and end-uses. This new energy economy must also be capable of satisfying Vermonters' needs across the transportation, industrial, commercial and residential sectors for heating, lighting, mobility, and other services.

Some of the changes that will be needed for this transition have already begun, driven by technological innovation, market economics, and the existing policy environment. Energy efficiency is a proven, cost-effective energy resource for Vermont. The costs of some forms of renewable energy have fallen dramatically in recent years. These factors, combined with structural changes[7] to Vermont's economy, resulted in statewide greenhouse gas emissions in 2011 which were no higher than they were in 1990[8]. However, achieving a 75% reduction in greenhouse gases will require major changes to Vermont's current patterns of energy production, distribution, and usage. In terms of the 90% renewable energy goal, renewables currently (2012) supply only about 20 percent of Vermont's total energy consumption. Clearly, significant new policies are needed to drive Vermont's clean energy transition fast enough, and far enough, to meet the statewide goals.

SCOPE OF WORK

To assist in completing the TES, the Vermont Public Service Department (PSD) contracted the Dunsky Team to perform comprehensive modeling of alternate energy future policy scenarios for Vermont. This work is intended to help the Vermont Legislature, other policy makers, and the public chart a path to achieving Vermont's ambitious greenhouse gas mitigation and renewable energy goals.

The Dunsky team was tasked with defining, in close collaboration with the PSD, an array of twenty future technology and policy scenarios, and subsequently with modelling three of them using the Framework for Analysis of Climate-Energy-Technology Systems (FACETS[9]) optimization model. This report describes the process leading to the analysis, and then presents the results of the FACETS model – including the ability of each scenario to achieve Vermont's greenhouse gas and renewable energy goals. Finally, we discuss conclusions that can be drawn from model results. Please note that this study

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[7] For example, according to the US Energy Information Administration thousands of short tons of coal were still burned annually as fuel in Vermont until the end of the 20th century. This illustrates that it can take a long period of time for obsolete technologies to completely disappear from Vermont's energy economy. http://www.eia.gov/state/seds/data.cfm?incfile=/state/seds/sep_use/total/use_tot_VTa.html&sid=VT

[8] Vermont Greenhouse Gas Emissions Inventory Update 1990-2011; 12/2013; VT Agency of Natural Resources

[9] More information on the FACETS model is available at http://facets-model.com/.

considers only greenhouse gas emissions associated only with energy production, transportation, and consumption.

The long-term modeling of Vermont's energy economy described in this report was designed to present Vermonters with a state-of-the-art tool for evaluating different sustainable energy futures for the state, with a view to informing Vermont's policy choices going forward. It is intended to inform the next Vermont Comprehensive Energy Planning process.

PURPOSES OF THIS REPORT

The PSD is required by Act 170 of 2012, modified by Act 89 of 2013, to conduct a Total Energy Study of policies and funding mechanisms designed to achieve the state's greenhouse gas and renewable energy goals in an integrated and comprehensive manner. The TES has been a multi-phased process with Phase 1 beginning in January 2013 with the preparation of the "Policy Options for Achieving Vermont's Renewable Energy and Carbon Targets" Report"[10] and the solicitation of input from stakeholders via written comments, public hearings, and a series of focus groups through the balance of the year. The Dunsky Team's role began with Phase 2 of the TES and involved the assessment of the technology and policy scenarios identified in Phase 1, including in-depth modeling of three of those policy scenarios. This document describes the policy scenarios assessment process and presents the results of the energy modeling.

DIALOG WITH THE PSD, STAKEHOLDERS, AND CLIMATE CABINET

During the project, the Dunsky Team worked closely with the PSD to ensure cohesion with the State's objectives, and to ensure access to, and application of, the most current Vermont-specific energy data. PSD staff have been consistently available and engaged with each step of our work.

The TES is also designed to gather input from the public and interested stakeholders. As part of Phase 1, in August and September of 2013, the PSD held eleven stakeholder meetings on different topics related to the TES. In December of 2013 the PSD also solicited public input on a Legislative Report and provided the Dunsky Team with a summary of the comments received.

In February 2014, the PSD held a consultative session with the Governor's Climate Cabinet at which the Dunsky team was invited to review consideration of key issues as well as present initial assessment of

[10] Policy Options for Achieving Vermont's Renewable Energy and Carbon Targets (Prepared for the Vermont Department of Public Service), RAP, 2013, available at http://publicservice.vermont.gov/sites/psd/files/Pubs_Plans_Reports/TES/Total_Energy_Study_RFI_and_Framing_Report.pdf

the array of technology and policy options available to Vermont, and to discuss which policy scenarios would be modelled using the comprehensive FACETS tool. Following this session, the PSD provided the Dunsky team with direction regarding the specifics of the three policy scenarios retained for modelling.

HOW TO READ THIS REPORT

If Vermont takes no additional action to reach its statewide greenhouse gas and renewable energy goals, and economic growth follows historic trends, energy consumption per capita, total energy consumption, and total carbon dioxide emissions will all decrease from 2014 to 2050[11]. The energy intensity of the Vermont (and the national) economy, in terms of pounds of CO_2 per unit of economic output, has been gradually dropping for decades. With the turn of the 21st century, Vermont's absolute energy consumption appears to have turned a corner and now exhibits a negative growth rate — thanks in part to innovative state policies like the Energy Efficiency Utilities.

By itself, the projected decrease in emissions under a "business as usual" scenario[12] will not be nearly enough to meet Vermont's statewide goals by 2050. The new emissions projection needed to achieve Vermont's goals demands a new perspective on approaches to mitigating greenhouse gas emissions. Instead of trying to turn back the tide of rising energy use and emissions, the charge for policy makers is to figure out how to accelerate existing trends (a much more attractive and achievable prospect).

This report is rooted in a complex modelling exercise designed to assess how Vermont's energy system would evolve in reaction to various policy options. As with any effort to look forward in time, it should be considered as a source of directional, rather than descriptive information about potential energy futures for Vermont. We suggest that the reader focus on the relative, rather than the absolute, estimates of the differences between the policy scenarios discussed.

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[11] Annual Energy Outlook 2014 with projections to 2040, EIA, 4/2014

[12] A so called "Business as Usual Scenario (BAU)" or "baseline" estimates future greenhouse gas emissions if Vermont adopts no new policies aimed at reducing those emissions.

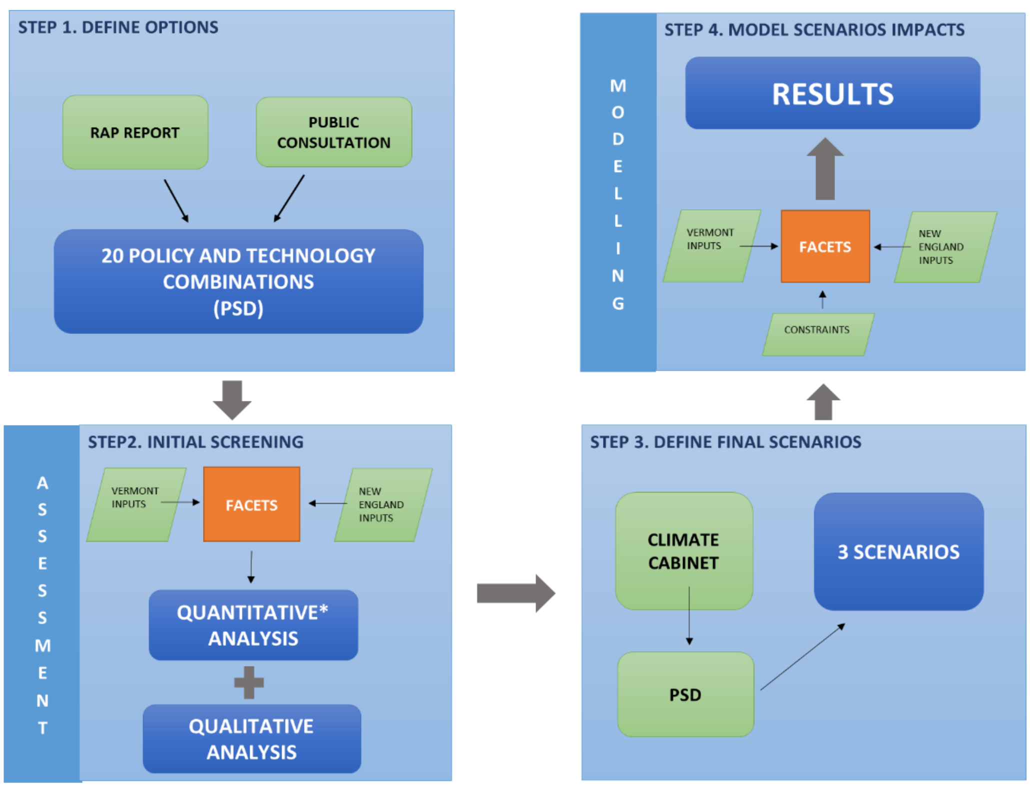
METHODOLOGY

The Dunsky Team set out to assist the PSD in narrowing the analytical focus from a broad range of potential future policy and technology pathways (called policy options in this report) to a limited number of most attractive options, and then to submit those to comprehensive analysis using the FACETS model. This report describes the process of narrowing the focus of the TES from twenty to three policy options, and discusses the results of the FACETS modelling of those final three.

We adopted a four-step process as illustrated in Figure 2:

1. Define the array of options
2. Conduct an initial assessment to screen options
3. Define a smaller set of three policy options for comprehensive energy and economic modelling
4. Conduct comprehensive modelling and describe the energy, greenhouse gas, and economic results associated with each policy scenario.

Figure 2: Summary TES Modeling Process



**Preliminary FACETS model runs*

Below we expand on the process undertaken for each of the four key steps.

MODELING VERMONT'S ENERGY ECONOMY IN THE FACETS MODEL

Reducing Vermont's GHG emissions will require changes in the consumption patterns of multiple fuels across multiple sectors and end-uses. To understand how this can best be achieved, sophisticated computer models like FACETS can be critical tools in addressing complex systems, and can help to answer questions such as:

- What are the best ways of achieving emissions reduction targets given the fuels and technologies currently available or potentially available in the future?
- Which fuels will need to be used more and which less, in order to achieve the targets?
- What penetration of established and innovative technologies into specific sectors of the economy will be necessary to reduce emissions to a desired target?
- How will measures undertaken in one sector impact the choices and costs available in other sectors?
- How much will it cost to effect these changes?
- What are the key risks Vermont faces in meetings its goals and managing the costs of energy system changes?

The Vermont FACETS Model

- *Supports optimization, not just simulation*
- *Allows for complex interactive effects*
- *Represents the entire energy economy of Vermont*
- *Is built on an extensive array of data, including significant Vermont-specific data*
- *Covers energy resources, technologies, and demand for useful energy services*
- *Contains over 20,000 combinations of technologies and commodities (e.g. light diesel consumption in heavy trucks)*
- *Includes 11,000 existing power plants, and hundreds of options for new plant types*
- *Allows several dozen options to meet each end use demand, including space heaters, lightbulbs, cars and trucks, among others*

The FACETS computer model is designed to answer questions like these on a system-wide basis. FACETS goes beyond merely simulating potential future options, and allows users to account for complex interactive effects and optimize for lowest total energy system cost. These capabilities serve the objectives of the TES project by allowing identification of the most cost-effective technology and policy combinations to meet energy service needs.

FACETS is based on the TIMES (The Integrated MARKAL-EFOM System) model generator.[13] A TIMES model represents the entire energy system of a country or region as a network, including all forms of energy extraction, transformation, distribution, end-uses, and trade. Each stage in the network has many different specific technologies available, each characterized by economic and technological parameters. The model also tracks greenhouse gas and criteria air pollutant emissions.

The model calculates through the network to find the least-cost options[14] for meeting all demands for useful energy services (e.g. vehicle-miles of transportation, BTUs of space heat, and so on). These end use service demands are exogenously specified in a business-as-usual scenario, driven by projections of population and economic activity. In policy options, where additional model constraints and/or taxes may be imposed to model new policies, energy service demands are elastic to their own prices, allowing for partial equilibrium adjustment to changes in the prices of each individual service. For example, people will drive more (or less) if the price of vehicle travel goes down (up) relative to baseline projections.

The model solves to minimize the net costs of the entire energy system, including investment costs, operation and maintenance costs, and the costs of resources and imported fuels, minus the incomes of exported fuels and the residual value of technologies at the end of the model horizon, in addition to any welfare losses due to endogenous demand reductions. Model outputs at each point in time include future investments in and activities of all technologies, including all fuel consumption and emissions, and the marginal prices of all fuels. Figure 3 summarizes the key model inputs and outputs. Additional information about FACETS can be found in Appendix A.

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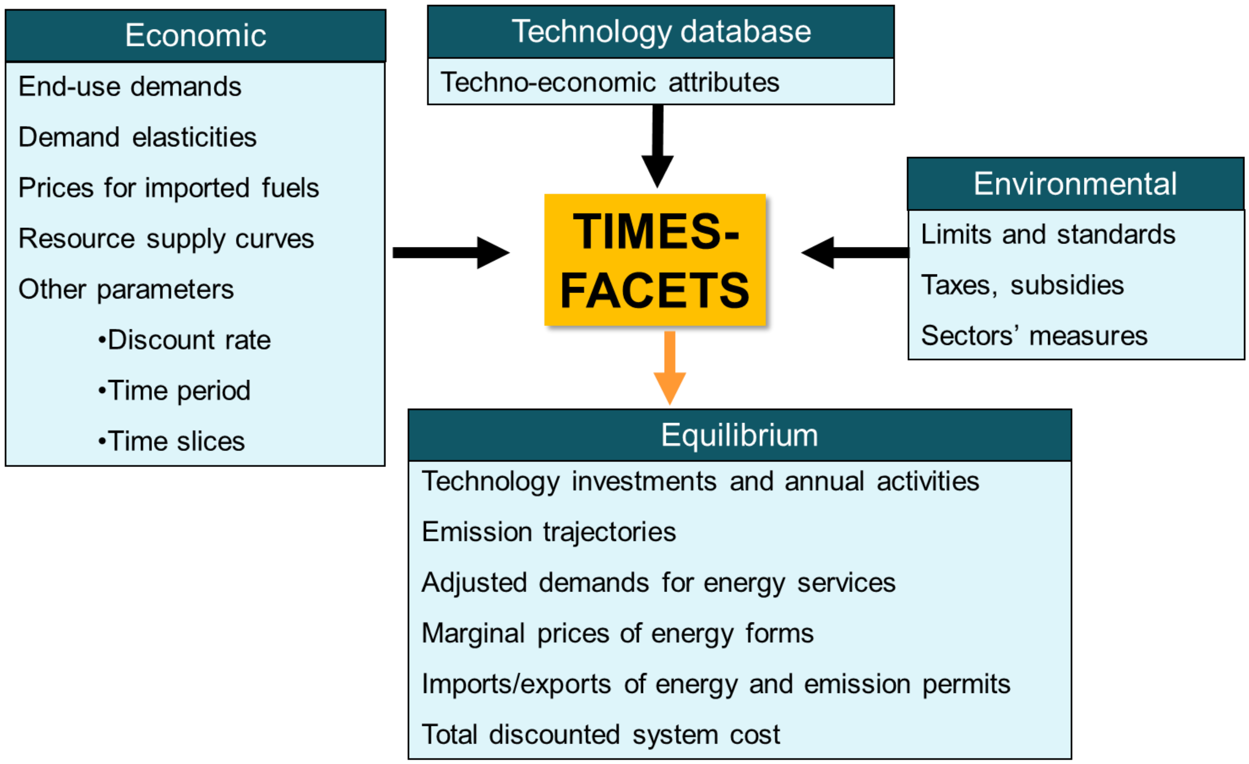
[13] Within the Energy Technology Systems Analysis Program of the International Energy Agency, MARKAL and TIMES models are currently used by more than 80 institutions in nearly 70 countries for various purposes including economic analysis of climate and energy policies.

[14] Technically, this corresponds to an assumption that *energy markets are under perfect competition*. A single optimization simulates market equilibrium by searching for the maximal net total producer plus consumer surplus or, equivalently, minimizing the net total cost of the energy system.

Figure 3: Vermont FACETS Inputs and Outputs



FACETS was originally developed as model of the entire energy economy of the United States, with demand disaggregation at the nine region census levels, and electricity production regionalized to the major US grids. For the TES project, the Dunsky Team extracted Vermont from its New England demand and electricity regions, using Vermont-specific population, energy consumption, and electricity capacity. For others, where aspects of Vermont's energy economy differed significantly from New England's, we augmented the FACETS database with other Vermont-specific data. The model was then run with Vermont embedded in the larger New England region, which in turn is embedded in the national energy system. Thus trade in electricity and other fuels takes place across state and regional borders.

The power of optimization energy computer models is the ability to keep track of a very large number of variables and their interactions over time, and thereby model complex systems like state or national energy systems. It is the Dunsky Team's intention that the Vermont's FACETS analysis provide useful insights into the complex interactions between energy, greenhouse gas emissions, and public policy in Vermont, and serve as a common reference for the next stage of Vermont's political engagement on meeting the State's renewable energy and greenhouse gas goals.

STEP 1: DEFINE OPTIONS

Prior to commencement of the Dunsky Team's work, the PSD retained the Regulatory Assistance Project (RAP) to outline options for the state to consider. The RAP Framing Report, published in June of 2013, provided a broad overview of available technologies and policies and was designed to facilitate discussions with stakeholders about the potential means to reach Vermont's greenhouse gas reduction and renewable energy goals.

In August and September of 2013, the PSD held eleven stakeholder meetings on different topics related to the TES. Based on the RAP report, the stakeholder sessions, and subsequent discussions with the Dunsky Team, the PSD defined twenty combinations of policy approaches and technology pathways that might contribute to meeting the statewide goals.

STEP 2: INITIAL SCREENING

The second phase of the TES process involved assessing the twenty policy and technology combinations with the objective of choosing three for full-scale computer modelling. This initial screening required a mix of both qualitative and quantitative analyses.

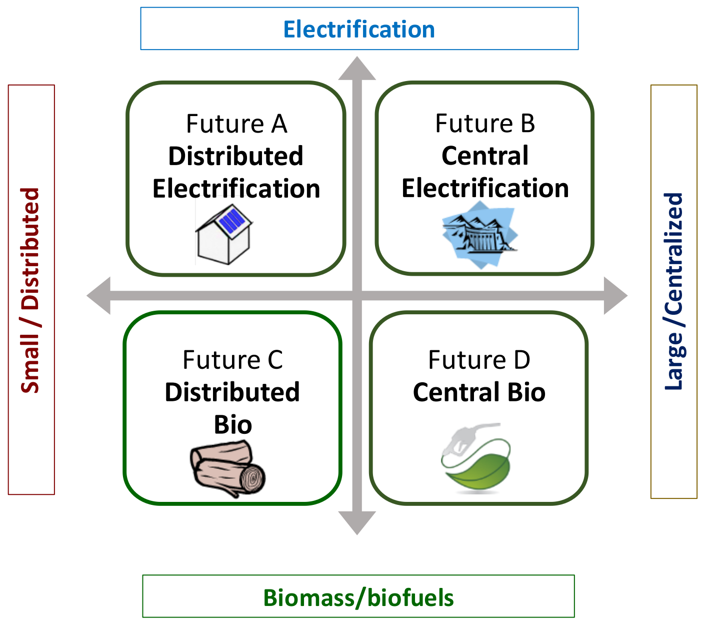
- **Quantitative:** To generate quantitative data to help inform the qualitative assessment process, the Dunsky Team conducted preliminary runs of the FACETS model, first developing a Business as usual baseline scenario, and then applying Vermont's 2028 and 2050 greenhouse gas reductions goals as additional constraints[15]. FACETS then determined the least-cost pathway to the targets by investing in efficiency, switching fuels, and adopting new technologies as needed to achieve the targets. A set of parametric carbon tax runs were also used to develop a cost curve for carbon emissions reductions, showing how much reduction could be achieved at different cost levels under varying assumptions. These simplified first runs did not attempt to model an actual policy approach. However, the results helped to pinpoint the lowest cost greenhouse gas emissions reductions available in Vermont's energy economy. They also identified the significant impact that the price and availability of liquid biofuels—which are assumed to be imported to Vermont from the rest of the country—will have on the cost and achievability of meeting Vermont's emissions goals. The risk posed by biofuels price and availability was then treated a primary sensitivity variable for the remainder of the study.

- **Qualitative:** The Dunsky Team and PSD staff used their combined professional experience, including in-depth knowledge of options, costs, and risks, to qualitatively assess each scenario based on the following criteria: Contribution to the greenhouse gas and renewable energy

[15] Developing appropriate technical constraints for FACETS was an important part of the model development process. Economic and policy constraints were added in the final three policy scenarios.

targets; Cost minimization; Pacing (time required to implement); Maximizing in-state economic activity; and Risk. Note that the first two criteria benefited from the preliminary quantitative analysis described previously.

Figure 4: Technology Emphasis Matrix



The initial screening illustrated a number of interesting aspects of Vermont's energy economy. First, energy efficiency and energy conservation will continue to play a central role beyond current projections. Biofuels and woody biomass already have shares of Vermont's energy economy and are poised for growth. Biomass (solid fuels) tends to be local and relatively small scale while biofuels (liquids, primarily ethanol) are almost entirely imported in the form of ethanol mixed into gasoline. Vermont's electricity supply is centralized and relatively low-carbon. There appears to be a sufficient supply opportunity to power the electrification of light-duty transportation (automobiles). In the transportation and space heating sectors, electricity, biofuels and woody biomass will compete to replace the liquid fossil fuels consumed in those sectors today. Fuel switching within each sector is highly dependent upon relative fuel commodity price, and the cost and availability of efficient new technologies that use the new fuel resources (such as cold climate heat pumps and pellet-fired residential boilers).

These insights led to a technology emphasis matrix, shown in Figure 4. The matrix has four quadrants defined by the four distinct directions which Vermont could follow in the future. The actual path Vermont takes will probably involve some elements of each quadrant. Nonetheless, these divisions are useful for considering policy approaches, each of which can put more or less emphasis on a technology direction. The four technology futures and some pros and cons are described below:

- ***Distributed Electrification –*** In this future, low-carbon electricity replaces fossil fuels in areas like light-duty transportation and home heating (biomass). More electricity is generated from local, in-state power sources, like solar PV. Distributed generation has a greater overall impact on emissions in the long-term due to the avoidance of transmission losses and an overall low risk profile, since risk is distributed across multiple options. However, Vermont's electricity system is currently centralized and it would take time and investment to put the necessary distributed electrification infrastructure in place.

- ***Central Electrification –*** Low carbon electricity replaces fossil fuels for transportation and heating/cooling, but the power is provided by the current, centralized electric utility model from utility-scale renewable energy projects. Considering in-state resource limits, major imports from Québec and other areas in the Northeast can be expected. On the other hand, the existing utility infrastructure allows electrification to start quickly and could be promoted under different policy approaches with manageable risks.

- ***Distributed Bio –*** Biofuels replace gasoline and diesel as motor fuels, and woody biomass replaces heating oil, in particular in the residential and institutional sectors. After an initial period of importing out-of-state know-how and expertise, a relatively speedy saturation of use of in-state capabilities can be anticipated, as well as an increasing in-state economic activity. Low carbon fuels can be manufactured in Vermont, with mostly in-state or New England production and distribution. Pellets are a form of woody biomass that would play a relatively large role in space heating. We note greater uncertainty for the bio-energy than for the electrification futures due to uncertainties about the price and availability of liquid biofuels. The ability of local sources to meet the demand for transport biofuels is also a significant source of uncertainty, since local production of biofuels is expected to remain very limited.

- ***Central Bio*** – A strong policy approach favouring biomass and biofuels, large-scale biomass for heat and power, and/or biofuels for transportation. Potential liquid biofuel availability concerns are mitigated by allowing most of the supply to be imported from out-of-state, particularly for transportation but also for a portion of space heating. As we noted for Distributed-Bio future, there is greater uncertainty for the bio-energy than for the electrification futures, due to uncertainties about price and availability of biofuels and the low efficiency of centralized biomass electric generation[16].

These technology futures proved useful to the team in considering policy options, since different policies will lead to different mixes of technology adoption.

STEP 3: DEFINE POLICY OPTIONS

FIVE INITIAL POLICY SETS

In the third step of the process, the Dunsky Team proceeded to examine five distinct policy approaches to enabling the deployment of low carbon technologies. These approaches consisted of bundles of

[16] The modeling confirmed that centralized biomass electric generation is uneconomic, except in very constrained cases, because of its relatively low efficiency.

policies and regulations that may appear in one or more policy approaches.[17] Vermont's energy future may involve components of some or all of them. It is worth noting that the PSD recognises the paramount role of energy efficiency, but rather than design a specific "Enhanced Efficiency" policy scenario, it is assumed that policies promoting energy efficiency would be an essential part of all the policy options.

The policy approaches initially considered were:

- ***A Total Renewable Energy and Efficiency Standard (TREES) –*** This would require Vermont's energy distributors to acquire a steadily increasing portion of their energy sales from renewable energy sources, or to offset sales by corresponding improvements in customer energy efficiency. To benefit from the lowest-cost options, clean energy providers could generate tradable "TREES Certificates", which could then be traded among distributors. TREES is fundamentally an expanded version of renewable portfolio standards, which have a long track record across the U.S., but which have been primarily associated with electric power generation. *The inclusion of a TREES scenario was required by the Total Energy Study enabling legislation*.[18]

- ***A Carbon Tax Shift –*** This places a tax on each ton of greenhouse gas emissions at a sufficient magnitude to drive substitution for low-carbon fuels and technologies. The tax would apply to all energy-related activities across Vermont. A corresponding series of tax *reductions*, not specified in this analysis, would ensure that the carbon tax shift remains "revenue neutral", and that total state tax collections do not change.

- ***Renewable Targets with Carbon Revenue –*** This would involve setting voluntary clean energy targets by sector, backed up by mandatory requirements in the event that voluntary targets are not met. In addition, a very modest carbon tax (significantly smaller than under *Carbon Tax Shift*) would generate revenues to fund new energy efficiency programs and other mechanisms to support the transition to clean energy.

- ***The Sector Specific Approach –*** This approach implies custom policies tailored to particular aspects of critical sectors such as transportation, space heating, and electricity generation.

- ***A NE Regional Focus –*** Finally, this approach acknowledges that Vermont is already part of a regional energy network and works with neighboring New England states (and Canadian provinces) to aggregate more market power and invest in clean energy infrastructure.

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[17] A comprehensive discussion of the five policy sets considered in this analysis is included in the PSD's TES Legislative Report. Refer to Appendix C of this report for a summary table comparing the scenarios proposed for evaluation.

[18] Act 170 of 2012, modified by Act 89 of 2013

Based on an initial assessment of the strengths and weaknesses of each of these policy approaches, the Dunsky Team and the PSD held a consultative session with the Governor's Climate Cabinet and their staff on February 25, 2014. This meeting provided both critical feedback from a broad perspective, and informed the PSD's choice of the final three policy approaches to submit to comprehensive modelling with FACETS.

FINAL THREE OPTIONS FOR MODELING

The quantitative and qualitative assessment of the twenty initial options yielded the choice of the final three – a carbon tax shift and two TREES options – for a number of reasons. In particular, they were found to be attractive in terms of expected cost and effectiveness in meeting state goals; they are fully implementable by the State of Vermont; and they allow for a useful contrast of objectives (cost minimization, renewable energy, and economic development) and associated impacts.

We note that the three approaches selected for modelling are largely "technology agnostic" (not linked to or favoring the development of specific technologies), and face different risks in terms of meeting emissions goals and expected costs. Tax policies are likely to achieve emissions reductions at lowest cost, since they allow the market to choose winners and losers among the broadest range of solutions. Meantime, a Total Renewable Energy and Efficiency Standard (TREES) also allows for market-driven cost-optimization (thanks to its inclusion of certificate trading), but within the somewhat more restricted realm of renewable energy and energy efficiency solutions. Finally, a TREES-Local policy adds further restrictions to certain solutions (namely, out-of-state renewables), in exchange for increased certainty of in-state economic benefits.

For example, if biofuels prices are low, a carbon tax may translate into reduced oil consumption for transportation (replaced with biofuels), but fossil fuels may still be used in other sectors. TREES policies, on the other end, will likely reduce the use of nuclear and fossil fuels and incentivize efficiency and earlier development of technologies like solar PV.

1. REVENUE-NEUTRAL CARBON TAX SHIFT

This revenue neutral tax is applied to all fuels and follows a Pigouvian redistribution of tax burden from "goods" like income to a "bad" (carbon emissions). Beginning at $10/ton of CO_2 equivalent in 2015, it grows linearly over time to a maximum value in 2050. The specific trajectory needed to meet Vermont's 2028 and 2050 goals depends heavily on the assumed price for imported biofuels. A parametric set of runs with tax levels starting at $10/ton in 2015 and ramping by different degrees was used to identify the levels needed to reach Vermont's emissions goals. The Results section below reports on the two trajectories needed to achieve the targets if biofuels prices are low (ramp up from $10/ton to a maximum of $450/ton by 2050), or high ($10 up to $1,250/ton by 2050). Full graphical results for all the parametric runs are shown in Appendix E.

The Carbon Tax Shift scenario does not focus on a specific fuel or technology, is agnostic regarding whether energy is imported or domestically produced, and does not differentiate whether the energy comes from renewable or non-renewable sources, nor whether its production is geographically centralized or distributed. Notably, it does not directly incentivize renewable energy.

2. TREES BASIC

The TREES options apply a schedule, provided by the PSD, of mandatory shares of total energy needs to be derived from either renewable energy, or improved energy efficiency (beyond already-anticipated *baseline* improvements). Under this schedule, renewable energy ramps up linearly from current levels of approximately 20%, to 90% of Vermont's projected needs by 2050[19].

3. TREES LOCAL

The TREES Local policy option imposes the same TREES standard for inclining renewable energy use as above, and then introduces an additional constraint: the use of in-state renewable energy sources. This bias is modeled as a maximum share of total energy needs met by out-of-state resources, declining from the current level of approximately 80%, to only 40% by 2050. This results in a threefold increase in the share of the state's total energy needs that would be sourced in-state.[20]

In practice, this policy could be implemented in the form of greater credits for in-state renewables and energy efficiency, lower credits for out-of-state renewables, or some combination thereof. Please note that energy efficiency beyond BAU trends and federal policies is considered an in-state resource for these purposes.

Table 1 below shows the out-of-state shares for the TREES-Basic and TREES-Local options. Note that the TREES-Basic achieves a higher in-state share under high biofuels prices than under low biofuels prices, because of the greatly reduced biofuels imports when prices are high.

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[19] For purposes of calculating Vermont's total energy needs in each model year, a modified Business as usual scenario was constructed including national energy efficiency policies, such as Corporate Average Fuel Economy standards, but which backs out additional state efficiency programs that are expected to reduce consumption in the Business as usual scenario. See more discussion in the Energy Efficiency section below.

[20] Following PSD's direction, the maximum out-of-state share for the TREES-Local policy was set at 40% in 2050. Using the shares from the TREES-Basic runs for a guideline, the constraint was set to create an achievable, but modestly more ambitious, target than achieved by TREES alone, ramping to 60% in 2042 on the way to reaching 40% in 2050.

Table 1: Share of Renewable Energy Imported under TREES-Basic and TREES-Local

		2020	2028	2034	2042	2050
BUSINESS-AS-USUAL		81%	82%	82%	82%	82%
TREES POLICY OPTION *(and Biofuel Price Scenario)*						
TREES Basic	*Low Bio $*	75%	68%	59%	44%	40%
	High Bio $	78%	77%	75%	63%	48%
TREES Local	*Low Bio $*	75%	68%	58%	44%	40%
	High Bio $	78%	77%	70%	60%	40%

By applying this constraint, the TREES Local scenario further restricts the options available to meet the State's goals, but ensures that by the end of the period, the majority of energy consumed in Vermont is also produced in-state.

STEP 4: MODEL POLICY SCENARIO IMPACTS

To prepare the Vermont FACETS model for scenario analysis, the Dunsky Team worked in close cooperation with the PSD to build a Business as Usual (BAU) base case to simulate Vermont's current energy economy. We calibrated the model by applying appropriate supply constraints, and adjusting demand until FACETS consistently produced the current energy consumption for the Vermont market.

As indicated above, a large amount of the energy that Vermonters currently use is imported from outside of the state. Energy prices and availability are determined by regional, national, and international markets. To fully reflect the actual flows of energy into the state, the BAU scenario was built on a database that includes relevant Vermont, New England regional, and US energy system resources, including import/export options with Canada. The key issues and assumptions are discussed in the following sections, and are summarized in Table 2.

MODEL ASSUMPTIONS

OVERVIEW OF KEY CONSTRAINTS AND ASSUMPTIONS

Model calibration involved setting exogenous limits on the availability of resources and penetration of some fuels and technologies to reflect realistic non-economic barriers, technical or otherwise, in the Vermont market. The PSD provided a maximum development schedule for wind and small-scale (non-utility) solar electricity based on current trends and an assessment of regulatory and siting issues. The PSD and the Dunsky team developed estimated limits on the future penetration of woody biomass as a home heating fuel and limitations on the ability of some homes to switch away from delivered liquid fuel. Vermont Gas Systems provided projections on the future expansion of the natural gas distribution system. Table 2 below summarises key model assumptions.

Vermont's statewide goals include both greenhouse gas reduction and renewable energy share targets. While the two are linked, our analysis assumes that achieving the greenhouse gas reductions has primary importance, and the policy approaches were designed to meet those goals.

Table 2: Key Energy Resource Assumptions

ENERGY SOURCE	CONSTRAINTS AND KEY ASSUMPTIONS[21]
Natural Gas	**Technical Constraints:** none (price driven) (Carbon emissions are based on the carbon content of the fuel only.)
Biofuels (liquid)	**Technical Constraints:** none (price driven) **Carbon content**: As provided by the PSD using an *energy return on ton of fossil carbon invested* approach. Carbon contents for liquid biofuels: • Biodiesel 100%: 13.2 kg/MMBTU, (perhaps falling over time to 9.1 kg/MMBTU • Ethanol 100%: corn ethanol 56 kg/MMBTU shifting over time to cellulosic at something like 8 kg/MMBTU **Price scenarios**: As provided by the PSD • The "low" biofuels price case is based on current market price premiums for corn ethanol and biodiesel includes a \$0.31 retail price premium for E100 and a \$0.47 retail price premium for E100 (to be applied proportionately to fuel blend mixes – e.g. E85 would be 85% of \$0.31. Values based on EBISnewsletter-sample.pdf) corresponding to a 9% premium over the prevailing price for gasoline for ethanol and a 12% premium for biodiesel. This case corresponds to an assumption that the US biofuels industry can scale up current production at these premiums such that

[21] Carbon intensities for renewable fuels were provided by PSD.

	Vermont can import unlimited quantities of biofuel, with acceptable carbon intensities, at these prices without impacting the broader US market. • The "high" case includes the first 10 million gallons at a 50% price premium (based on a low estimate of the amount of local biodiesel that could be produced), with the remainder at a 250% price premium – designed to be high enough to effectively price biofuels out of the running. This case corresponds to an assumption that no mature US biofuels industry develops, and low-carbon biofuels remain a niche commodity. Although this case was designed to price biofuels out of the running, they continue to penetrate substantially where the model lacks other options to reduce carbon emissions, particularly for medium and heavy-duty vehicle travel.
Biomass (solid)	**Technical Constraints:** • Cordwood: max 25% penetration of cord wood for residential space heating. • Pellets and Chips: none **Supplies:** Woody biomass supplies for cordwood and chips were based on data from the *2010 Basic Update of the Vermont Wood Supply Study*[22], drawing on supplies available within Vermont and surrounding counties. A resource supply curve was developed in conjunction with PSD, guided by data from the Oak Ridge National Lab *Billion Ton Update*[23]. Pellets are assumed to be available as unlimited import from out-of-state sources, at a price two-thirds that of home heating oil, consistent with recent *Vermont Fuel Price Report* data. **Carbon content:** As provided by the PSD using an *energy return on ton of fossil carbon invested* approach. Carbon contents for solid biomass: • Pellets: 6.4 kg/MMBTU • Cord Wood: 1.8 kg/MMBTU • Chips: 2.8 kg/MMBTU
Wind and Solar	**Technical constraints:** See table below; values chosen to reflect reasonably-anticipated constraints (e.g. siting).

Year	Max Non-Utility Solar PV Capacity (MW)	Max Utility Solar PV Capacity (MW)	Max Wind Power Capacity (MW)
2010	42		
2015	84		

[22] Biomass Energy Resource Center, *2010 Basic Update of the Vermont Wood Supply Study*, 2010.

[23] U.S. Department of Energy. 2011. U.S. Billion-Ton Update: Biomass Supply for a Bioenergy and Bioproducts Industry. R.D. Perlack and B.J. Stokes (Leads), ORNL/TM-2011/224. Oak Ridge National Laboratory, Oak Ridge, TN.

	2020	105		150
	2025	140		
	2030	176		
	2035	214		
	2040	253		350
	2045	294		
	2050	300	1000	400
Hydro imports	**Technical constraints:** none. **Others:** Imports from Hydro Quebec are considered zero carbon and renewable, as defined by statewide goals.			
Nuclear	**Technical constraints:** none (imports from NE pool available). **Others:** Nuclear is assigned a fossil equivalent of 10,500 BTU/KWh for purposes of exclusion from the statewide renewable energy goals. It is assumed to be zero carbon.			
Farm methane	**Technical constraints:** The current 4 MW of existing production increases to 11 MW over 15 years and then stays constant. **Others:** Farm methane is assumed to be zero carbon.			
Oil/Propane	**Technical constraints:** 5% each *minimum* shares for oil and propane heated homes in 2050, to account for portion that cannot or will not switch to another source.			

Among the many assumptions that feed into the model, the treatment of energy efficiency, liquid biofuels and woody biomass, transportation electrification, and the way in which the model accounts for future innovations are worthy of special attention. We briefly discuss each of these below.

SPOTLIGHT ON ENERGY EFFICIENCY

Entering into this project, stakeholder opinion strongly suggested that energy efficiency was readily available and most often the least expensive resource in Vermont, and should play a primary role in meeting statewide goals. Subsequent quantitative analysis confirmed this (see Model Calibration Scenarios below). Therefore rather than design a specific "Enhanced Efficiency" policy scenario for modelling, the PSD asked the Dunsky Team to assume that policies promoting energy efficiency would be an essential part of all three final options.

In the BAU scenario, the efficiency of energy use increases over time, due to improvements in available technologies, as well as U.S. national policies such as appliance efficiency standards and automobile CAFE standards, are part of the baseline demand projection. However, all three of the final options modeled for this project allow for and make use of additional energy efficiency, beyond what we see today in Vermont and the BAU case.

While it is useful in policy terms to conceptualize energy efficiency as a "resource" like fossil fuels or wind power - that can and should be considered to meet demands alongside other resources - modeling energy efficiency in a systems model like FACETS requires it to be thought of in a different way. FACETS does not explicitly consider energy efficiency programs, except in cases where specific constraints on the rate of energy use are imposed (e.g. federal CAFE standards). Rather, for each energy end use, FACETS considers specific energy technologies, with different efficiency levels, to satisfy demand for energy services at the lowest-cost. For example, FACETS includes over a hundred different furnaces, boilers, and other devices to meet home heating demand, which use a variety of fuels, are gauged at up to five levels of efficiency, and are available at different upfront capital costs. FACETS also offers seven levels of building shell efficiency improvement. In selecting the cost-optimal technologies to satisfy demand, FACETS considers the investment costs of technologies, their fixed and variable operating and maintenance costs, and the fuel prices, generated within the model. For example, if the price of heating oil increases, FACETS considers the cost of switching to a pellet-fired boiler, against the cost of adding attic insulation and the cost (and availability) of switching to natural gas. The substitution of electric motor drive for internal combustion engines for automobiles is one example of technology shift that can generate large energy and cost savings due to improved efficiency.

FACETS also allows demand to change as consumers respond to energy price increases. In the residential sector, for example, the model might reflect the likelihood of increasing numbers of households choosing to use clotheslines in the summertime rather than electric clothes driers, as prices increase. As a result, energy consumption reductions are achieved not only through the penetration of more energy efficient technologies, but alsot through price-induced changes in consumption behavior.

Thus in FACETS, efficiency does not appear as a resource that can be added up and accounted for similarly to other resources, but rather shows up as energy that is not consumed when the model makes more efficient choices. Modeling a policy like the TREES Basic, which requires efficiency and renewables to supply a growing portion of Vermont's energy needs, requires creating a counter-factual case without additional efficiency programs to serve as a baseline from which policy-induced efficiency will reduce consumption. For this purpose, a modified Business as usual scenario was created that added consumption expected to be avoided by Vermont programs including current Efficiency Vermont, Vermont Gas System, and Burlington Electric energy efficiency programs – based on US EPA's estimate of embedded program efficiency in AEO 2013[24] – back into the energy consumption baseline. This baseline then served as the basis for calculating the maximum amount of fossil and nuclear energy that could be consumed each year in the TREES options, as well as the maximum out-of-state resource consumption in the TREES-Local options.

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[24] http://www.epa.gov/statelocalclimate/state/statepolicies.html

In Vermont, the greatest efficiency impacts in the model results appear where the energy service demand is greatest, that is in light-duty vehicle choice (e.g. more efficient vehicles, electric vehicles) and in space heating equipment choices (e.g. pellet boilers, heat pumps).

In all scenarios that meet the statewide greenhouse gas reduction and renewable energy goals, energy efficiency increases significantly over current levels because it is often cheaper than adding renewable energy to the system.

SPOTLIGHT ON BIOFUELS AND BIOMASS

For the purposes of this report, renewable fuels derived from plant matter are referred to as *biofuels* when in a liquid state, and *biomass* when in a solid state. (Methane gas harvested from anaerobic microbial digestion of organic matter[25] is also categorized as biomass, but is available in relatively small amounts). Biofuels consist primarily of biodiesel and ethanol. Ethanol is commonly blended with the gasoline used in light-duty vehicles. Biodiesel can be used as a transportation fuel or as a substitute for #2 heating fuel oil. In the US, most biofuels are produced through large-scale industrial agriculture from crops like corn and soybeans. The potential for local production in Vermont is limited and our analysis assumes that most biofuels would be imported.

Solid biomass includes cord wood, wood chips, and wood pellets[26]. Cord wood is a common heating fuel in Vermont, used in wood stoves and wood fired boilers, primarily in residential applications. According to US census data[27], at 15.4% Vermont has the highest percentage of households that use wood as a primary heating fuel of any U.S. state.

Wood chips are a by-product of logging and sawmills. Wood chips are burned in two Vermont power plants to generate electricity and Vermont has over 45 schools that heat with wood chips. Some school wood chip boilers have been in continuous operation for over 25 years.

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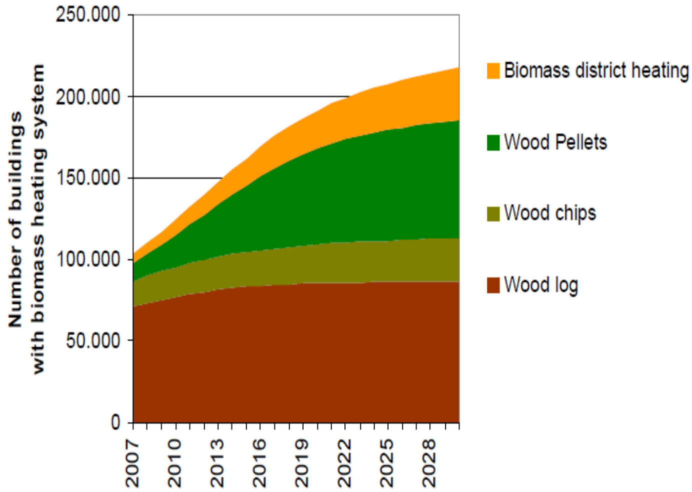
[25] Examples include the methane harvesting at some Vermont wastewater treatment facilities and Green Mountain Power's "Cow Power" manure to methane program.

[26] Grass-based biomass was not considered in this study.

[27] Wood Heating House Percentage State Rank based on U.S. Census American Community Survey 2008-2012. EIA also indicates that, from 2005 to 2012, the number of households in Vermont that burn wood as their main source of heat has increased by more than 100 percent, available at: http://www.eia.gov/todayinenergy/detail.cfm?id=15431

Figure 5: Upper Austria Biomass Heating Systems



Pellets are a refined fuel made from wood chips and sawdust compressed to a consistent size and shape. Pellets take up considerably less space per Btu than wood chips and are easy to move mechanically, to store, and to burn. Pellet burning stoves, furnaces and boilers offer automated operation similar to oil or natural gas-fired equipment. There are also an increasing number of pellet boilers in use in commercial applications. Pellets have already begun to demonstrate an ability to make woody biomass space heating feasible and attractive to Vermonters who cannot, or prefer not, to heat with cord wood.

The state of Upper Austria shares some similarities with Vermont, and currently obtains a third of building space heating energy from woody biomass. Further, it expects to reach a 50% share by 2030, on a total of about 450,000 buildings (see Figure 5)[28,29].

Almost all cord wood used in Vermont comes from Vermont forests, as do most of the approximately 60,000 tons of wood chips used to heat Vermont schools and other buildings each year. About two thirds of the roughly 600,000 tons of woodchips burned annually at two Vermont power plants comes from surrounding states. There is currently one pellet production plant in Vermont with several more proposed. Currently, much of the pellet fuel that is consumed in Vermont comes from out of state.

Both biofuels and biomass are low carbon, but not carbon free in terms of net greenhouse gas emissions. See Table 2 above for assumptions regarding the carbon content of these fuels. We note that much as the evolution in the price of biofuels is uncertain, so too is its future carbon content. In that respect, the reader may view the price sensitivities used in this exercise as proxies for carbon content sensitivities (for example, a high biofuels price scenario could equally reflect a lower-priced, but higher-

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[28] Christine, Gerhard Del & Christiane Egger, *Target setting for RES-H/C in Upper Austria*. Öhlinger. February, 2010.

[29] European residential biomass combustion technology tends to be more efficient and cleaner burning than equivalent U.S. equipment. Northeast States for Coordinated Air Use Management (NESCAUM) has reported that the adoption of more stringent emission limits on solid wood fueled-units in Europe expanded the residential market for wood heating by increasing the ability to install units in more populous settings. NESCAUM has suggested that the U.S. could see similar results if comparable standards were adopted by EPA. EPA's proposed Phase 2 emissions standards for residential wood heating devices should help spur technology improvement.

carbon content scenario). We caution though that this analogy extends only to consideration of carbon emissions, not to assumptions around renewable energy.

SPOTLIGHT ON ELECTRICITY GENERATION

Vermont is part of the New England electricity grid, which generates and distributes relatively low-carbon electricity. With an electric portfolio containing significant renewable and nuclear resources, electricty consumption in Vermont contributes to only 5% of the state's total greenhouse gas emissions (see Figure 1). This makes switching transportation and building heating demand to rely on electricity rather than fossil fuels an intriguing greenhouse gas emission reduction strategy.

As explained above in the "FACETS Model" section, FACETS takes all costs associated with electricity generation as model inputs, minimizes the costs of meeting all end use service demands, whether using electricity or some other fuel, and provides the marginal prices of electricity as a model output.

For each energy service, such as personal vehicle transportation, FACETS makes decisions based on the marginal costs of each technological option, including capital, operating, and fuel costs. In the real Vermont marketplace, some fuels may be priced close to their marginal costs, while others, such as electricity, are priced in different ways. Regulation, market structures, and energy utility tariff designs may distribute the costs of electrification as a greenhouse gas reduction strategy across society in different ways. These will have significant impacts on the rate of adoption of new electro-technologies (like electric cars or cold-climate heat pumps).

SPOTLIGHT ON INNOVATION

FACETS assumes that, over time, market share will shift to the technologies that offer the energy services Vermonters need at the lowest prices. For example, electrically-powered, ductless air-source heat pumps compete with oil-fired residential furnaces to provide heating for Vermont homes in FACETS, just as they do in the actual market.

FACETS projects the future of Vermont's energy economy by drawing from a large existing database of energy-related technologies. Some of these technologies have limited availability and are not cost-effective today, but may become cost-effective in the long term under conditions that increase the price of high carbon fuels. The Dunsky team included newer technologies only when it was possible to develop reasonable assumptions regarding their likely costs and efficiencies, drawing from expert sources and professional judgement.

What FACETS—and all other energy models—cannot do is project surprises, such as breakthrough innovations, or a rapid change in fuel prices due to geopolitical events or new resource discoveries. For example, a breakthrough in electricity storage technologies, in particular for vehicles, could dramatically change the economics of fuel switching opportunities. The results presented here represent the least cost way of achieving Vermont's goals using a reasonable set of projections for future cost and performance of existing or currently anticipated technologies.

RESULTS

OPTIONS OVERVIEW

As discussed above, the Vermont FACETS model was used to simulate Vermont's energy future under a number of policy options, including most notably:

1. **Business As Usual (BAU):** the evolution of Vermont's current energy system in the absence of any specific new statewide policies
2. **Preliminary Optimization and Parametric Tax runs:** preliminary model runs, used to inform the initial qualitative screening.[30]
3. **Carbon Tax Shift:** a revenue-neutral tax shift, reducing tax on "goods" (e.g. income, employment) and increasing tax on a "bad" (greenhouse gas emissions).
4. **TREES Basic:** a requirement that energy suppliers source a growing percent of their energy from renewable resources; allows for market trading among vendors and buyers.
5. **TREES Local:** a modified version of TREES Basic that requires a share of the eligible renewable energy to be derived from in-state projects or resources.

In the following section we present the key results of each of these modelling scenarios. Readers will note that as we proceeded, it became evident that the results were very sensitive to the price/availability of biofuels. For this reason, we decided to run high and low biofuels price cases for the Preliminary Optimization scenario as well as for each of the three final policy options. This change further required that we also run the Carbon Tax Shift scenario at two different tax levels in order to meet the emissions goals under the two biofuels price cases.

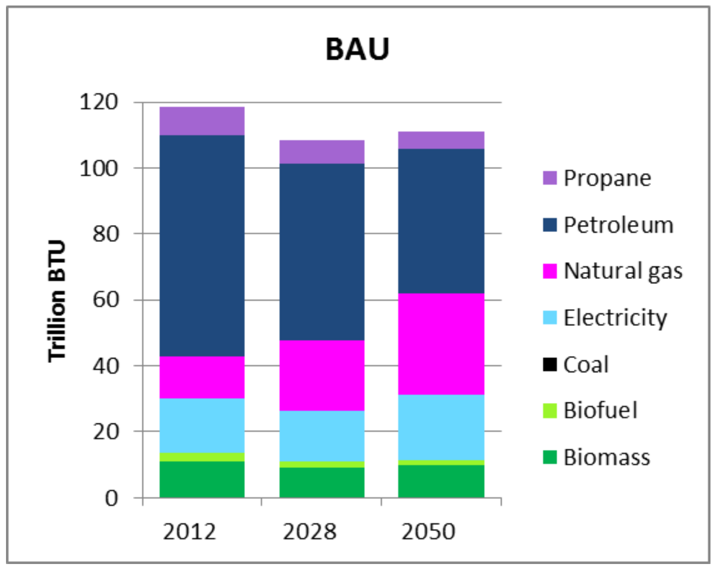
[30] The optimization run asks what would occur if CO_2 were reduced by 50% by 2028 and 75% by 2050 in the lowest cost manner (with no other specific policy direction or other constraints). The tax runs allowed the construction of a cost supply curve showing how the availability of emission reduction opportunities at different prices.

MODEL CALIBRATION

The Dunsky team worked in close cooperation with the PSD to calibrate the model by building the Business as Usual (BAU) base case to simulate Vermont's current energy economy. We provided Vermont energy supply costs and resource constraints as inputs, and then adjusted the model until it consistently produced the current energy consumption for the Vermont market. For this purpose, the Dunsky team drew from data provided by Vermont Gas Systems on current and projected natural gas consumption, from the Biomass Energy Resource Center on the availability and pricing of woody biomass fuels, and from the PSD and other state agencies on a wide range of other parameters.

Most importantly, as shown in Figure 6, the total amount of energy consumed annually in Vermont is projected to decrease slightly from 2012 to 2050. Flat or negative growth in electricity consumption is now evident in several parts of the U.S.[31] Fuel oil sales per household for residential space heating in Vermont have been declining for decades and the legislature has recently had to confront the impact of declining gasoline sales on gasoline tax revenues. There are multiple reasons for these trends, but underlying them has been a steady increase in energy productivity and the slow decoupling of economic growth from growth in energy consumption.

Figure 6: VT Energy Consumption - Business as Usual



Home heating, lighting, and other devices have steadily become more efficient, and new light-duty vehicle CAFE standards, which require nearly a doubling of new vehicle efficiencies over the coming decades, are a major contributor to the declining energy consumption in the BAU. It is also worth noting that Vermont's population stability – the number of Vermonters is projected to remain constant between 2014 and 2050 – also influences to the trajectory for energy demand. As the productivity of energy use increases, energy consumption per capita declines. Because Vermont's population remains constant, total energy consumption declines as well.

Under the BAU scenario greenhouse gas emissions slowly decrease, but only by a total of approximately 10% by 2050, as shown in Figure 7 below.

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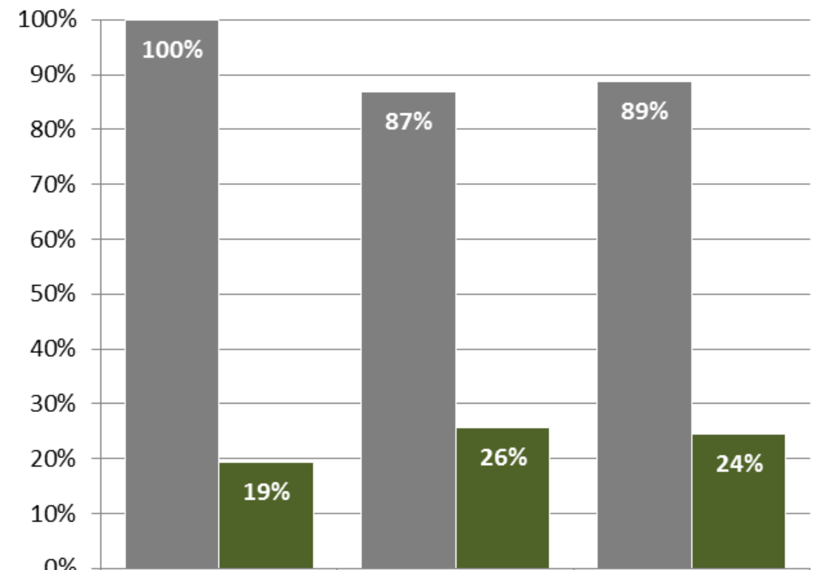
[31] Why Is Electricity Use No Longer Growing? American Council for Energy Efficiency Economy (ACEEE), 2014. Nadel, Steve; Rachel Young

Figure 7: Emissions & Renewables: Business-As-Usual



	2012	2028	2050
CO2 Emissions	100%	87%	89%
Renewable content	19%	26%	24%

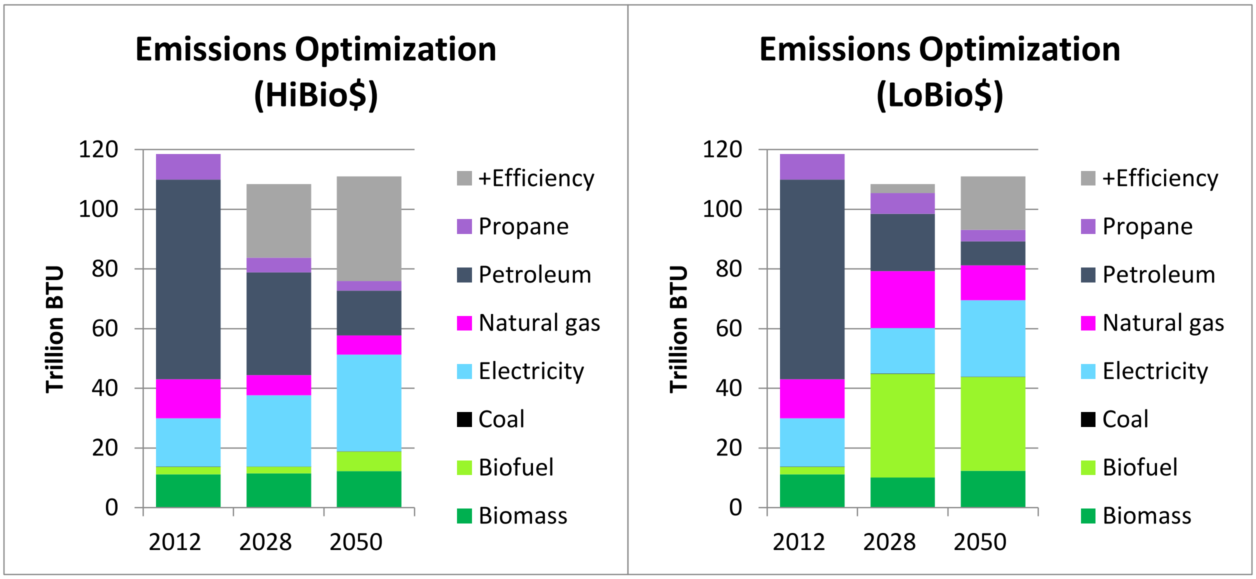
In this world, the total share of renewable energy in Vermont's fuel mix does not increase significantly. Without significant new policies, Vermont's energy system falls dramatically short of both its dual carbon emissions goals (achieving 13% and 11% reductions by 2028 and 2050, respectively, in lieu of the 50% and 75% reduction targets), and its renewable content goal (achieving 24% in lieu of the 90% target by 2050).

PRELIMINARY OPTIMIZATION AND TAX RUNS

For the Preliminary Optimization runs, the Dunsky Team instructed FACETS to reduce Vermont's greenhouse gas emissions by 50% by 2028 and 75% by 2050 relative to 1990 levels. All policies and constraints applied exactly matched the BAU case. Under this scenario, FACETS calculated the lowest cost path to reach Vermont's greenhouse gas emissions goals by switching from higher-carbon to lower-carbon fuels, substituting more efficient technologies for less efficient ones, importing additional low carbon electricity, and in some cases reducing demands in response to higher prices. Given the impact of uncertainty regarding the future of biofuel prices, the Dunsky Team chose to run the model using two biofuel price scenarios: the "low" case assumes a 9% premium over the prevailing price for gasoline for ethanol and a 12% premium for biodiesel, which is roughly the current price premium for the biofuels currently blended into gasoline and diesel. The "high" price biofuels case assumes a 50% premium for the first 10 million gallons and the remainder of supply available at 250% premium.

By comparing the BAU and Preliminary Optimization scenarios, the Vermont FACETS model added a useful quantitative dimension to the process of choosing the three final Vermont energy future options for comprehensive modeling.

Figure 8: VT Energy Consumption – Preliminary Optimization, Two Biofuels Price Levels



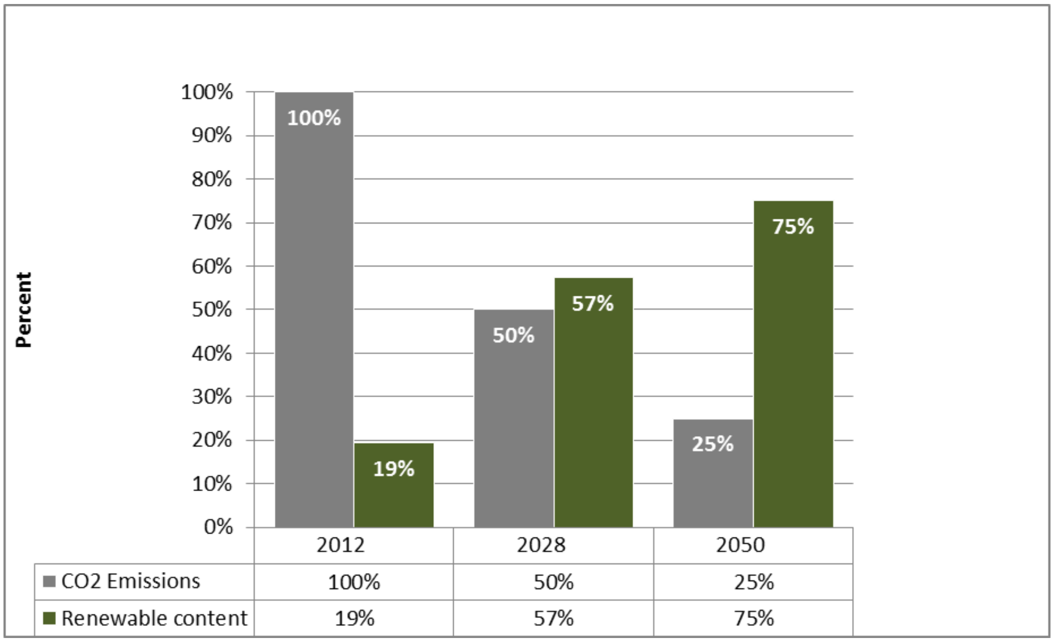
As shown in Figure 8, in 2028 and 2050, both biofuels price cases of the Preliminary Optimization scenario utilize more energy efficiency than the BAU scenario does. As described above in the "Spotlight on Energy Efficiency" sub-section, FACETS selects more energy efficient technologies when doing so costs less than switching to lower carbon fuels or renewable technologies. As long as efficiency is the relatively least expensive resource, more of it is purchased. Moreover, both scenarios above involve a significant expansion of electricity for transportation (e.g. electric vehicles) and/or space heating (e.g. heat pumps). In both cases, the electric technologies are also more energy efficient than the fossil fuel powered technologies they replace, resulting in both a switch from fossil fuels to lower-carbon electricity *and* an increase in absolute energy efficiency.

The role of efficiency is considerably more pronounced, particularly early on, in the high biofuels price case, suggesting that efficiency provides an important opportunity to insulate Vermont against the risks posed by uncertainty around biofuels price and availability.

The differences between the two biofuels price cases are profound in their implications for technology and infrastructure. If biofuels are cheap and available, they dominate the market for transportation and the infrastructure to transport, sell, and use motor fuels with increasingly high percentages of biofuels must be installed. If biofuels are expensive and scarce, there is more electricity in light-duty transportation, requiring battery charging infrastructure for electric vehicles.

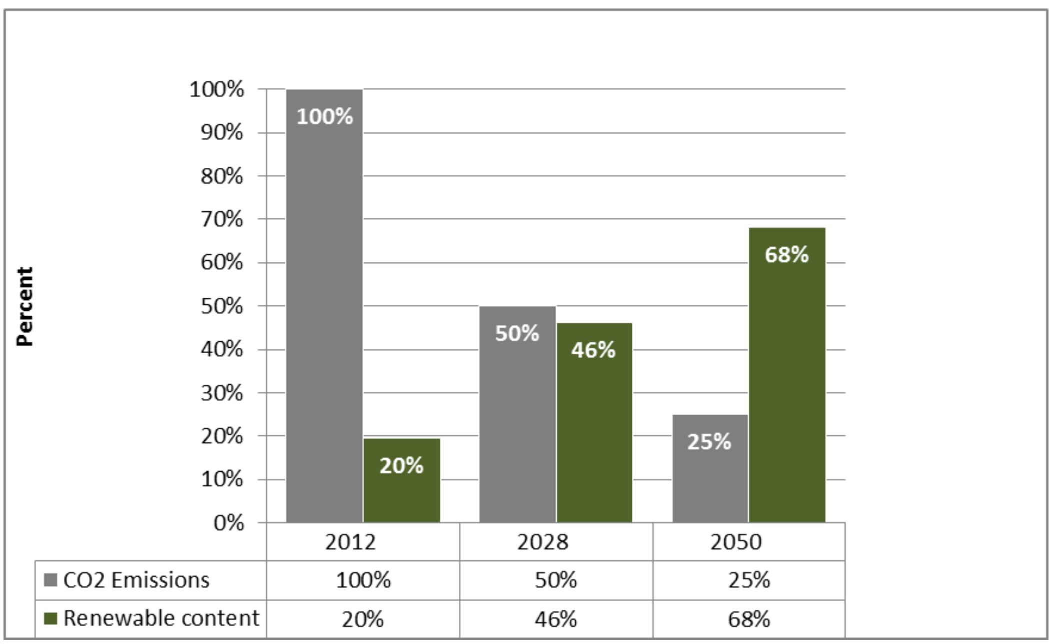
Figure 9 and 10 below illustrate how, under an economically-optimal model constrained to achieve the emission reduction goals, different biofuel price scenarios impact the ability to simultaneously achieve the state's 90% renewable energy target by 2050.

Figure 9: Emissions & Renewables: Preliminary Optimization Scenario (Low Biofuels Price)



	2012	2028	2050
CO2 Emissions	100%	50%	25%
Renewable content	19%	57%	75%

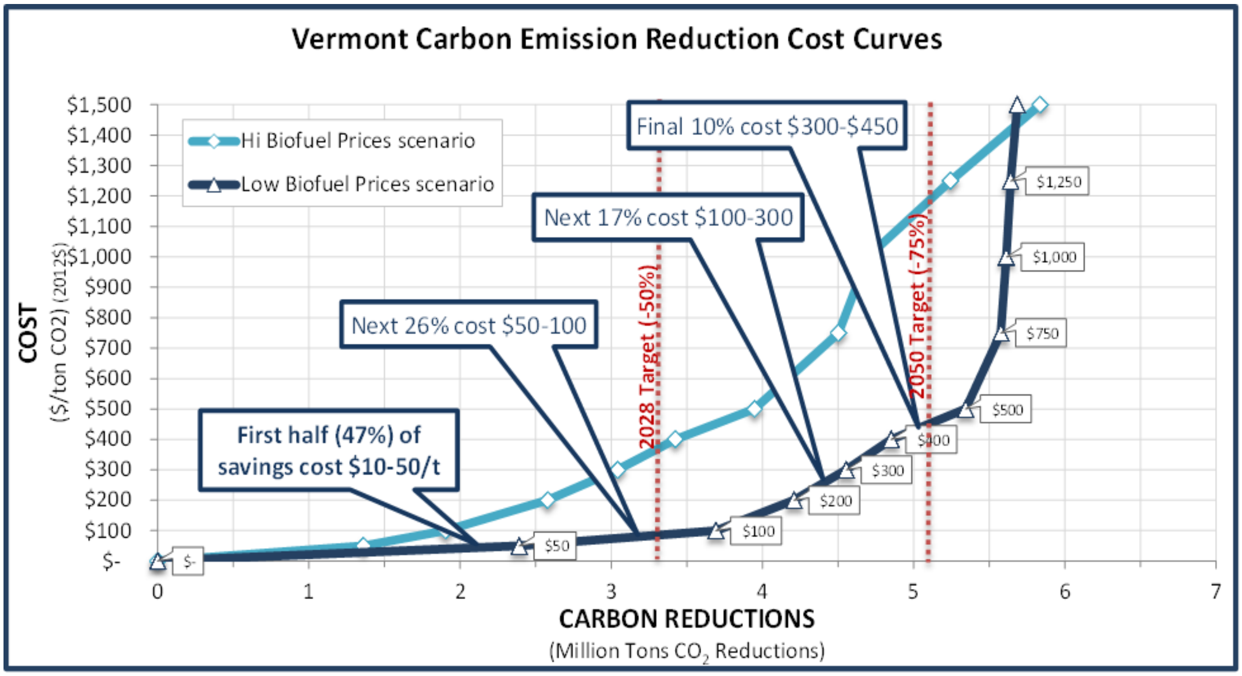
Figure 10: Emissions & Renewables: Preliminary Optimization Scenario (High Biofuels Price)



	2012	2028	2050
CO2 Emissions	100%	50%	25%
Renewable content	20%	46%	68%

During this preliminary analysis phase, a set of parametric carbon tax runs were also used to develop a cost curve for carbon emissions reductions, showing how much reduction could be achieved at different cost levels. Figure 11 below shows the resulting curves in 2050, under both the high and low biofuels price assumptions, and dramatically illustrates the cost impacts for Vermont of this key uncertainty.

Figure 11: Vermont Carbon Emission Reduction Cost Curve



Under the low biofuel price scenario, the first 3.7 MT, i.e. nearly three-quarters of the 2050 emissions reduction target, and all of the 2028 target, can be achieved at a cost of between $10 and $100 per ton.

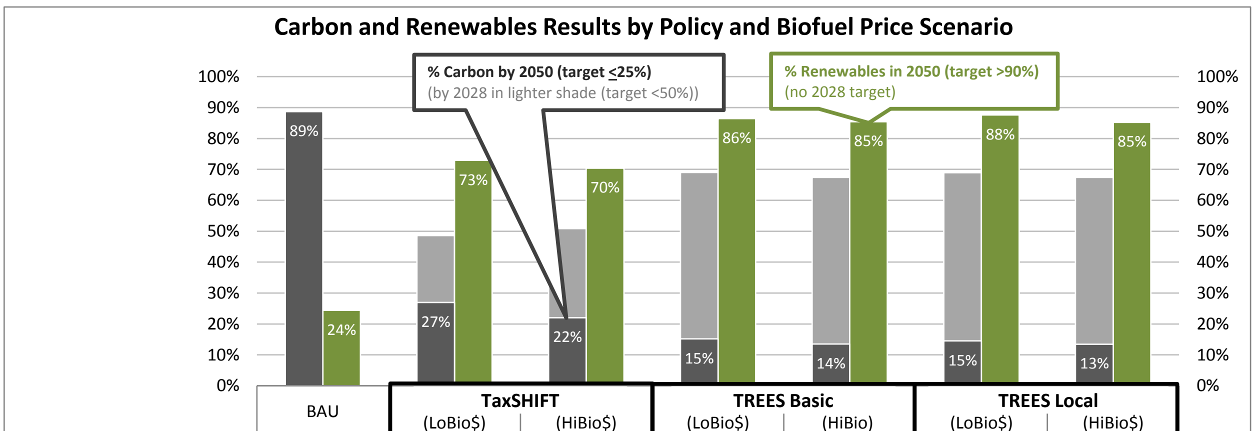
As we can see, when biofuels are readily and cheaply available to be swapped in for current petroleum uses, significant emissions reductions are available at very low cost, and all the reductions needed to achieve the 2050 target are available for less than $500 per ton. When biofuels are very expensive, substantial reductions are still available at low cost, but the cost curve rises much more steeply, and a very high tax rate is required to get all the way to the 2050 target. These curves were used to select the tax rates needed to model the tax policies in the next phase of the project.

POLICY OPTIONS: OVERVIEW OF RESULTS

All three of Vermont's goals – emissions reductions of 50% and 75% by 2028 and 2050, respectively, and renewable energy content of 90% by 2050 – are intrinsically linked. Nonetheless, in designing policy options, priority was given to the long-run greenhouse gas emissions reductions.

Accordingly, the Dunsky Team's analysis finds that achieving the goal of a 75% reduction in Vermont's greenhouse gas emissions by 2050 is achievable under all three policy options, and at a moderate cost. Specifically, the Carbon Tax Shift options *by design* produce almost exactly the desired outcome; meanwhile, the TREES options, because they are focused instead on the more aggressive renewable energy target, exceed the carbon savings goal by roughly 10%. Still, each option evokes a trade-off regarding the other targets. For example, a Carbon Tax Shift also precisely achieves (again, by design) the mid-term GHG target of 50% by 2028, but falls significantly short of the 2050 renewable energy target (by up to 20%). Inversely, both TREES policies achieve the long-term GHG *and renewable energy* targets, but fall short of the mid-term (2028) GHG reductions goal.

Figure 12: Emissions & Renewables: Policy Options Overview (under both Biofuel Price scenarios)



	BAU	TaxSHIFT (LoBio$)	TaxSHIFT (HiBio$)	TREES Basic (LoBio$)	TREES Basic (HiBio)	TREES Local (LoBio$)	TREES Local (HiBio$)
2028 CO2 Emissions	87%	49%	51%	69%	67%	69%	67%
2050 Renewable content	24%	73%	70%	86%	85%	88%	85%
2050 CO2 Emissions	89%	27%	22%	15%	14%	15%	13%

Table 3 below provides somewhat more information, including most notably the addition of cost values. The *gross* emissions reduction costs presented show results in terms of both the percent increase in total costs needed to meet Vermonters' energy service needs (%) – including capital, operating, and fuel costs of all energy producing and using technologies –, as well as the *average* cost of reducing emissions (\$/ton CO_2e). Both are expressed in present value (2013) costs.

As discussed previously, these costs are much lower than the highest marginal tax rates in the tax options. Indeed, as shown by the cost curves in Figure 11, when the tax rate is, say, \$450/ton, the vast majority of the emissions reductions occur at much lower costs, so the average cost is always considerably lower than the marginal cost. Second, the costs as calculated are present value costs (using a 3% discount rate), so a reduction achieved at $450/ton in 2050 costs less than one-third as much in present value terms.

The reader will note that two costs are presented: the gross cost (top value), followed by the net cost (bottom value). The "net cost" was derived by assuming a "cost of inaction" of $100 per short ton of CO_2e, as directed by the VT PSD, representing the consequences of a warming climate on the state's economy (including adaptation costs).[32] Net negative costs indicate that the cost of action is lower than the assumed cost of inaction.

Finally, the costs presented in Table 3 do not account for likely economic benefits, including GDP, employment, and fiscal benefits, as Vermont shifts spending from primarily imported fuels (90% of statewide emissions), to a combination of imported *and in-state* renewables. Depending on the policy option, *in-state* renewables – with associated economic benefits – can contribute to as much as 60% of the state's total energy consumption, all sectors combined. Macroeconomic modeling could illuminate the full economic costs and benefits of these policy options.

Following Table 3 below, we discuss the results of each policy individually. More detailed model results, including sectoral emissions, electricity supply, and technology choice, and fuel consumption for transportation and space heating individually, are presented in Appendices C and D.

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[32] The value adoption - $100 (in 2013 dollars) per short ton of CO2e – is the value recommended by the authors of the most recent *Avoided Energy Supply Costs in New England: 2013 Report* (Synapse Energy Economics, July 12, 2013; see page 4-23).

Table 3: Final Policy Options Results Summary

POLICY OPTION			CO2e EMISSIONS (% Change from 1990 Baseline)				RENEWABLE ENERGY* (% of Total Energy)		COSTS† (% change re. BAU)		COSTS† ($/ton)	
			2028		2050		2050		2012-2050•		2012-2050•	
		TARGETS:	50%		75%		90%					
		BIOFUELS PRICES:	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH
TAX SHIFT	LOW‡	2015: $10/t; 2028: $70/t; 2050: $450/t	-51%	n.a.	-73%	n.a.	**73%**	n.a.	**2.6%** (-4.2%)	n.a.	**$42** (-$68)	n.a.
TAX SHIFT	HIGH‡	2015: $10/t; 2028: $460/t; 2050: $1250/t	n.a.	-49%	n.a.	-78%	n.a.	**70%**	n.a.	**4.5%** (-2.9%)	n.a.	**$67** (-$43)
TREES	BASIC		**-31%**	**-33%**	**-85%**	**-86%**	86%	85%	**2.2%** (-4.3%)	**5.4%** (-1.3%)	**$38** (-$72)	**$89** (-$21)
TREES	LOCAL°	2020: 22% in-state; 2042: 40% in-state; 2050: 60% in-state	**-31%**	**-33%**	**-85%**	**-87%**	88%	85%	**3.3%** (-3.2%)	**5.5%** (-1.3%)	**$56** (-54$)	**$90** (-$20)

NOTES

Green cell shading indicates where targets are effectively met or exceeded. Pink cell shading indicates where results fall short of targets.
***Bold fonts** further indicate where variances from the target are considered significant.*

** Renewable energy content referred to above is exclusive of energy efficiency; this explains why renewable energy shares fall just short of 90% under the TREES standard.*

† In the Cost columns, the top value in each cell represents Gross Cost, i.e. the additional costs for providing the energy services demanded by each sector, taking into account the pre-tax cost of fuel and the incremental technology cost. The lower values in parentheses represent Net Cost. Net cost accounts for Gross Cost minus the assumed societal cost of CO_2 emissions. Per Vermont PSD instructions, we used $100/short ton CO_2e as an approximate reflection of the cost of inaction. Note that because we only account for carbon savings within the 2012-50 period, the full value of savings that take place in later years is understated (e.g. a measure adopted in 2048 with a 15-yr life will reduce CO2 emissions for 15 years, but our analysis only accounts for the first two of those years). On the other hand, and contrary to capital outlays, the future value of CO2 costs has not been discounted.

‡ The Carbon Tax scenario is shown for two different tax trajectories which achieve the targets under both the Low and High biofuel price scenarios. In the table we provide the tax levels at three time intervals (2015, 2028 and 2050). The tax ramps linearly between these values in the intervening years.

° The TREES Local scenario contains a constraint on the amount of renewable energy imported from outside of Vermont, resulting in a minimum local share of total energy consumed of 22%, 40% and 60% in 2020, 2042 and 2050 respectively.

• Cost results are presented for years 2012-2050, which represent milestone years for this project. In practice, the emissions and system costs had to be modelled over a slightly longer period (2011-2054).

POLICY A: CARBON TAX SHIFT

Both the low and high biofuels carbon tax cases are able to meet the 2028, as well as the 2050 statewide emissions goals. However, as discussed above under neither carbon tax case does reach the goal of a 90% renewable energy share of total Vermont energy by 2050.

As a general rule, a carbon tax shift strategy – because it provides the most flexibility in meeting the goals, and because it is squarely focused on the carbon goals – can be expected to represent the lowest-cost policy approach, at least insofar as carbon is concerned. This is borne out in the modelling results, with one, relatively minor exception (see discussion on page 45 below).

Significantly, the results presented in Table 3 underline the impact of biofuels prices on this analysis. If biofuels are available at a modest premium over liquid fossil fuels (the low biofuels price case), a carbon tax beginning at $10 and rising to $70/ton could be sufficient to reduce Vermont's carbon emissions by half by 2028. Having the carbon tax level continue to increase thereafter, to a maximum of $450/ton by 2050, could in turn reduce carbon emissions to 25% of their 1990 levels by that later year. Yet if the *high* biofuels price case better represents the future, it could require a carbon tax rising to some $460/ton by 2028, and $1250/ton by 2050, to reach the same reduction targets.

Put differently, whereas the low biofuels price case only requires a 2.6 % increase in the full, society-wide cost of meeting the state's energy service needs, the high biofuels price case, at 4.5% over baseline, requires nearly double that effort.[33] Hence implementing a successful carbon tax shift policy requires closely monitoring the evolution of fuel prices – particularly biofuels prices – and emissions results, with periodic adjustment of tax levels to meet emissions goals.

The gross cost of avoided CO_2 emissions over the 2012-2050 analysis period would be $42/ton with low biofuels prices and the lower carbon tax rate. If high biofuels prices require the use of the higher carbon tax rate, the gross cost would be $67/per ton on average.

Figure 13 and Figure 14 illustrate this policy's carbon reduction and renewable content results. For more details on sector-specific impacts of the Carbon Tax policy option, please see Appendix C.

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[33] The increased cost estimate accounts for all capital, operating, and fuel costs associated with all energy producing *and using* technologies in the state. It does not account for economic or environmental benefits flowing from these scenarios.

Figure 13: Emissions & Renewables: Low Carbon Tax (Low Biofuels price)

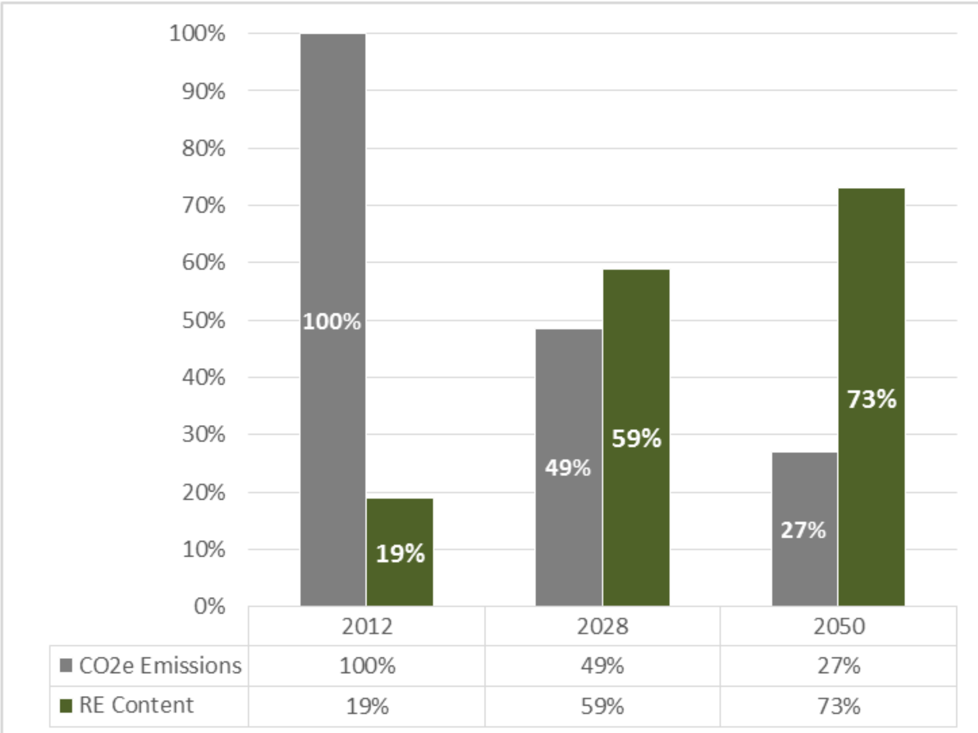
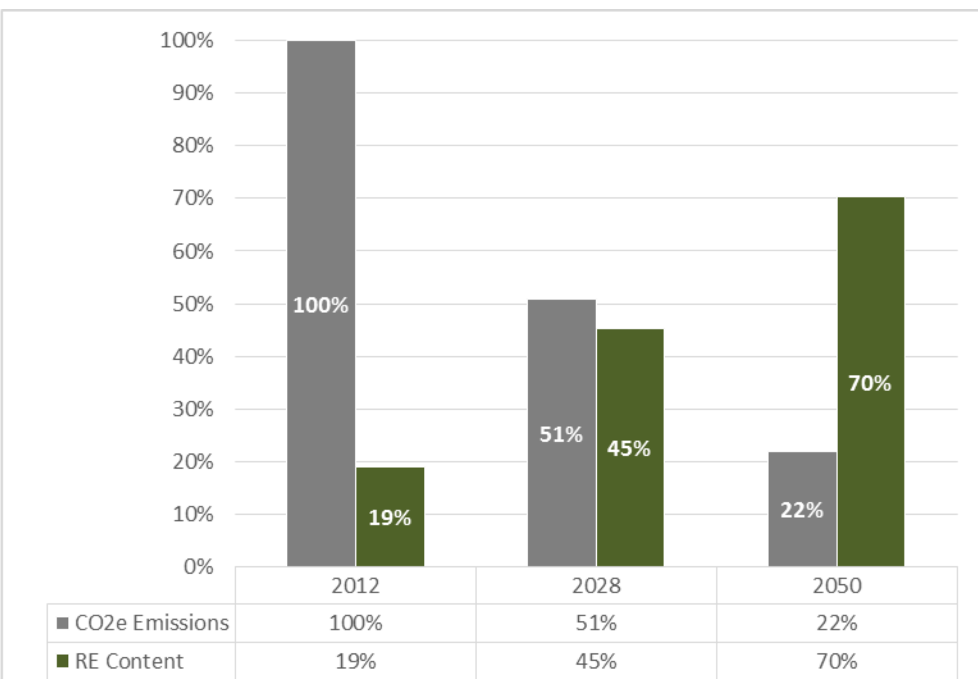


Figure 14: Emissions & Renewables: High Carbon Tax (High Biofuel price)



POLICY B: TREES BASIC

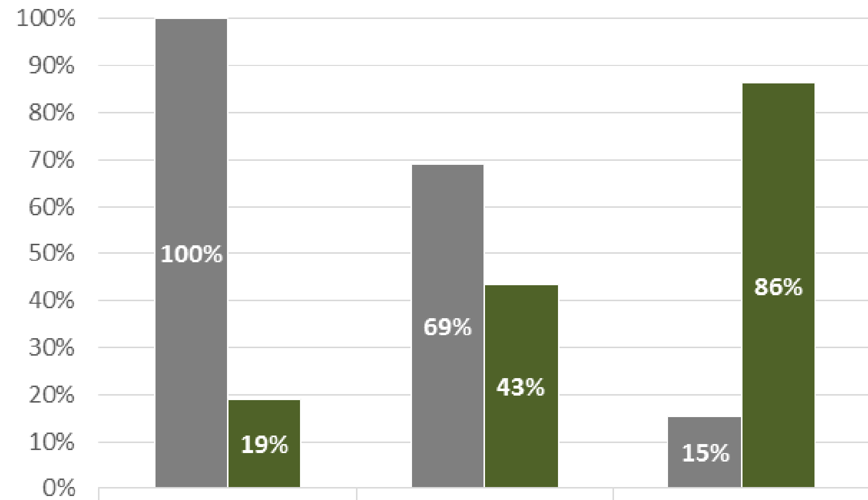
Under both the low and high biofuels scenarios, the TREES Basic policy is able to meet the 2050 renewable energy content goal, and far exceeds the 2050 carbon reduction goal. However, as discussed previously, under neither scenario does the TREES Basic policy reach the mid-term carbon reduction goal of 50% savings by 2028.

The Vermont FACETS model results presented in Table 3 suggest that the TREES Basic policy option would cost about the same per ton of avoided CO_2 emissions as the Carbon Tax policy option under the low biofuels price case, but these reductions occur far later in the policy time horizon. Under the high biofuels price case, the TREES Basic policy is approximately 35% more expensive per ton of avoided CO_2 than the tax policy. Under the low biofuels price case the TREES Basic approach results in a 2.2% increase in estimated gross expenditures for energy services during 2012-2050. This rises to a 5.4% increase under the high biofuels price case.

Under the simple linear trajectory used in this analysis, TREES Basic significantly overshoots the ultimate emissions goal, both with low and high biofuels prices, achieving a reduction of CO_2e emissions from energy use of some 85% from 1990 levels by 2050. It almost achieves the 2050 renewable energy goal, bringing renewables to 86% (low biofuels price) and 85% (high biofuels price) of total energy supply.

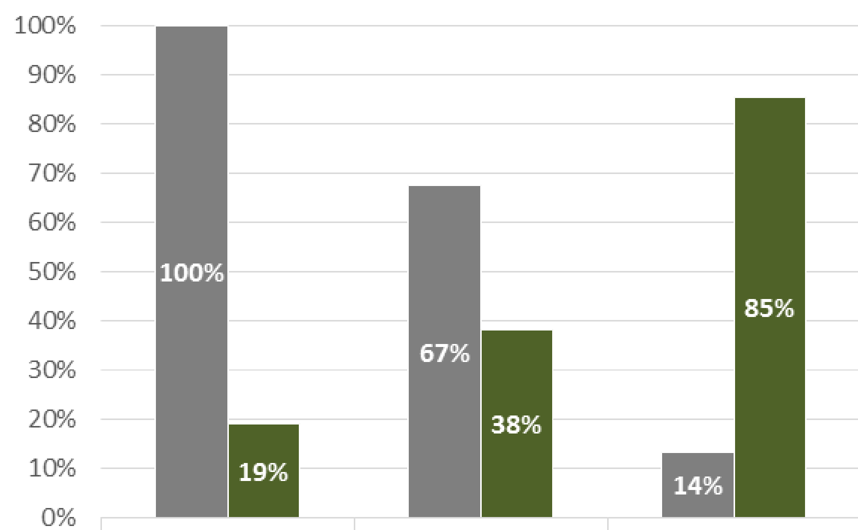
In practice, the trajectories could be adjusted to meet both emissions goals more precisely. Because this would entail a greater stringency to the TREES standard and lower emissions early on, this would increase the cost of the TREES Basic policies. For more details on sector-specific impacts of the TREES Basic policy option, please see Appendix C.

Figure 15: Emissions & Renewables: TREES Basic (Low Biofuels Price)



	2012	2028	2050
CO2e Emissions	100%	69%	15%
RE Content	19%	43%	86%

Figure 16: TREES Basic - High Biofuels Price



	2012	2028	2050
CO2e Emissions	100%	67%	14%
RE Content	19%	38%	85%

POLICY C: TREES LOCAL

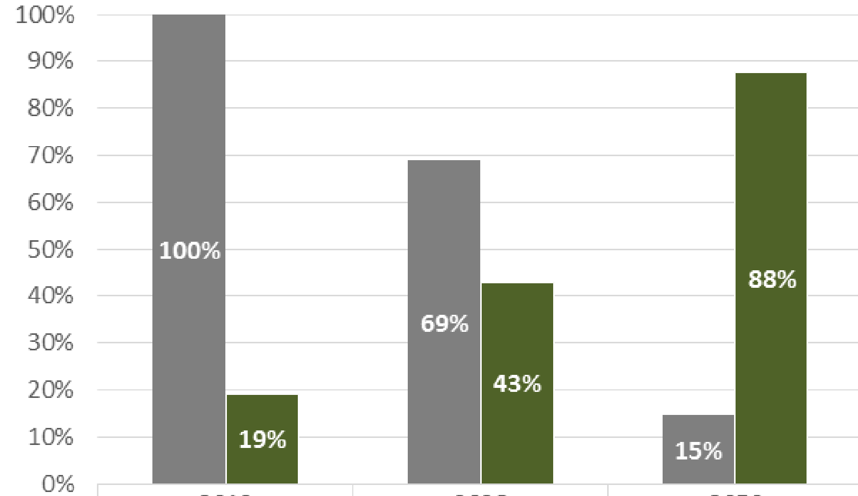
Like TREES Basic, TREES Local exceeds the 2050 emissions goal, by achieving CO_2emissions reductions from energy use in Vermont of 85-88% of 1990 levels, depending on assumed biofuels prices. TREES Local does not meet the 2028 emissions goal, but achieves the 2050 renewable energy goal in the low biofuels case and nearly meets it in the high biofuels case.

FACETS results for TREES Local are quite similar to TREES Basic, under the high biofuels price case, because it already has greater in-state content due to low biofuels imports. Unsurprisingly, the more constraining TREES Local policy option is the most expensive of the three policy options when biofuels prices are cheap, costing over 35% more per ton of avoided CO_2 emissions than the Carbon Tax policy option in the low biofuels price case. Yet under the high biofuels price case, the incremental cost is almost the same as under the TREES basic approach.

Under the low biofuels price case, the TREES local approach results in a 3.3% increase in estimated gross expenditures for energy services during 2012-2050. This rises to a 5.5% increase under the high biofuels price case.

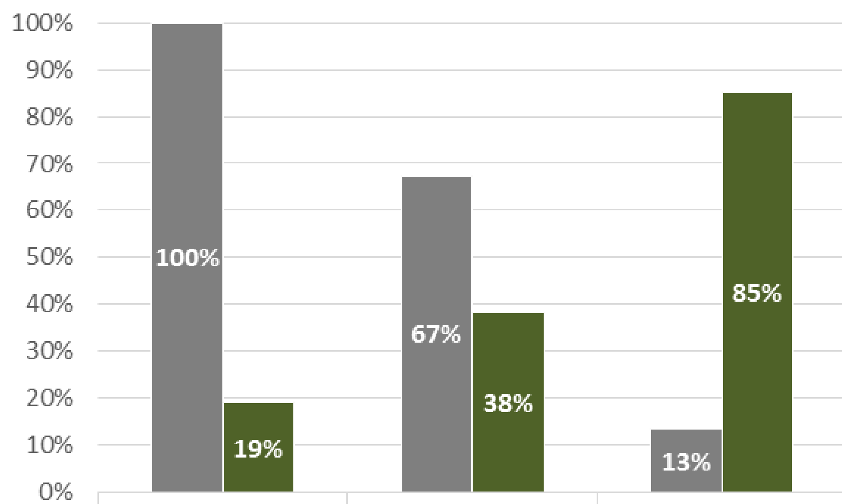
For more details on sector-specific impacts of the TREES local policy option, please see Appendix C.

Figure 17: Emissions & Renewables: TREES Local (Low Biofuels Price)



	2012	2028	2050
CO2e Emissions	100%	69%	15%
RE Content	19%	43%	88%

Figure 18: Emissions & Renewables: TREES Local (High Biofuels Price)



	2012	2028	2050
CO2e Emissions	100%	67%	13%
RE Content	19%	38%	85%

Can a TREES really cost less than a TaxSHIFT?

Economic theory would suggest that a carbon tax would be a more economically efficient policy to achieve carbon emissions reductions than TREES, because it targets carbon emissions directly and offers more options to achieve savings, whereas TREES targets fossil and nuclear energy use, and so has a less direct impact on carbon emissions. As such, we might reasonably expect that a tax could achieve the statewide emissions reduction goals at a lower cost.

Yet discounting of future costs affects the inter-scenario comparability of the average costs reported in Table 3 above. Notably, the TREES Basic policy (under low biofuels pricing) achieves a similar cumulative emissions reduction as the Carbon TaxSHIFT policy (also under low biofuels pricing), but *because the TREES emissions-reducing investments take place later in the model horizon*, the discounted average cost of the TREES is actually lower. In a sense, this is a result of the carbon goals focusing on both mid- and long-term horizons, while the renewable energy goal is concentrated solely in the long-term.

If the TREES trajectory were adjusted to comply with both the 2028 and 2050 goals, we would expect to see the cost of the TREES scenario rise above that of the corresponding tax scenario. Higher costs are seen in the high biofuels TREES Basic scenario compared to the corresponding tax scenario, because more high cost biofuels are needed to reach the more stringent 2050 renewable target than the 2050 emissions target.

Although a quantity-based policy, such as TREES, runs a greater cost risk than a tax policy, TREES offers an advantage over a tax policy when it comes to assurance that a goal will be met. If the tax trajectory from the low biofuels case were imposed, and biofuels prices turned out to be high, a rigidly implemented policy would fall short of meeting its emissions goals.

KEY FINDINGS AND RECOMMENDATIONS

DISCUSSION OF KEY FINDINGS

The comprehensive energy system modelling conducted for this project sought to provide answers to three key questions:

1. Are Vermont's sustainable energy goals achievable?
2. If so, at what cost?
3. What resources are needed to get us there, and what are the key trade-offs?

Given the inputs, constraints and assumptions built into the study, our key findings are set out below.

1. ARE GOALS ACHIEVABLE?

- Vermont's long-term goal of reducing greenhouse gas emissions by 75% by 2050 **is clearly achievable under each of the three policy options** examined.
- Vermont's mid-term goal of reducing greenhouse gas emissions by 50% by 2028 **is achievable under the Carbon Tax Shift** policy, assuming the tax level is adjusted to account for biofuel prices. However, both TREES options as modeled fall short, achieving only 34-38% reductions in the mid-term. A different TREES trajectory could achieve the 2028 goal, with most likely a modest increase in cost.
- Vermont's long-term goal of sourcing **90% of its energy from renewable resources by 2050 is largely achievable under both TREES policy options**. However, the results fall significantly short, at 71-72%, under the Carbon Tax Shift policy.

2. AT WHAT COST?

- The tested policy options, which in most cases met Vermont's GHG and renewable energy goals, **require only modest increases** to the total cost of meeting Vermont's energy needs over the 2012-2050 study period.
- The least expensive case, a TREES Basic policy operating in a low biofuel price scenario, **adds 2.2 % to the cost of meeting the state's energy needs**, spread over the 2012-2050 period. The Carbon tax shift scenario when biofuels price are low is only slightly more expensive (2.6%).

- **Under low the biofuel price scenario nearly three-quarter of the 2050 emissions reductions can be achieved at a cost between $10 and $100 per ton, and *all of the 2028 target* can be achieved at less than $70/ton.**
- The TREES Basic policy under a low biofuel price scenario achieves cumulative emissions reductions similar to the TaxSHIFT policy (also low biofuels scenario), but because the TREES emissions take place later in the model horizon, the present value cost of the TREES option appears lower. If the TREES trajectory were adjusted to comply with both the 2028 and 2050 goals, we would expect to see the cost of the TREES scenario rise somewhat above that of the corresponding tax scenario.
- The most expensive case, TREES Local with a focus on in-state sourcing of renewable energy and operating in a high biofuel price scenario, **adds 5.5% to the cost of meeting the state's energy needs**, spread over the 2012-2050 period.
- The choice of policy approach made a significant difference in total costs, under both biofuels price cases, with a carbon tax proving to be more economically efficient than TREES (with the only exception of TREES Basic under a low biofuel price scenario).
- In real-world implementation, the emissions reduction results of a given tax rate would be at higher risk of deviating from projections, depending on the costs of fuel and technology options. Conversely, a TREES policy would have more certain emissions reduction results, but more uncertain costs.

3. HOW?

- There are three pillars of the "greening" of Vermont's energy system:
    1. Increasing energy efficiency and conservation, beyond current projections;
    2. End-use substitution: biofuels and electricity in vehicles; woody biomass and electricity in buildings; and
    3. Growth in renewable power generation to support emissions-free electrification.
- **Improved energy efficiency** is achieved, even beyond the already strong baseline established by current Vermont policy (and aided by new federal standards). All policy options lead to greater energy efficiency through two primary means: price elasticity, and the switch to electricity for transportation services. Indeed, since electric-drive engines are approximately 60% more efficient than fossil fuel-powered engines, the electrification of transportation results in large energy efficiency gains across the system.
- **End-use substitution is critical**, and one in which "competition" between biofuels and electricity for transportation is the primary unsolved issue looking forward. Liquid biofuels (i.e. ethanol and biodiesel) in particular, being a relatively nascent industry that is heavily reliant on federal regulation and subsidies, face an uncertain trajectory — some anticipate relatively low

biofuel prices, while others forecast those prices (for the same carbon content) at multiples higher.

We accounted for this uncertainty by conducting a biofuel price sensitivity analysis on all policy options. We also adjusted the level of the carbon tax shift accordingly. As a result, we find that the share of liquid biofuels and woody biomass consumed may nearly double under a given policy option when biofuel prices are low. Similarly, gross costs are roughly half under a low biofuel price scenario than a high one, for the same policy option.

Risk from biofuels availability and cost – as well as whether biofuels can be produced at low lifecycle carbon intensities – emerges from this study as a key risk for Vermont to manage as it moves towards it energy and environmental goals.

We note that biofuel supplies (primarily ethanol) are expected to be almost entirely imported. Inversely, woody biomass (cordwood, pellets and chips) is an in-state resource[34], but for which growth beyond business-as-usual is relatively limited.

- **Renewable power supplies can be grown sufficiently to power the electrification of light-duty transportation.** The TREES policy approaches have a significantly stronger influence on the growth of renewable power generation, both in- and out-of-state.

  In the near- and mid-terms, growth in renewable power can be secured at far lower cost through large-scale / centralized resources, with relatively low associated risks. These resources are most likely to be sited out-of-state. In the longer term, in-state, distributed power sources, including solar power, can grow to play a significant if not dominant role, with both costs and risks expected to decrease over time.

[34] In this study, we modeled pellets as largely imported. Pellets could also be produced in Vermont in larger quantities than they are now.

RECOMMENDED NEXT STEPS

Vermont's ambitious sustainable energy goals are achievable, assuming new, relatively aggressive, and sustained policies can begin to be implemented in short order.

Recognizing the critical uncertainties before us – in particular re. the evolution of biofuel prices and/or carbon content – we recommend the following near-term steps be taken.

IMPROVE KNOWLEDGE: *Beyond the work conducted for this study, additional knowledge of key near- and long-term opportunities should be developed.*

- **Assess biomass potential.** While Vermont has already invested substantively in converting some institutional heating loads to biomass, near-term opportunities would appear to remain in the medium and large commercial and non-school institutional markets (wood chips), as well as in Vermont homes and small businesses (pellets). Vermont can immediately move to assess the potential for increased use of biomass resources, including the feasibility of policies aimed at growing a more comprehensive biomass supply chain, with an emphasis on delivery vehicles and storage.

- **Closely monitor biofuels evolution.** The scope of this study was limited to a cursory assessment of future biofuel prices (and to an assumption re. carbon content). Given its importance in model outcomes, Vermont would be well-advised to examine this issue more closely, including projections of the likely prices *and* carbon content of biofuels that could be delivered to the state over the coming 10-20 years.

- **Electrification of transportation:** While this study accounted for electrification opportunities in light-duty vehicles, we did not seek to assess opportunities in medium- and heavy-duty vehicles. Better understanding of these opportunities would be useful.

NEAR-TERM ACTIONS: *Immediate, targeted policy action can be taken while the state considers more comprehensive options. Options include:*

- **Electric vehicle promotion.** The electrification of light-duty vehicles will clearly play an important role in any low-carbon energy future. The state can (and has already begun to) aggressively promote electrification, through a variety of policies including rebates and/or tax exemptions for vehicles and in-home chargers, installation and/or cost-sharing and promotion of public high-voltage chargers, and high-value privileges (e.g. parking meter exemptions in conjunction with towns), among other targeted policies.

- **Non-electric shell conservation.** Similarly, energy efficiency improvements in buildings will continue to play a key role in minimizing carbon emissions. Vermont can continue to – and perhaps intensify – its efforts at non-electric building efficiency, in particular through measures aimed at improved building shells in homes and businesses currently heated by unregulated fuels (oil, propane).

- **Collaboration with regional partners.** Finally, continued collaboration with regional partners, given the regional nature of most markets for both energy supply and usage technologies (e.g. heating equipment), will remain a critical component of the state's efforts going forward.

EVALUATING POLICY PATHS

- **Evaluating TaxSHIFT and TREES.** Ultimately, Vermont will have to choose among policy options. This project identified two critical options most likely to achieve the state's goals – a revenue-neutral fiscal shift from current taxed items to carbon, and a renewable energy standard that encompasses all fuels and end-uses, including transportation (with or without an additional emphasis on in-state sourcing).

  These pathways elicit clear tradeoffs, in terms of primary focus (carbon or renewable energy); risk (of achieving secondary targets); cost (see report findings); sensitivity to key uncertainties (e.g. biofuels); administrative burden (a carbon tax requires relatively little administration; a TREES would be more demanding); compliance and enforcement; stateside economic benefits including job creation and fiscal revenue (including among the two TREES variants); other environmental benefits or costs; and political feasibility.

  Perfect information will never exist. Still, the choice among fundamental policy options would benefit from a feasibility study designed to examine most or all of these parameters. This study should be undertaken in close conjunction with state officials, and involve key legislators. Moreover, it will need to be launched expeditiously if policy decisions are to be made, implemented, and ramped-up on time to achieve the initial emissions reductions targets. Given the extent of change required of Vermont's energy system to meet the 2028 goals, fourteen years will be none too many.

APPENDIX A: THE FACETS MODEL

BACKGROUND

The Framework for Analysis of Climate-Energy-Technology Systems (FACETS) model is a multi-sector, multi-region model of the United States energy system. FACETS analyzes the costs and benefits of policy and technology options over all sectors of the energy system – resources, electricity generation, transportation for people and freight, and industrial and building energy use. Diverse policies and measures can be combined and assessed simultaneously, rather than simply being added up, identifying potential synergies and offsetting effects between approaches. It captures all efficiency-supply interactions, and enables analyses of options that may simultaneously transform multiple sectors, such as widespread use of electric vehicles.

FACETS represents real energy technologies and the infrastructure that connects them. For example, in the power sector, it models individual power plants and their dispatch, retrofit, and retirement options. In the residential sector, dozens of devices utilizing different fuels, at different efficiency levels, compete to deliver energy services including heating, cooling, refrigeration, and lighting. Unlike many other powerful energy models, FACETS is transparent, easy to explain, and flexible enough to explore technology futures far from the current energy system. Multiple scenarios can be run and interpreted quickly and easily, to allow for exploration of uncertainty about key variables, assess multiple possible policy variants, and design robust strategies. As a multi-region model, FACETS captures the geographical relationships – such as those between renewable resources, electricity loads, and transmission capacity – that are key drivers of the costs of energy system transition.

FACETS was created using the TIMES (The Integrated MARKAL-EFOM System) model generator was developed as part of the IEA-ETSAP (Energy Technology Systems Analysis Program) [35], an international community which uses long term energy scenarios to conduct in-depth energy and environmental analyses. The TIMES model generator combines two different, but complementary, systematic approaches to modelling energy: a technical engineering approach and an economic approach. TIMES is a technology rich, bottom-up model generator, which uses linear-programming to produce a least-cost energy system, optimized according to a number of user constraints, over medium to long-term time horizons. This design makes TIMES well-suited for analyses, such as the Vermont Total Energy Study, that require the exploration of diverse possible energy futures based on contrasted scenarios that differ greatly from business-as-usual system evolution.

[35] See http://www.iea-etsap.org/web/Times.asp.

INPUTS AND MODEL DESIGN

The FACETS model represents the Vermont energy economy using a Reference Energy System (RES), i.e. a network that links resource supplies, energy conversion and processing technologies, end-use devices, and energy services, tracking the flows of energy and associated emissions. The data collected for the FACETS model of the Vermont energy economy falls into the following broad categories.

- Existing energy flows, typically captured by the energy balance and energy statistics; e.g. imports/exports, production and consumption by fuel and by sector.
- Resource stocks, e.g. estimated fossil fuel reserves and production limits, renewable potential.
- Existing stocks of supply technologies; e.g. capacity and retirement schedule of existing power plants, pipelines, electricity transmission lines, and their associated running costs, efficiencies and other operating characteristics.
- Existing stocks of demand technologies, e.g. air conditioning units, types of appliances, industrial boilers, vehicle types, etc.
- Socio-economic drivers for energy services demands, e.g. projected population and GDP growth by economic sector and their sensitivities to each of the demand services.
- Planned future supply projects, e.g. planned pipelines, transmission lines, power plants; associated investment costs, operating costs and efficiencies.
- Anticipated future supply and demand technologies, e.g. investment cost and efficiency of new conventional and renewable power plants, various types of automobiles, air conditioners, etc.
- Hourly load curve for electric demand, and the breakdown of consumption by sector and end-use application.
- GHG emission coefficients for fuel combustion and some industrial processes.

Much of FACETS data is derived from high quality national databases, including as the NEMS (National Energy Modeling System) model[36] used by the U.S. Energy Information Administration (EIA) for the publication of their Annual Energy Outlook, and the U.S. Environmental Protection Agency's National Electric Energy Data System[37] database of power plants. In addition, the Vermont FACETS model includes a complete set of future technology options from other existing models and recent reports from the US EIA, the technology briefs of the ETSAP program of the IEA (International Energy Agency)[38], the IRENA (International Renewable Energy Agency)[39], etc. These data have been reviewed to ensure

[36] http://www.eia.gov/

[37] http://epa.gov/airmarkets/progsregs/epa-ipm/BaseCasev513.html#needs

[38] http://www.iea-etsap.org/web/E-TechDS/Technology.asp

[39] http://www.irena.org

that the cost and performance data used to characterize these future technology options is fully up to date and is adjusted as appropriate in the context of Vermont.

The Dunsky Team complimented these data sources with guidance provided by the VT PSD and from Vermont stakeholders with sector-specific knowledge. In particular, as the FACETS model originally described Vermont as part of the New England region, a significant amount of Vermont specific data was gathered to define the unique characteristics of the Vermont energy system, enabling it to be broken out as a distinct region in the model, as well as to reflect the objectives and constraints that will help achieving GHG and renewable energy goals in Vermont. Appendix B lists some of the most important assumptions guiding the characterization of Vermont's greenhouse gas emissions reduction potential.

For all Vermont FACETS scenarios the GHG emissions analysis was guided by the definitions established in 10 V.S.A. § 578, and by the structure established by the Vermont Agency of Natural Resources' GHG emissions inventory. This analysis does not include GHG from the embedded energy in products, but does account for emissions from electricity generated elsewhere and then consumed in Vermont. The PSD supplied the carbon contents for the solid biomass (cordwood, pellets, and chips), biogas, and biofuels.

APPENDIX B: POLICY OPTIONS PROPOSED FOR EVALUATION

The Dunsky team initially assessed 15 technology options (grouped into four technology pathways), as well as 14 policy instruments (grouped into 5 policy sets), before settling on the three policy options to model. The table below illustrates the initial set of options considered.

Table 4: Policy Options Considered for Early Assessment

TECHNOLOGIES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Distributed/Local/Diversified	●			●						●					
Economies of Scale		●				●		●			●		●		
Electrification			●		●		●					●			●
Biomass/Biofuels									●					●	
POLICY INSTRUMENTS	**Carbon Tax Shift**			**Prescriptive Taxes and Rates**				**CO2 revenue and new programs**		**Statewide Clean Energy Standard**			**New England Regional Policy**		
Tax on CO2 eq emissions equal to societal cost of emissions.	●	●	●												
Tax credits for voluntary program participants	●	●	●												
Continue EEU structure for fuels	●	●	●	●	●	●	●	●	●				●	●	●
Use CO2 tax to fund programs that advance state energy goals	●	●	●					●	●						
RPS standards				●	●					●	●	●	●	●	●
RE and EE standards for non-electric energy suppliers										●	●	●			
Utility regulatory models adapt to encourage fuel switching				●	●	●	●	●	●						
Encourage net metering				●	●		●								
Excise tax on fossil fuel content in heating fuels				●	●	●	●								
Feebate purchase and tax structure for vehicles				●	●	●	●								
VMT-based transportation funding				●	●	●	●						●	●	●
Land use policy incentives and Smart Growth				●	●	●	●								
Voluntary RE planning targets for energy suppliers						●	●	●	●						
Regional infrastructure and incentives for vehicles funded by regional tax/fee structure													●	●	●

APPENDIX C: ADDITIONAL MODEL RESULTS

SCENARIOS

This appendix provides additional modelling results – and preceding discussions – regarding four factors:

1. Carbon Emissions by Sector
2. Transportation Needs by Fuel and by Vehicle Technology
3. Space Heating Needs by Fuel
4. Electricity Supply

Results are provided for seven scenarios: the Business-As-Usual scenario, and each of the three modelled policies using both low and high biofuel price scenarios. Finally, results are provided for both 2028 and 2050 timeframes.

Legend for policy option runs in the following sections:

BAU	=	Business as usual. Evolution of the current energy system with no additional policies
Tax-HiBio	=	Carbon tax grows from $10/ton of CO_2in 2015 to at $1250/ton by 2050 with high biofuels price
Tax-LoBio	=	Carbon tax grows from $10/ton of CO_2in 2015 to at $450/ton by 2050 with low biofuels price
TREES-HiBio	=	Total Renewable Energy and Efficiency Standard, high biofuels price
TREES-LoBio	=	TREES, low biofuels price
TREES-HiBio-Local	=	TREES with constraints on out-of-state fuel imports; high biofuels price
TREES-LoBio-Local	=	TREES with constraints on out-of-state fuel imports; low biofuels price

CARBON EMISSIONS BY SECTOR

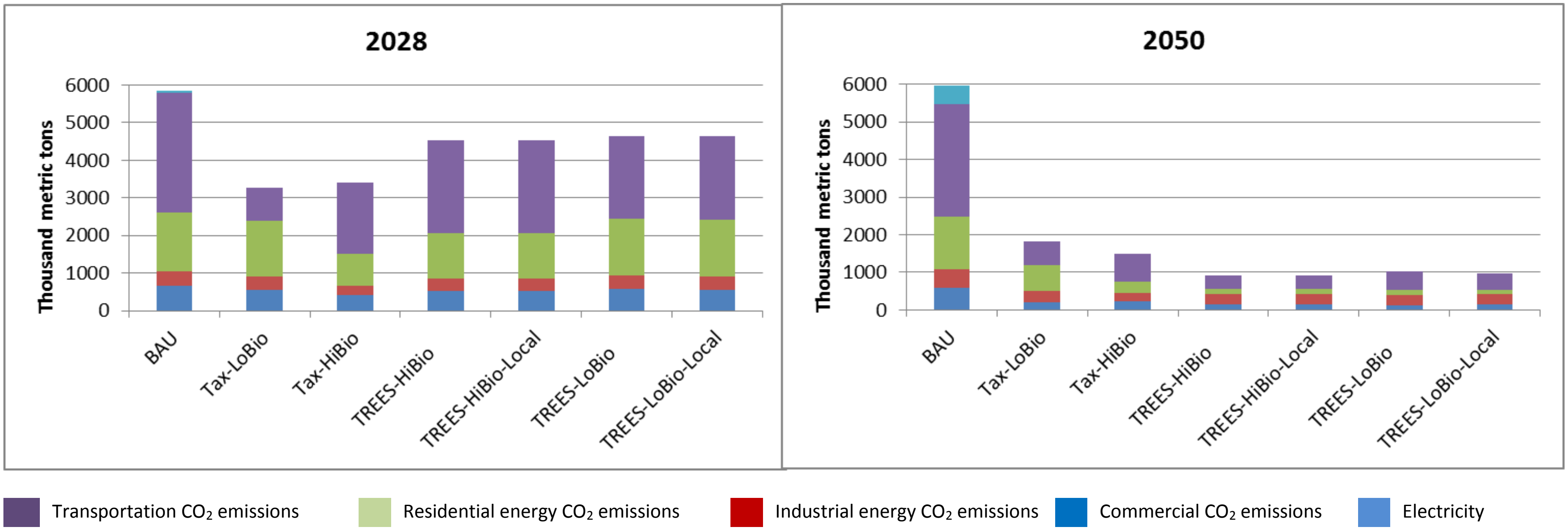
Under the tax policy, the sources of early emissions reductions are quite different, depending on the biofuels price. When biofuels are cheaply available, early reductions can be made at low cost in the transport sector by substituting biofuels for gasoline and diesel. When biofuels prices are high, early reductions are more cost-effective in the buildings sectors. By 2050, steep reductions are required in all sectors, so the differences between the two scenarios decrease, but residential emissions are still twice as high in the low biofuels price scenario as in the high price scenario.

As discussed in the Results section above, because of the particular Total Renewable Energy and Energy Efficiency Standard (TREES) trajectory modeled, all of the TREES policy options fail to meet the 2028 emissions goal and overshoot the 2050 goal. A different standard trajectory would lead to a different emissions trajectory. One important reason for the slow initial emissions reduction under TREES is that nuclear electricity imports are charged an effective efficiency of approximately one-third, similar to a low efficiency coal plant, in keeping with the broad policy goal of not encouraging nuclear power. As there are opportunities to use fossil fuels directly with much greater efficiency, for example, for end use heating, the nuclear imports are one of the first non-TREES compliant resources eliminated by the standard, as shown in Figure 24: Electricity Consumption by Source

Figure 25 below. Replacement of nuclear imports with renewable energy is a low-cost option for meeting the TREES standard, but of course does not contribute to reduction of carbon emissions.

The biofuels price has a similar, but lesser impact on the sectoral distribution of emissions reductions under TREES than under a tax policy, because the TREES trajectory tightens faster, later. The TREES Basic and TREES Local policy options produce similar emissions results.

Figure 19: GHG Emissions by Sector



ENERGY SUPPLY – TRANSPORTATION FUELS AND VEHICLES

It is in the transportation sector that the influence of biofuel prices on the relative value of the Carbon TaxSHIFT and TREES options become most evident. Currently in Vermont, about 80% of vehicle fuel sold is gasoline, with the remaining comprised primarily of diesel.[40] Under the Carbon TaxSHIFT policy option with low biofuels cost (Tax-LoBio), with no constraints on substituting biofuels for petroleum fuels, a $70 carbon tax in 2028 rising steadily to approximately $450 in 2050 is sufficient to meet the emissions goals for those years. In this scenario, substituting biofuels for petroleum in the transportation sector is a key strategy for achieving emissions goals, as shown in Figure 20 above.

Current "flex-fuel" vehicles run on any combination of gasoline and ethanol blend, and Figure 20 implies that under the low biofuels price scenario a majority of Vermont's vehicles would switch to new technologies and be either flex-fuel or diesel powered (by biodiesel) by 2028. It is worth noting, however, that the model assumes that cost alone drives stock turnover, i.e. it does not account for other drivers (e.g. innovators and early adopters whose adoption of new technologies may precede cost-effectiveness) or barriers (e.g. consumer perceptions or habits; lags in stocking changes; etc. that may slow mass adoption).

Under the Carbon Tax policy option with high biofuels cost (Tax-HiBio), and all TREES policy options, uncertainty regarding the pace of the transition to new vehicle technologies remains, but the share of petroleum in transportation fuel drops more gradually over time allowing a smoother transition than under the Carbon Tax with low biofuels cost (Tax-LoBio). Electricity's share of transportation fuel is significantly higher by 2050. Given the greater efficiency of electric drivetrains, this implies that electric vehicles' share of the Vermont vehicle market is higher than electricity's share of the energy supplied for mobility purposes.

Figure 21 shows the role of different vehicle technologies in the light-duty vehicles subsector, and the pronounced differences between the low and high biofuels prices cases. Electrification of vehicles is important even in the BAU scenario, with just over one-third of vehicles being electric by 2050. In the low biofuels price policy cases, electrification by 2050 is enhanced to over half of the vehicle fleet, but it is not accelerated, as liquid biofuels prolong the use of liquid fuel-powered mobility. In the high biofuels price cases, electrification is strongly accelerated, and by 2050, virtually all light-duty vehicles are fully electric or plug-in hybrids.

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[40] Data from the U.S. Energy Information Administration.

The light-duty segment is the only portion of the transportation sector for which electrification options were modeled in this study.[41] Other transport modes – including medium-duty and heavy-duty truck travel, which make up more than 20 percent of Vermont's transportation energy consumption in 2012, and up to 40 percent in some scenarios by 2050 – are reliant on a liquid-fuel mitigation technology. Although heavy vehicle efficiencies increase substantially in the high biofuels price scenarios, the demand for biofuels remains strong, because biofuels were the only options considered that could achieve deep emissions reductions. Should electric mobility options emerge for this segment, costs could diminish substantially under the high biofuel price scenario. Similarly, should biofuels not be available, or have an unacceptably high carbon content, Vermont would not achieve its goals without an alternative freight transportation technology.

[41] The 2014 *Energy Technology Perspectives* study from the International Energy Agency explores electrification technologies and strategies for freight and other transport modes. http://www.iea.org/etp/

Figure 20: Transportation Energy Consumption

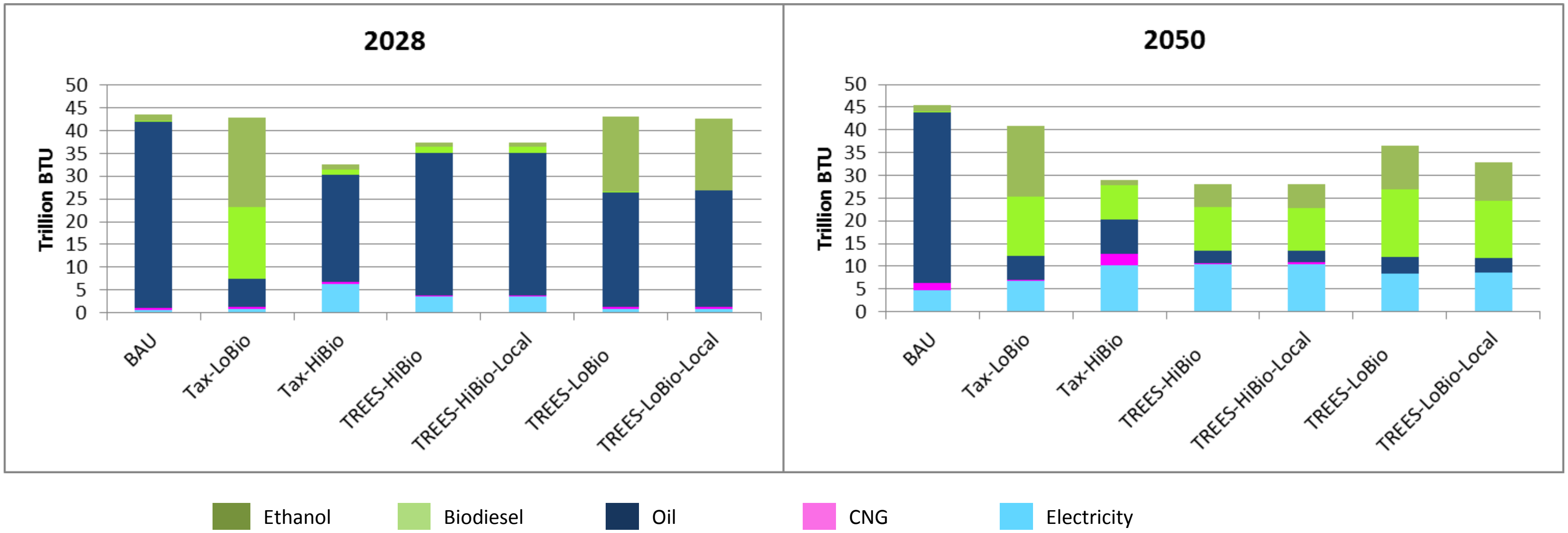
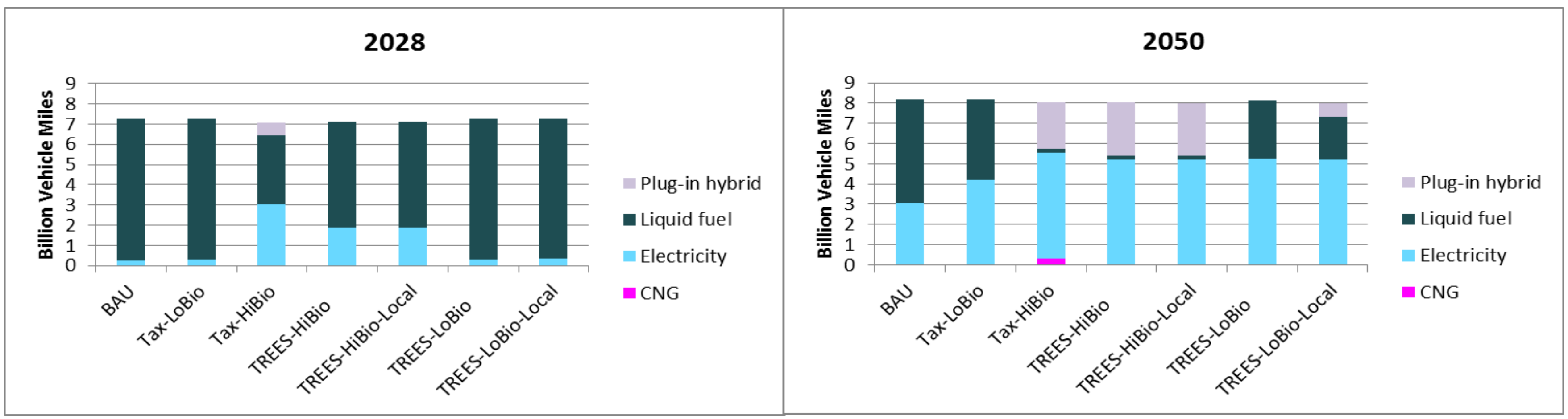


Figure 21: Transportation - Vehicle Miles Travelled (Light Duty Vehicles)



ENERGY SUPPLY – SPACE HEATING

Figure 22 shows energy consumed to produce space heat, while Figure 23 shows the portion of space heating *demand* contributed by each technology type (for example, the 2050 electricity bars are much higher in Figure 23 than in Figure 22 because of the high efficiencies of electric heat pumps.)

The differences between the policy options are less dramatic in the Space Heating sector here than in Transportation, but there are still significant differences between the low and high biofuels price cases. In this crucial sector of Vermont's energy economy, there is no one silver bullet technology. All options rely on a mix of efficiency, fuel-switching, electrification, and biofuels use, although in different proportions and with different time evolutions.

Technology patterns in this sector are influenced by a number of model constraints intended to represent consumer preferences and the diversity of housing stock. In 2028 the share of biomass remains at current levels. Increased penetration of cord wood is not limited by availability or price, but by a technical constraint which estimates the maximum share of households that will find managing cord wood feasible or desirable. The use of pellets for space heating is not constrained, but the high capital costs of pellet boilers prevent pellets from penetrating beyond a small share of households that are assumed to be able to retrofit existing boiler systems at lower cost. It is assumed that some share of households' currently using propane and heating oil are unable or unwilling to switch fuels by 2050. This minimum share is set at 5% each by 2050. Biodiesel is allowed to substitute for heating oil in all households where heating oil is used.

Under current Department of Energy-projected natural gas prices, gas is the cost-effective space heating fuel in the BAU scenario wherever it is available, reaching over 50 percent of space heating fuel consumption by 2050.[42] In the low biofuels price scenarios, natural gas use for space heating is prolonged by the ability to get cheaper reductions from biofuels use in the transport sector. Under the tax policy, gas retains a substantial portion of the space heating demand, and a correspondingly high share of remaining emissions by 2050. The TREES and TREES-Local policies, with their explicit constraint on fossil fuel use, dramatically reduce gas use by 2050.

Improvements in building shell efficiencies play an important role in all scenarios except the Tax-Lo scenario, reducing heating demand by more than 20 percent in the high biofuels policy cases. Shell efficiency is also a major in-state resource for complying with the TREES-Local policy even under low biofuels prices. Electrification in the form of advanced air-source heat pumps also plays a major role in

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[42] No explicit costs for extending natural gas distribution infrastructure were modeled. This extension was assumed as part of the Business as usual scenario.

all scenarios except the Tax-Lo scenario. Biofuels are used to substitute for heating oil by 2050 in all but the Tax-Hi scenario.

Given the importance of biofuels price risk for the cost of meeting Vermont's emissions goals, these results suggest that an early investment in space heating measures, particularly building shell efficiency, is a key opportunity to hedge against risk.

Figure 22: Space Heating Fuel Consumption

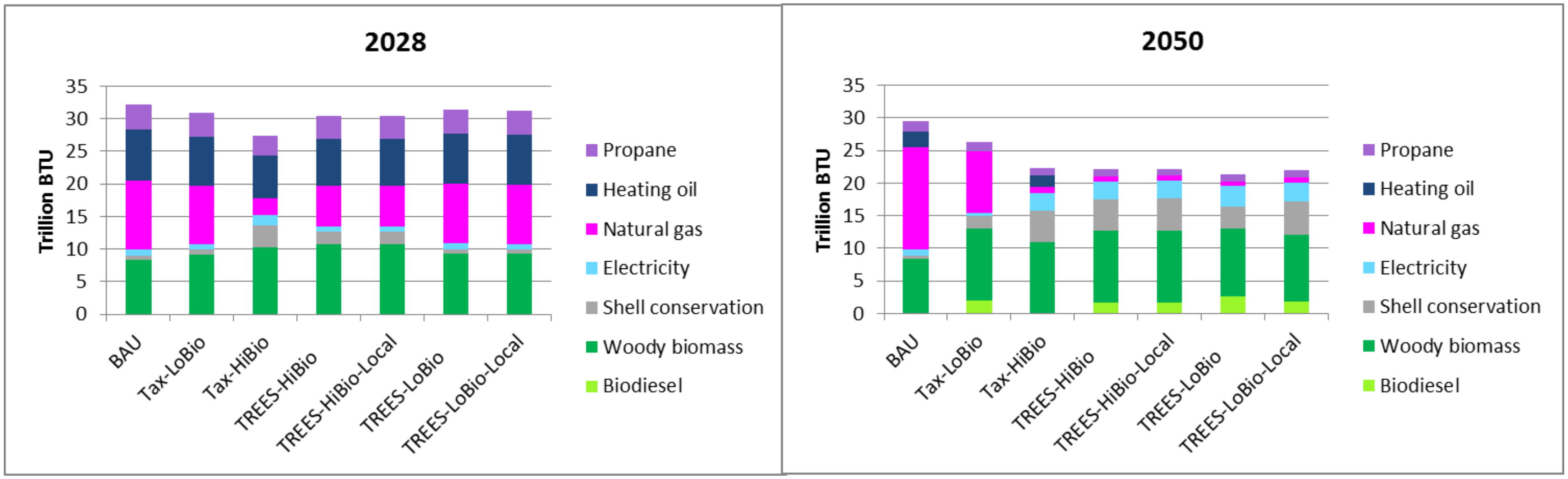
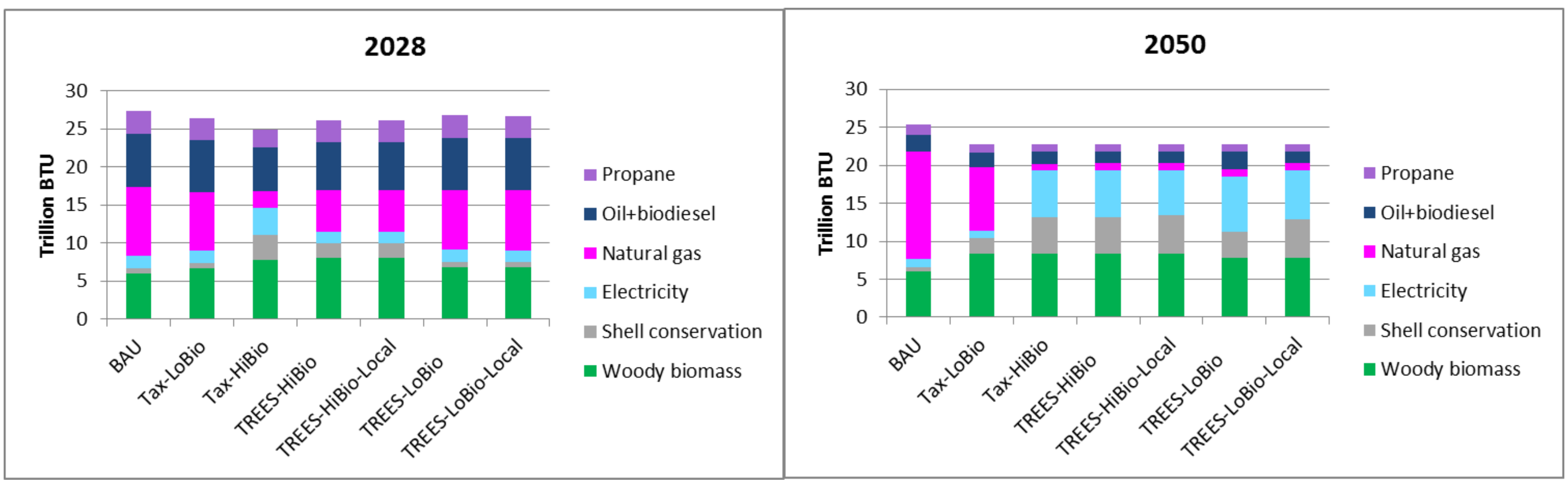


Figure 23: Space Heating Delivered



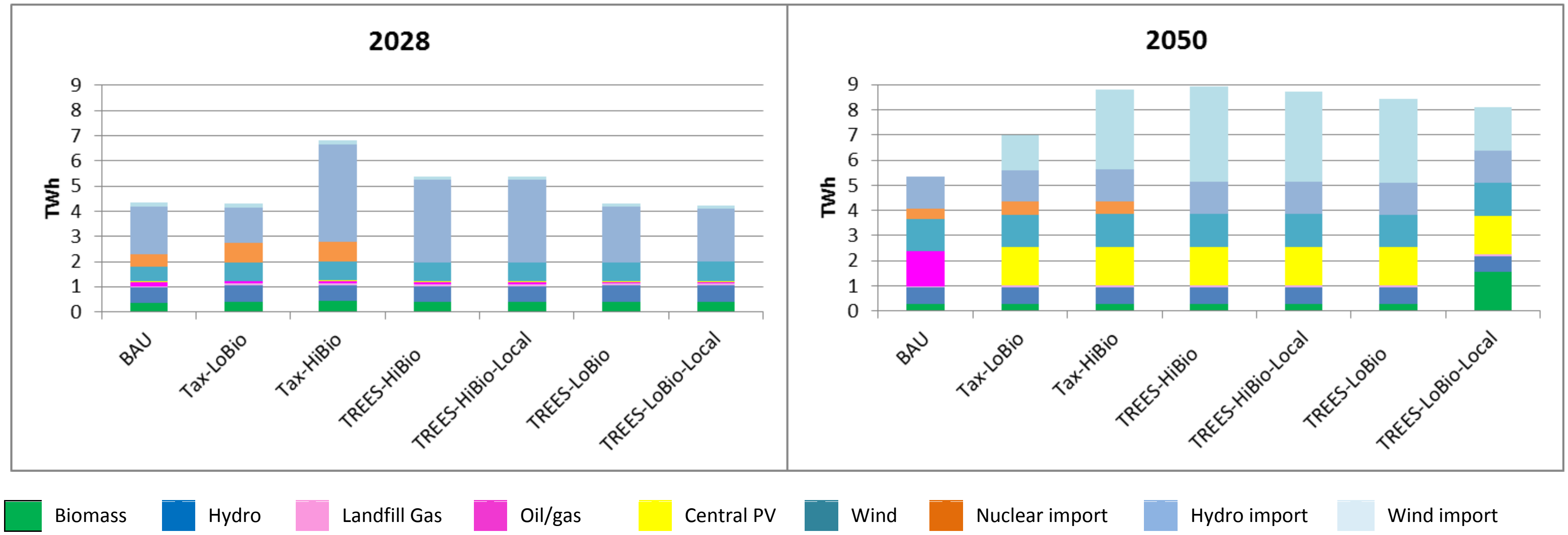
ENERGY SUPPLY – ELECTRICITY

In general, the high biofuels price scenarios use more electricity than the low, due to greater and earlier electrification in transport and heating. Much of this electricity comes from imports of hydroelectricity from Quebec and, later, wind electricity from New England. These additional imports are needed because all of Vermont's wind capacity and distributed PV capacity are used in the Business as usual scenario. All of the policy options also fully utilize Vermont's assumed utility-scale solar PV capacity by 2050.

All TREES options eliminate nuclear imports early, because of the high fossil-equivalent efficiency charge built into the model. Direct fossil use in other sectors is more economically efficient for the TREES constraint, relative to nuclear electricity.

The TREES-Local scenario under low biofuels prices meets the in-state requirement by reducing wind imports and bringing on additional biomass generation. This resource has very low efficiency, and is cost-effective only in this scenario, because of the combination of low prices for imported biofuels and the in-state resource requirement.

Figure 24: Electricity Consumption by Source



APPENDIX D: RELATED DOCUMENTS

In addition to the enabling legislation and regulations that establish Vermont's statewide greenhouse gas reduction and renewable energy goals, this report also mentions four other related documents[43] (in chronological order):

Meeting the Thermal Efficiency Goals for Vermont's Buildings
(Published by the Vermont Public Service Department, January 2013)

The Vermont Energy Efficiency and Affordability Act (2007-2008 legislative session Act 92; 10 V.S.A. § 581) established building efficiency goals for the state. This report was produced by the Vermont Thermal Energy Taskforce as part of the ongoing effort to improve the energy efficiency of Vermont's buildings. It includes a wealth of data and analysis regarding Vermont buildings that was used to create the scenarios described in this report.

Policy Options for Achieving Vermont's Renewable Energy and Carbon Targets
(Published by the Regulatory Assistance Project, June 2013)

This report by the Regulatory Assistance Project (referred to below as "the RAP report") was designed for use by the PSD to facilitate discussions with stakeholders about the statewide goals and the means to reach them. It provides an overview of the most promising technologies and policies available to Vermont.

PSD Legislative Report
(Published by the Vermont Public Service Department, December 2013)

The PSD issued this report to inform the Legislature and the public of progress to-date in carrying out the Total Energy Study. It also describes the renewable energy sources that are included in the Total Energy Study analysis, and talks about where and how non-renewable energy would continue to be used when greenhouse gas emissions have been reduced by 75%, and 90% of energy comes from renewable resources.

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[43] All documents are available on-line:

Meeting the Thermal Energy Goals for Vermont's Buildings is available at: http://www.leg.state.vt.us/reports/2013ExternalReports/285749.pdf

Policy Options for Achieving Vermont's Renewable Energy and Carbon Targets & PSD Legislative Report are both available at: http://publicservice.vermont.gov/publications/total_energy_study#

Vermont Comprehensive Energy Plan is available at: http://publicservice.vermont.gov/publications/energy_plan

Vermont Comprehensive Energy Plan (Vols 1 & 2)
(Published by the Vermont Public Service Department, December 2011)

The Comprehensive Energy Plan addresses Vermont's energy future for electricity, thermal energy, transportation, and land use. This document represents the efforts of numerous state agencies and departments, and input from stakeholders and citizens who shared their insights and knowledge on energy issues.

APPENDIX E: DETAILED RESULTS PER POLICY OPTION

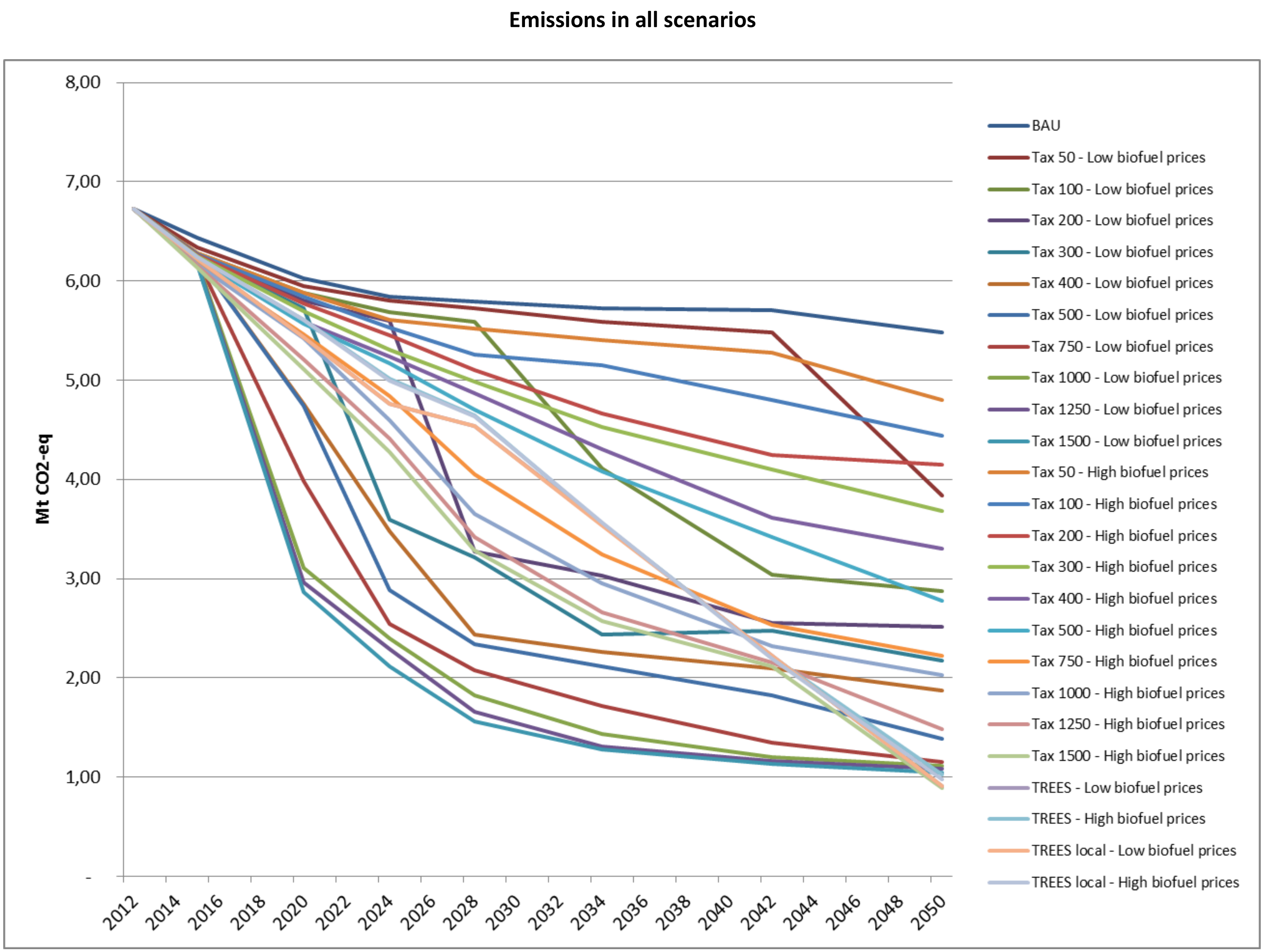
Below we provide visual illustrations of the full set of results derived from the modelling exercises. Each page provides results for one policy option under one scenario. For example, the "TREES low biofuel prices" provides results for the TREES Basic policy, under a scenario of low biofuels prices.

The reader is cautioned that the shorthand titles representing the Carbon Tax Shift policy options are indicative of the maximum carbon tax at the end of the full period. For example, the "Tax 400" policy represents a policy under which taxes are shifted from other areas of the economy to carbon, at a rate that begins at $10 and gradually increases to a maximum of $400 per ton of CO_2 by 2050.

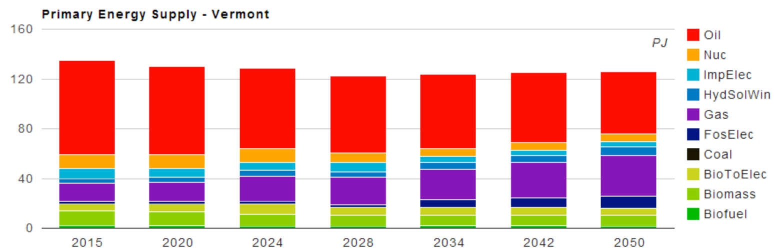
To avoid any confusion, the reader will note that this appendix provides results for a broader set of carbon tax shift options than are discussed in the report. Indeed, the main report limits its discussion to two levels of carbon tax shift, chosen as sufficient to meet or exceed the carbon reduction targets under different biofuel price scenarios.

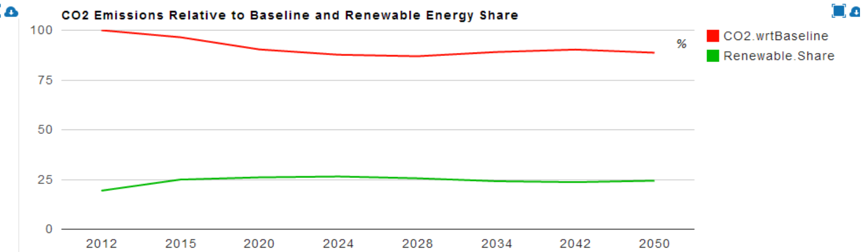
We also invite the reader to note that all results in this appendix are expressed in energy – not GHG, nor services – terms. For example, when examining the issue of electrification of transportation, the reader should note that because electric vehicles are significantly more efficient than gasoline or diesel-powered vehicles, the shares of electric *energy* used in transportation does not reflect the share of *electric vehicles*, or more accurately of vehicle miles travelled (VMT) using electric power. Put differently, a 10% electric *energy* share of transportation needs, as illustrated in one of the charts below, may in fact represent a 20-30% share of vehicles running on electricity, all else being equal.

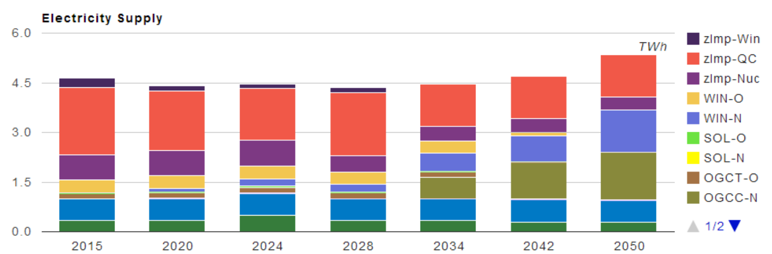
Finally, we note that the FACETS model does not yet properly account for real-world lags in adoption of newly cost-efficient technology. As such, the more disaggregate charts presented below may include sudden – and somewhat unrealistic – jumps or declines in market share, when in practice these changes would likely involve a smoother adoption curve (both on the front and back ends).This should not materially impact the long-run targets.

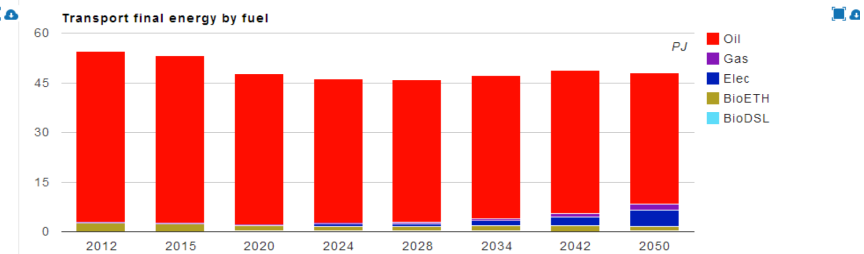

Emissions in all scenarios
Mt CO2-eq
8,00
7,00
6,00
5,00
4,00
3,00
2,00
1,00
-
2012
2014
2016
2018
2020
2022
2024
2026
2028
2030
2032
2034
2036
2038
2040
2042
2044
2046
2048
2050
BAU
Tax 50 - Low biofuel prices
Tax 100 - Low biofuel prices
Tax 200 - Low biofuel prices
Tax 300 - Low biofuel prices
Tax 400 - Low biofuel prices
Tax 500 - Low biofuel prices
Tax 750 - Low biofuel prices
Tax 1000 - Low biofuel prices
Tax 1250 - Low biofuel prices
Tax 1500 - Low biofuel prices
Tax 50 - High biofuel prices
Tax 100 - High biofuel prices
Tax 200 - High biofuel prices
Tax 300 - High biofuel prices
Tax 400 - High biofuel prices
Tax 500 - High biofuel prices
Tax 750 - High biofuel prices
Tax 1000 - High biofuel prices
Tax 1250 - High biofuel prices
Tax 1500 - High biofuel prices
TREES - Low biofuel prices
TREES - High biofuel prices
TREES local - Low biofuel prices
TREES local - High biofuel prices

Business-as-usual (BAU)

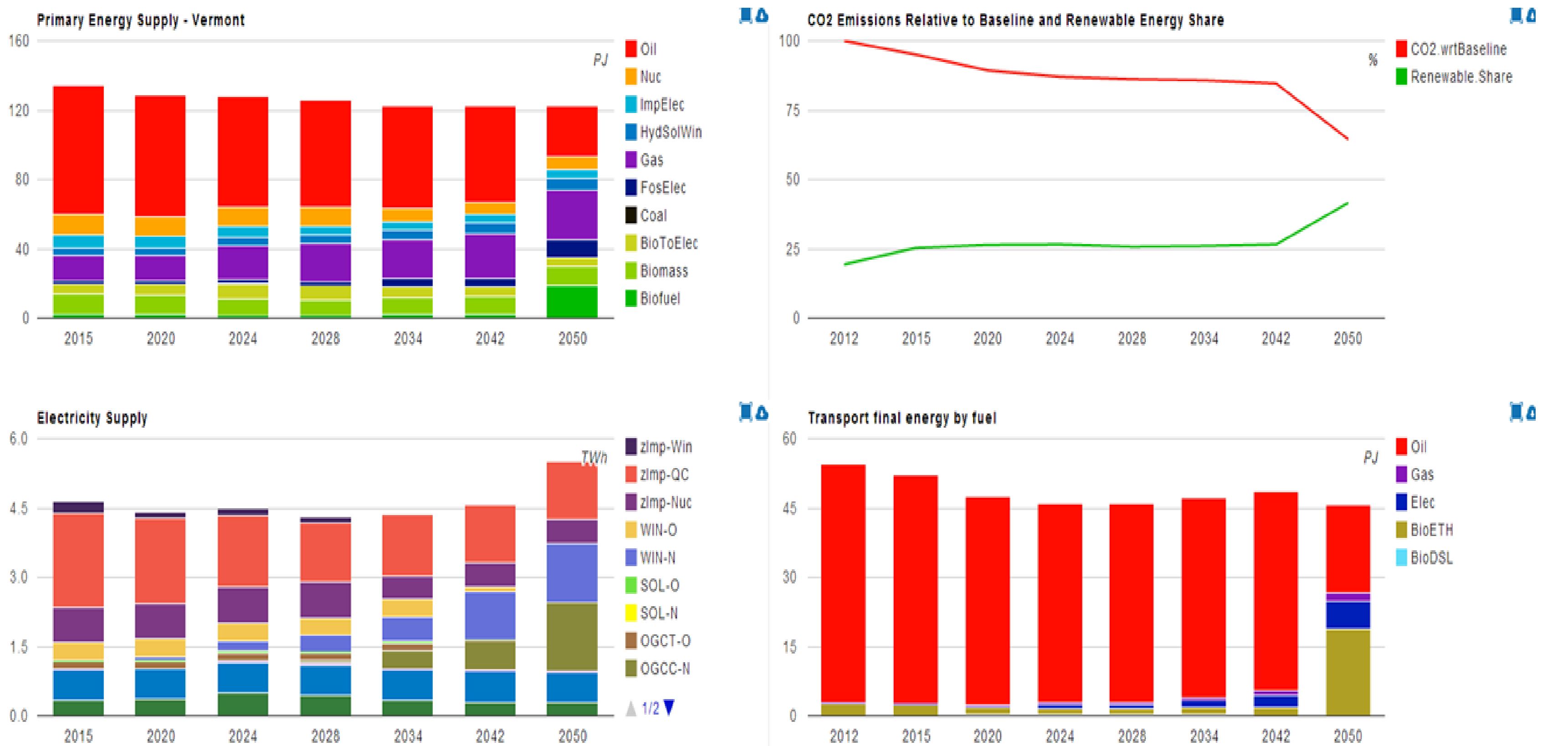




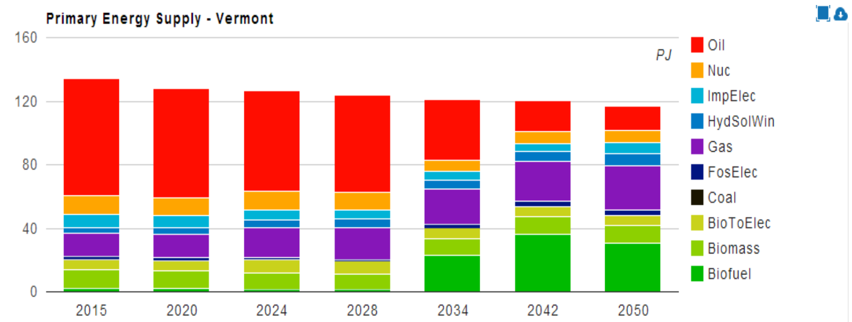


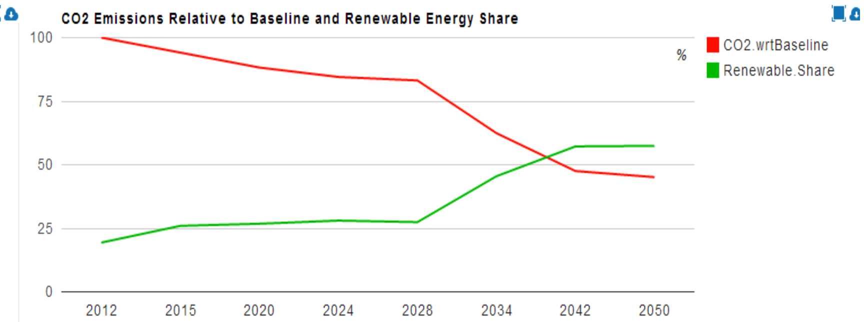


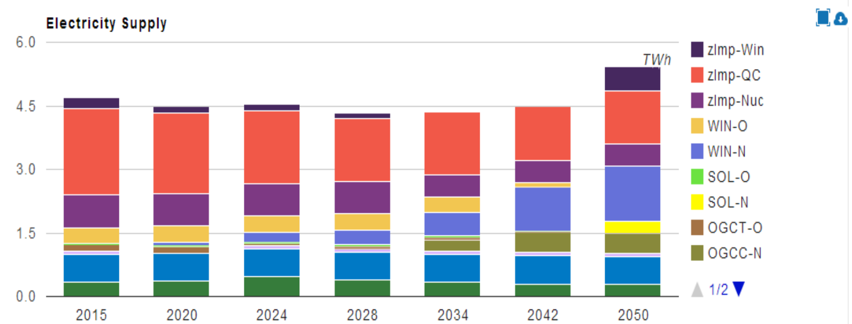
Tax 50 - Low biofuel prices

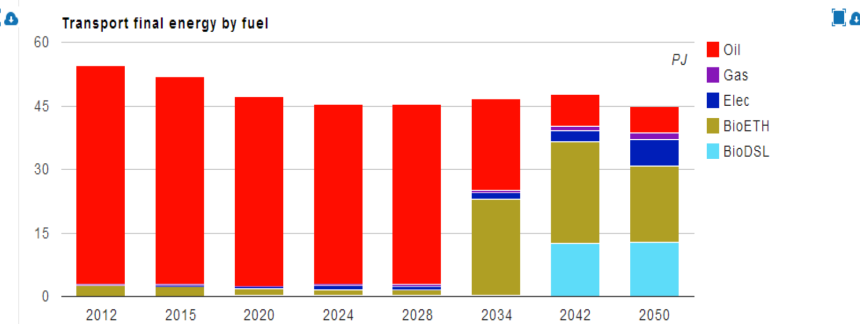


Tax 100 - Low biofuel prices

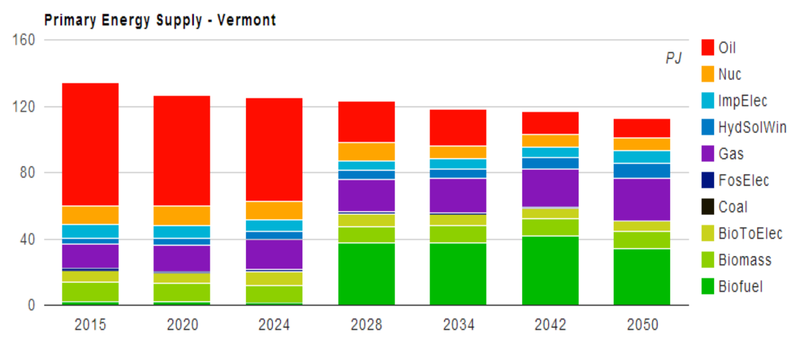


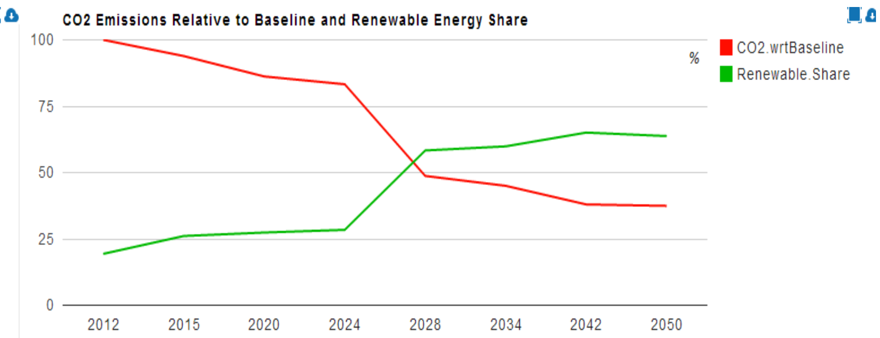


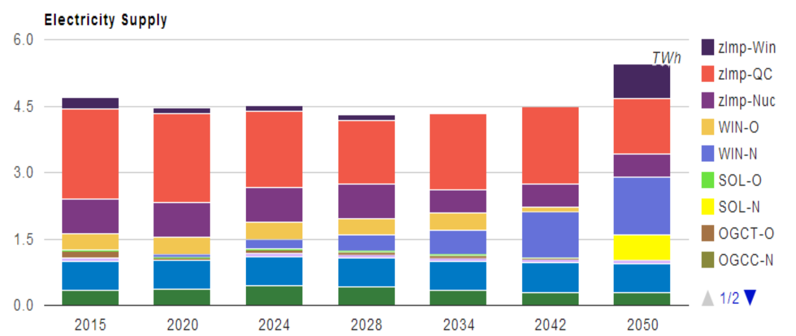


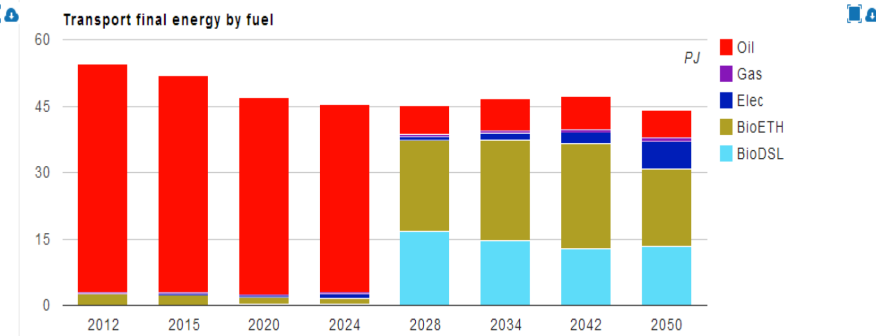


Tax 200 - Low biofuel prices

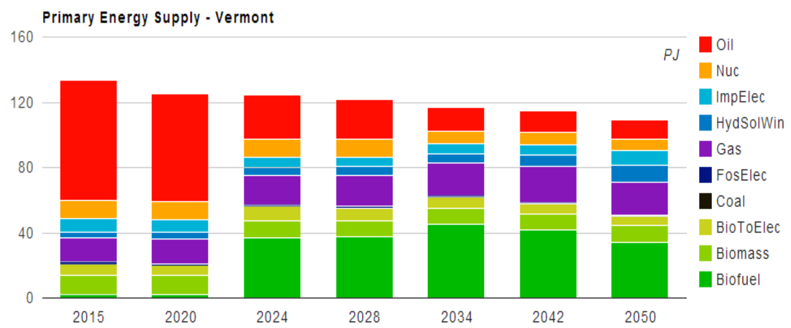


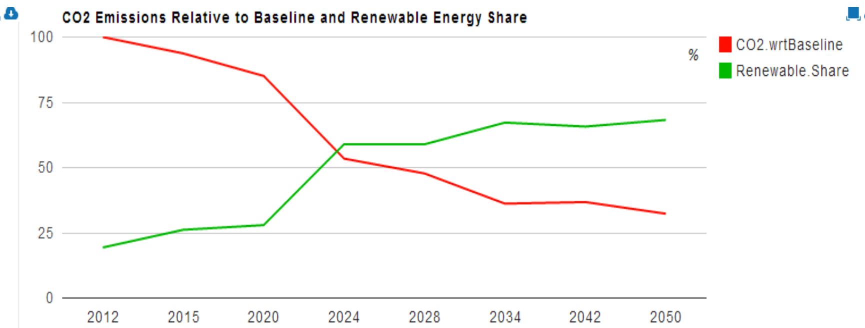


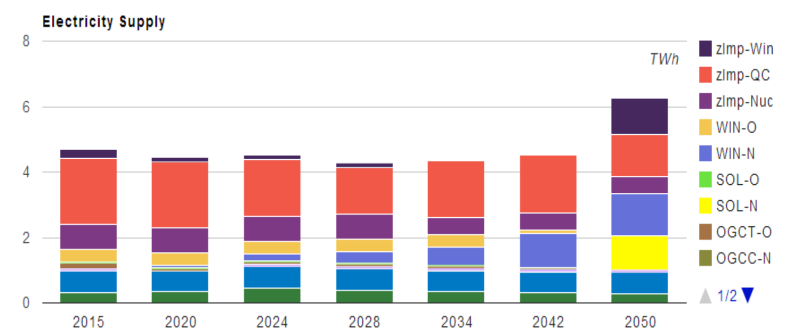


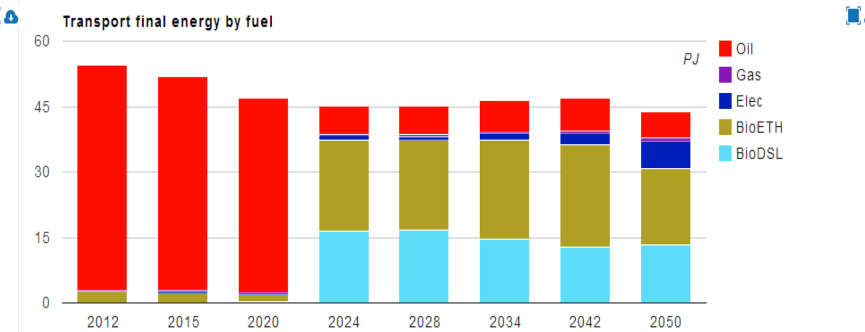


Tax 300 - Low biofuel prices

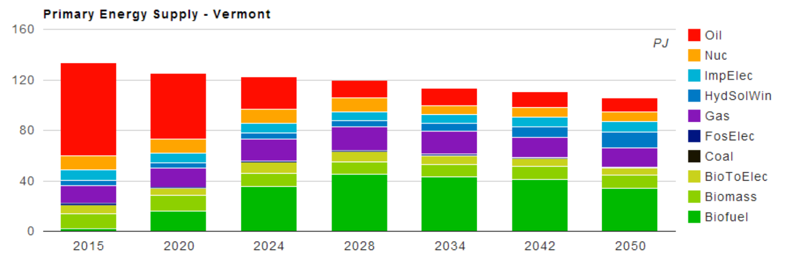


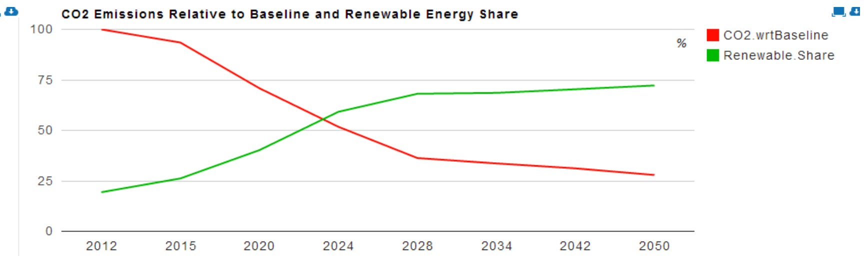


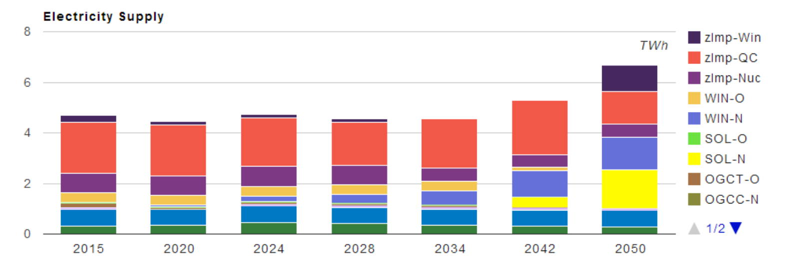


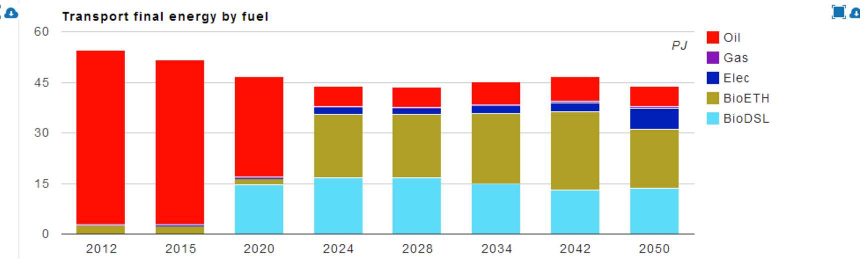


Tax 400 - Low biofuel prices

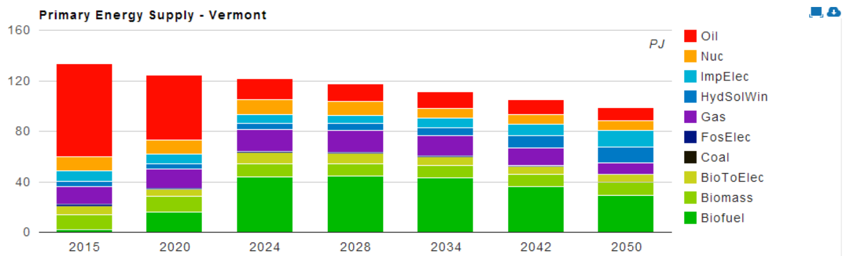


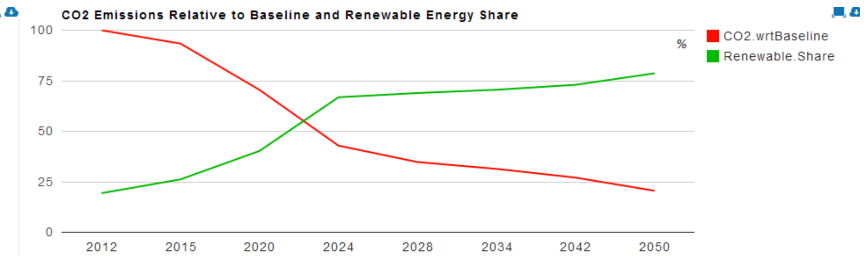


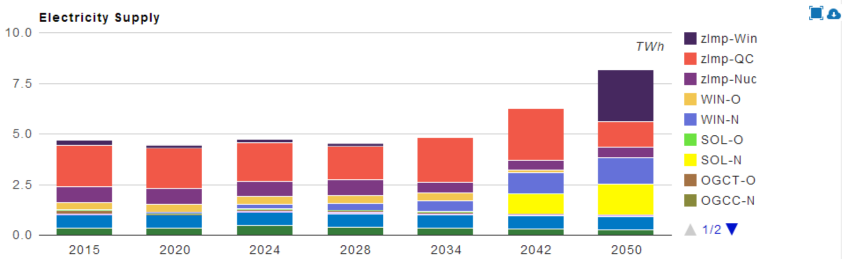


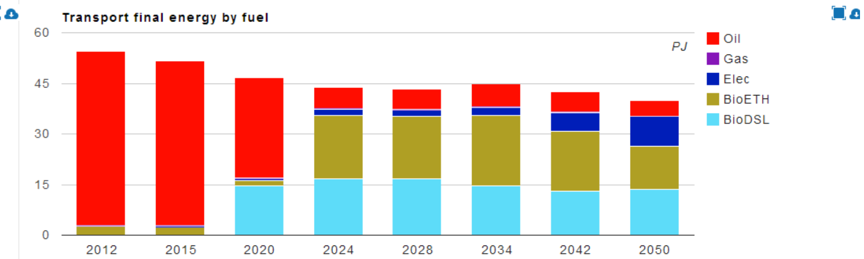


Tax 500 - Low biofuel prices

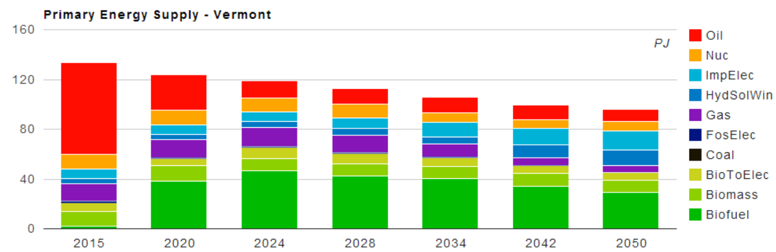


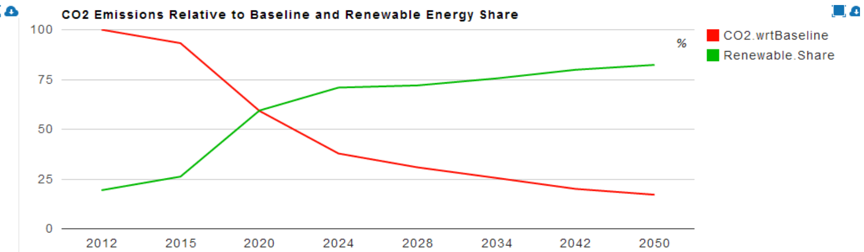


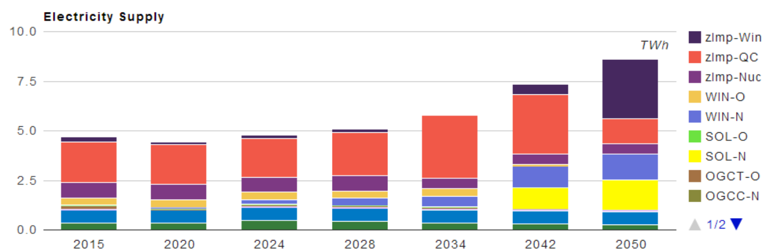


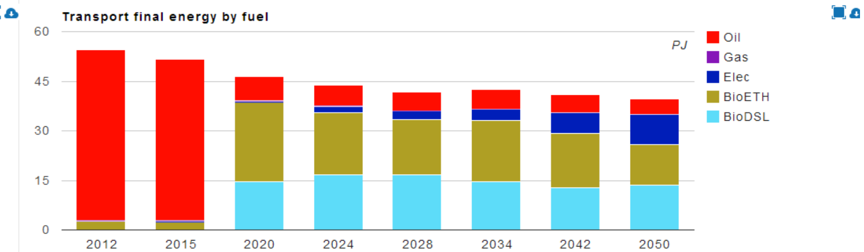


Tax 750 - Low biofuel prices

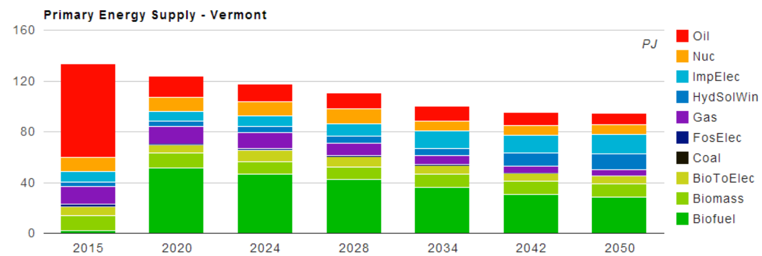


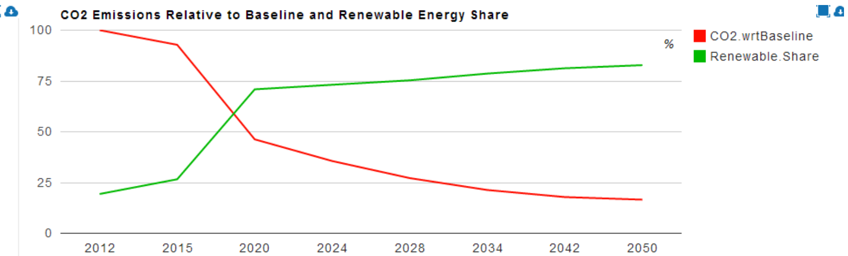


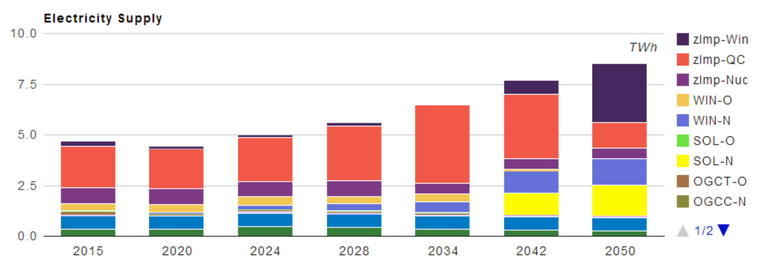


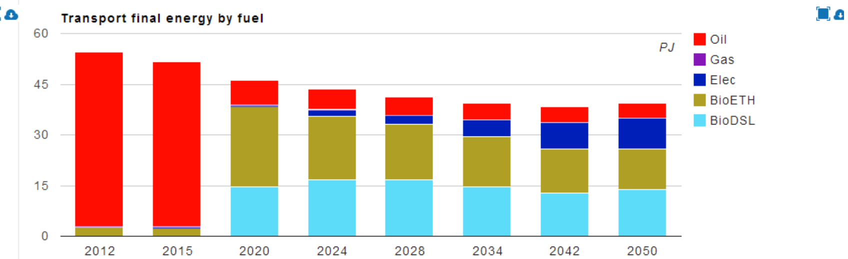


Tax 1000 - Low biofuel prices

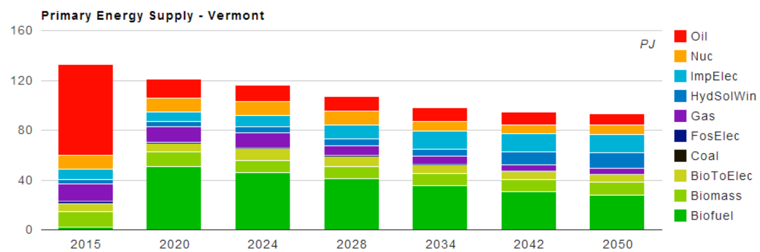


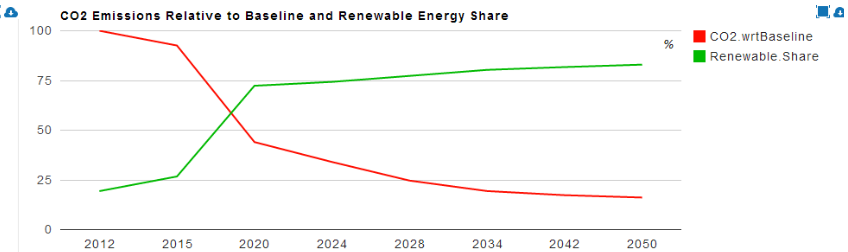


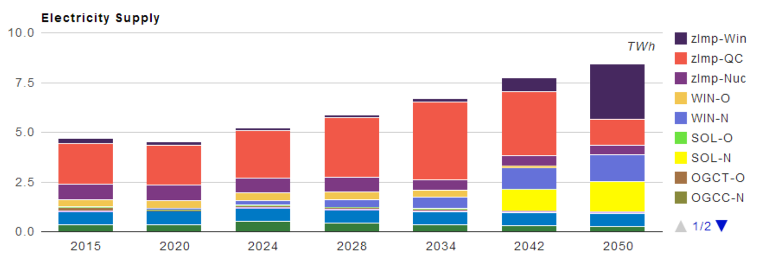


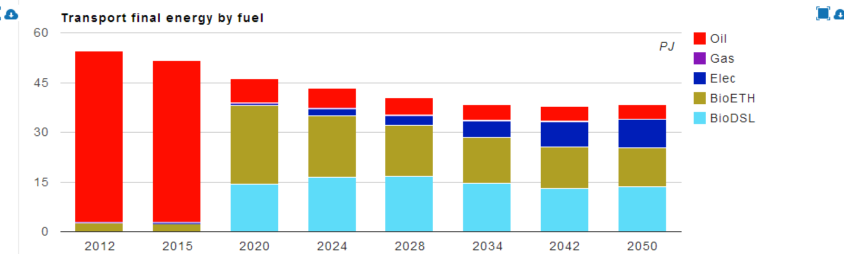


Tax 1250 - Low biofuel prices

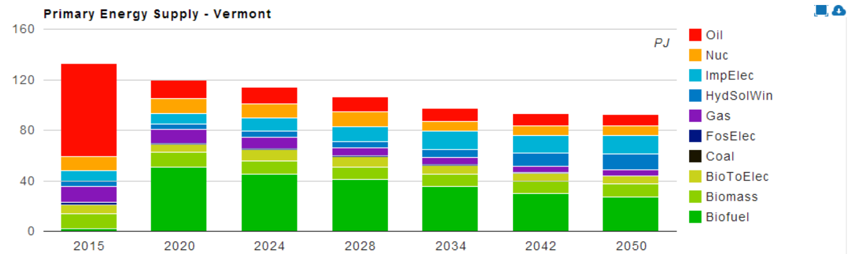


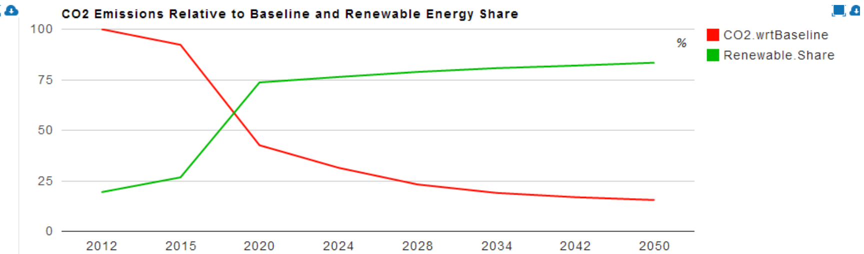


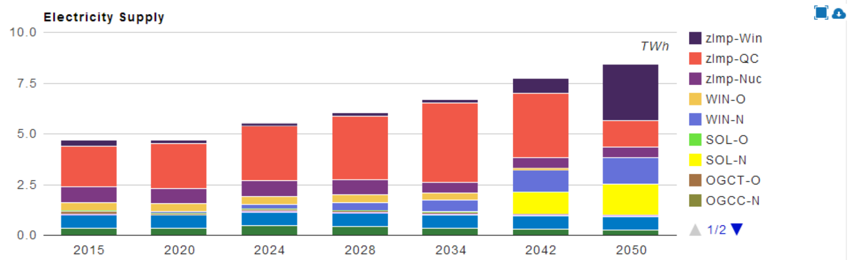


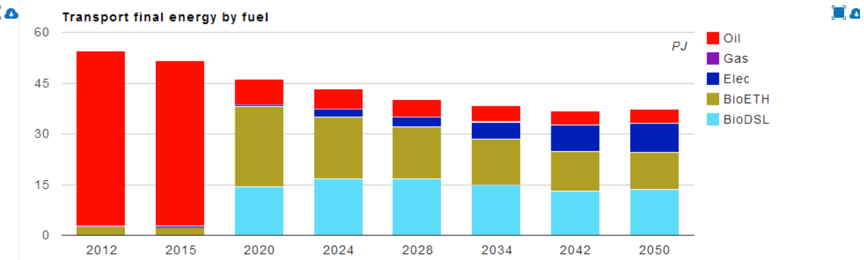


Tax 1500 - Low biofuel prices

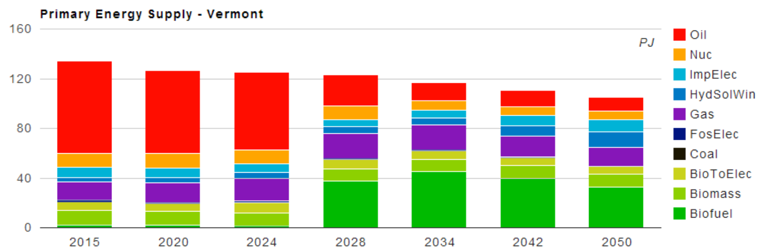


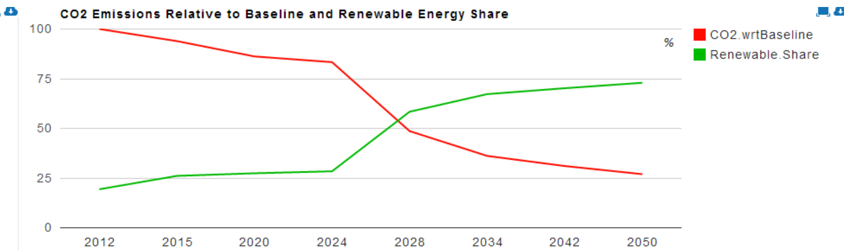


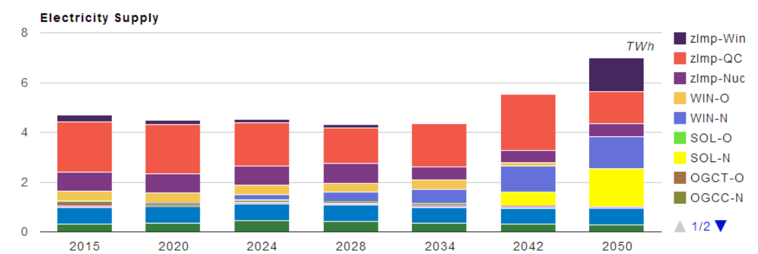


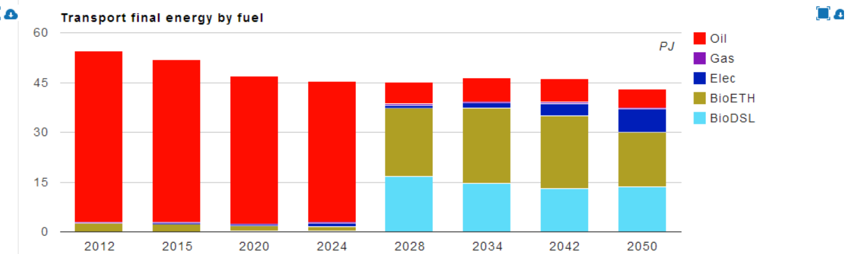


Compliant - Low biofuel prices

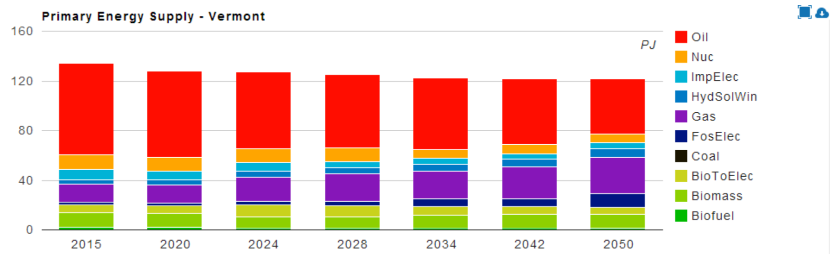


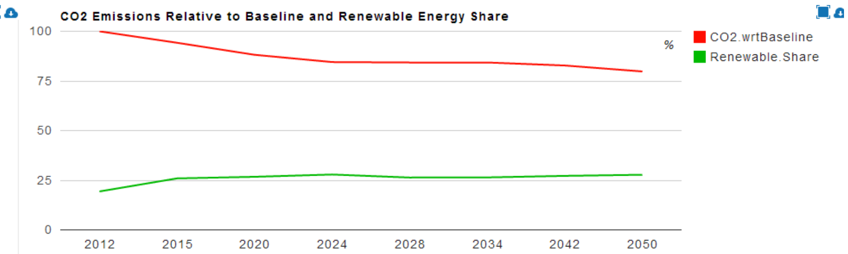


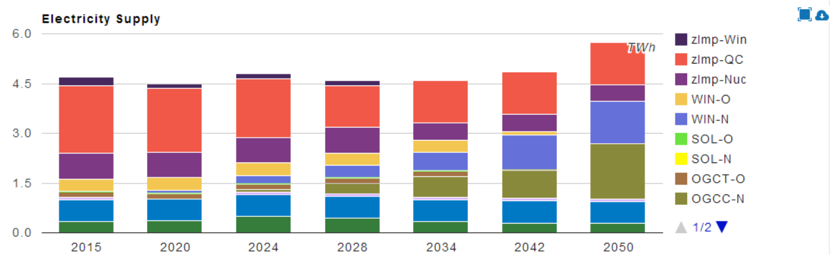


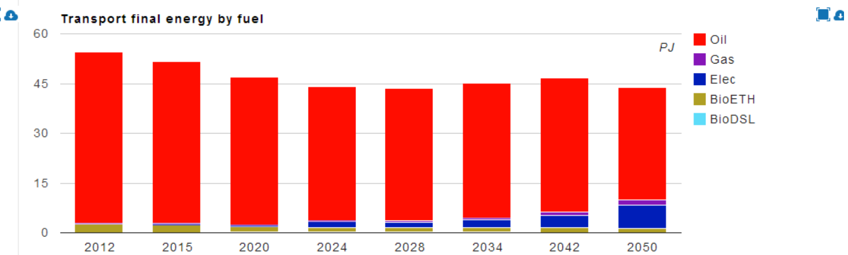


Tax 50 - High biofuel prices

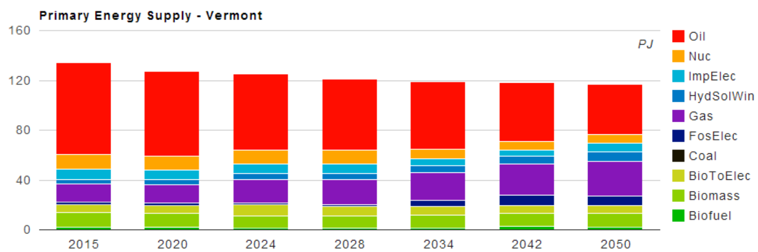


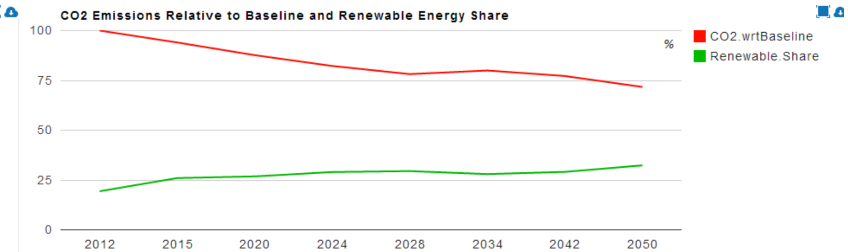


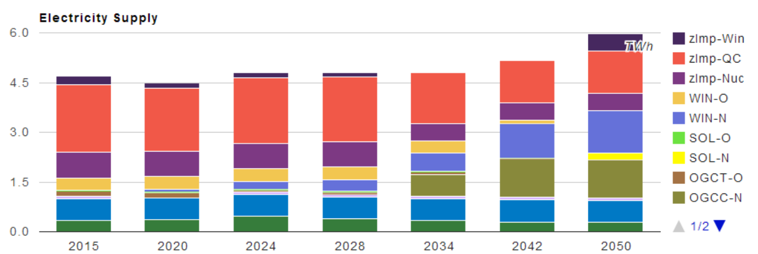


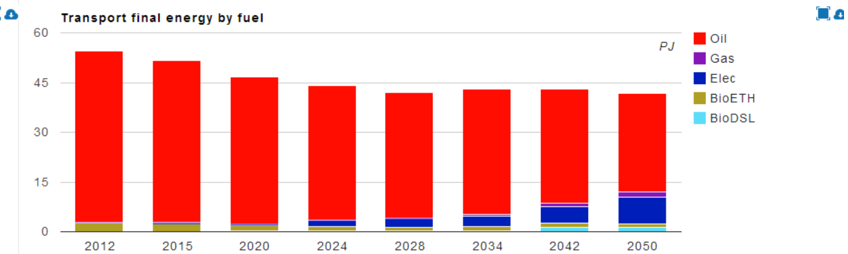


Tax 100 - High biofuel prices

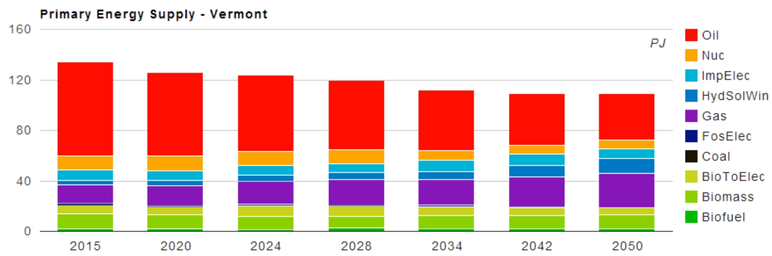


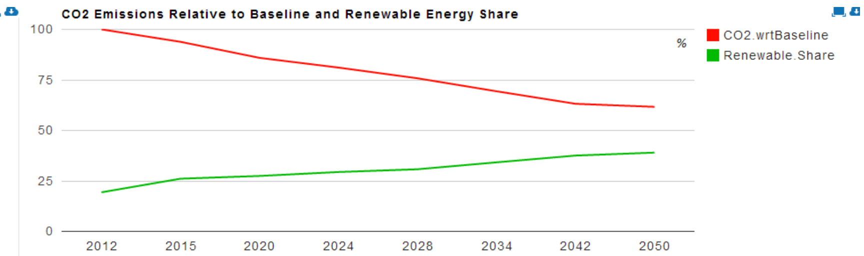


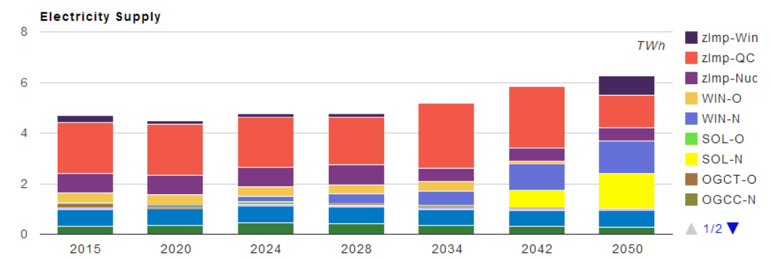


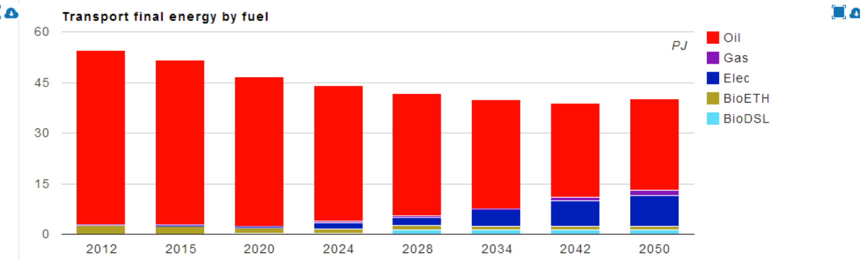


Tax 200 - High biofuel prices

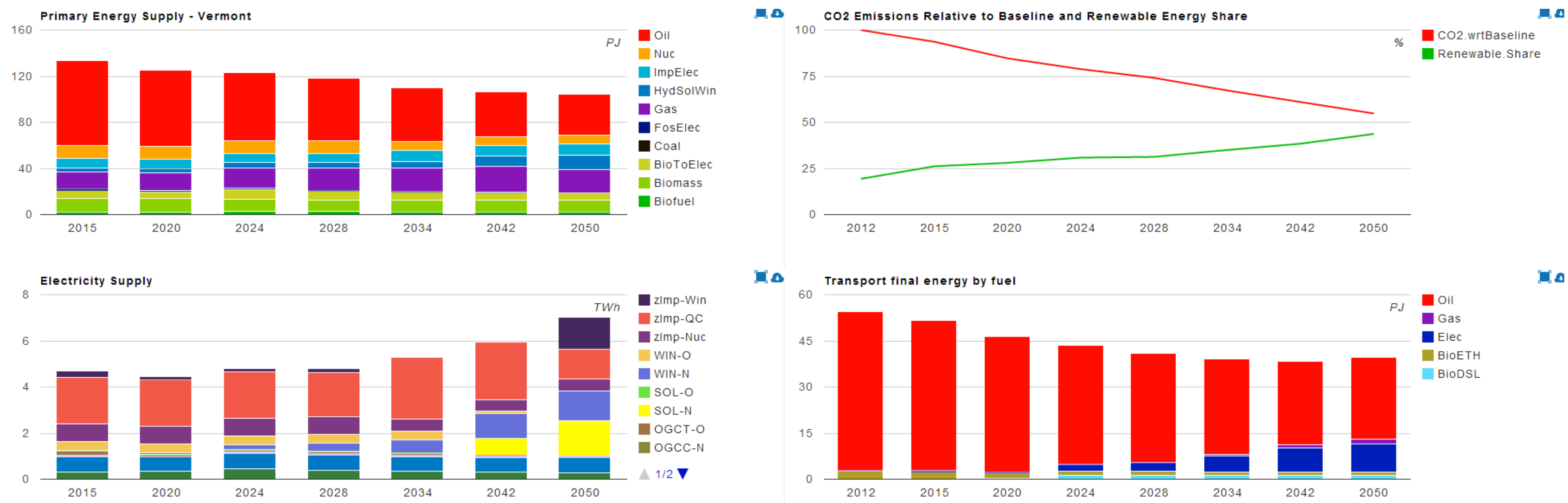




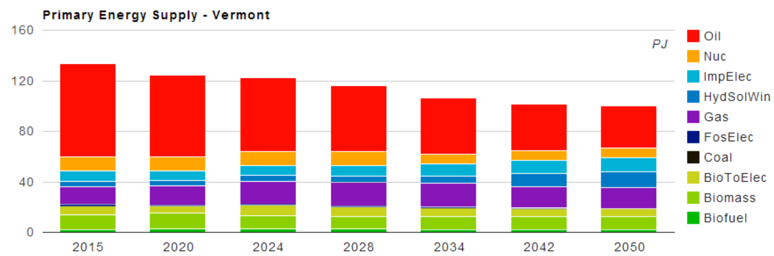


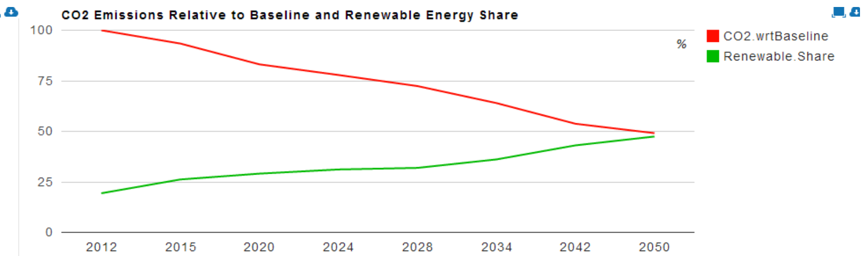


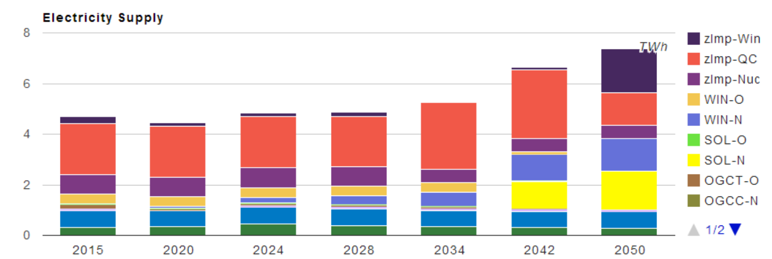
Tax 300 - High biofuel prices

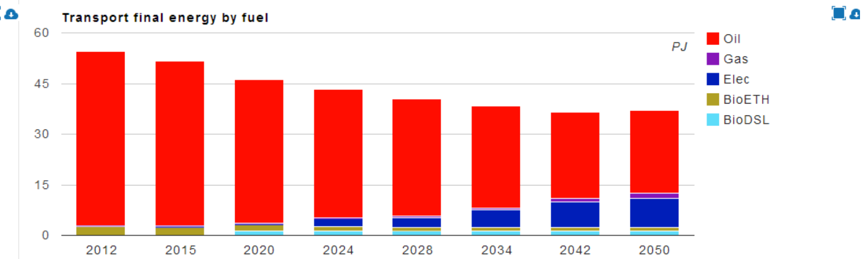


Tax 400 - High biofuel prices

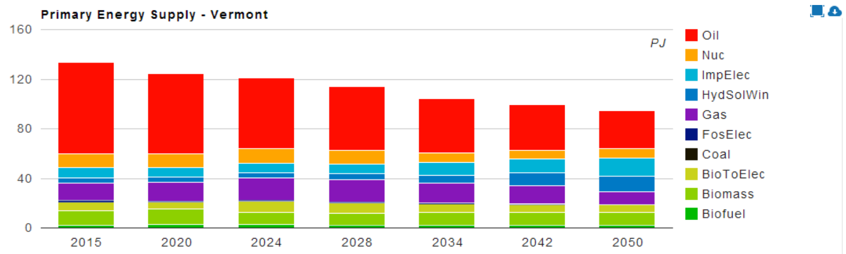


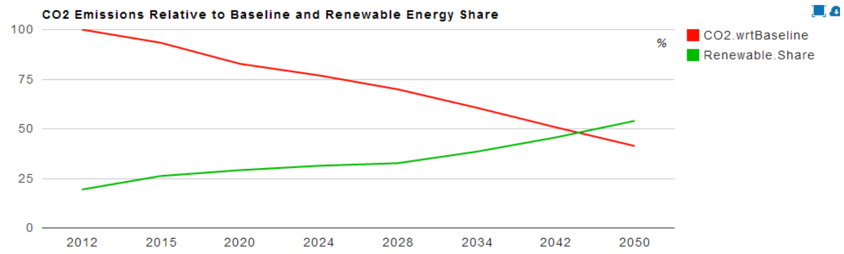


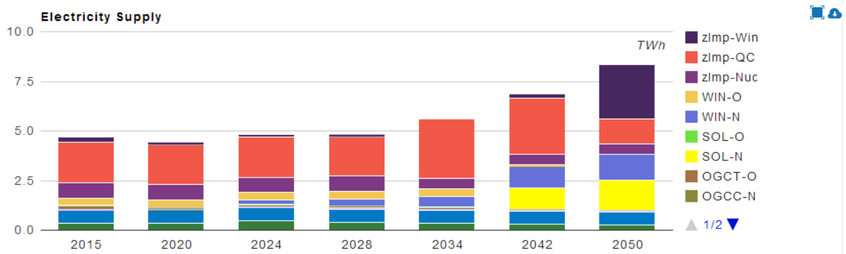


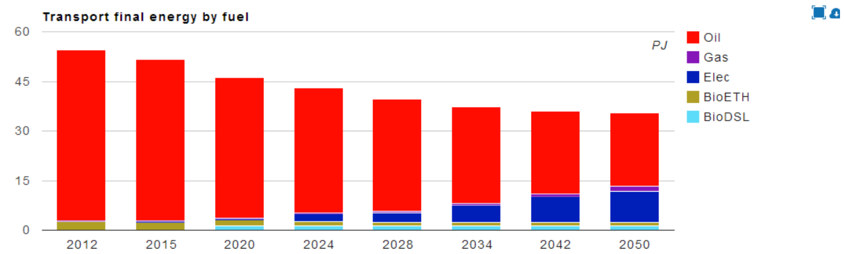


Tax 500 - High biofuel prices

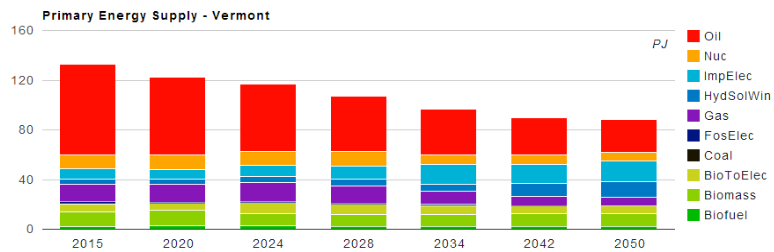


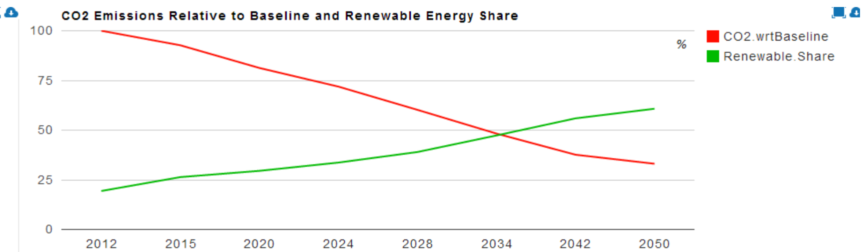


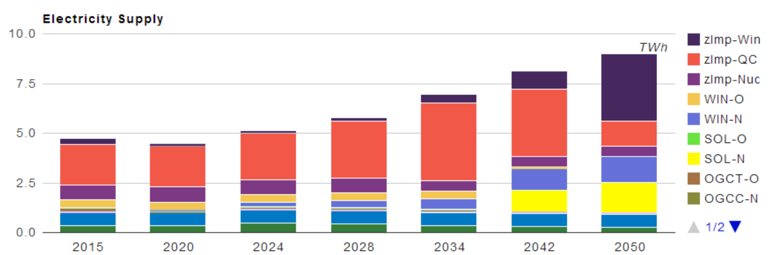


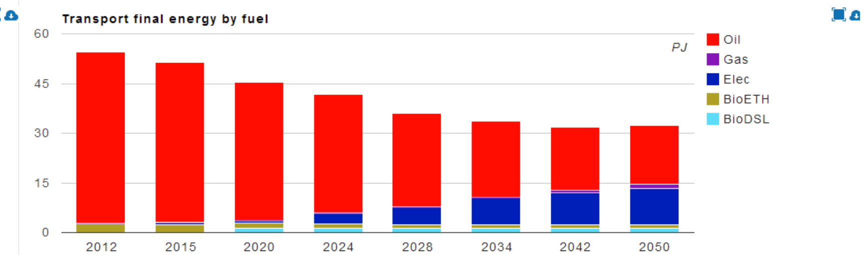


Tax 750 - High biofuel prices

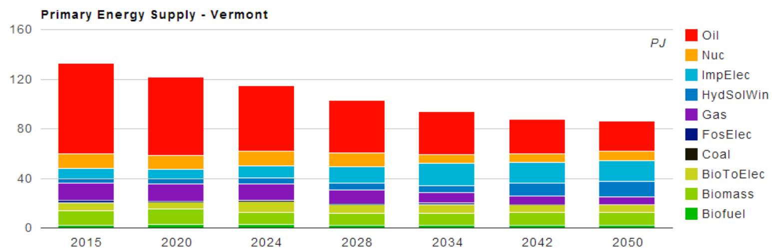


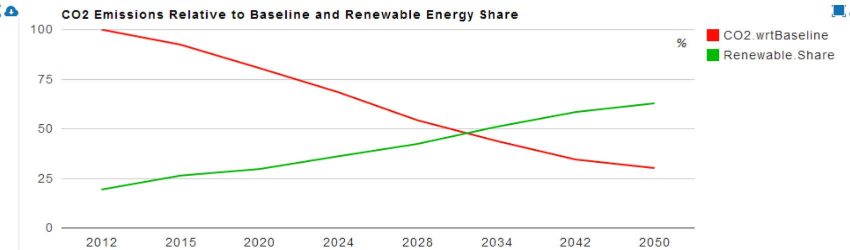


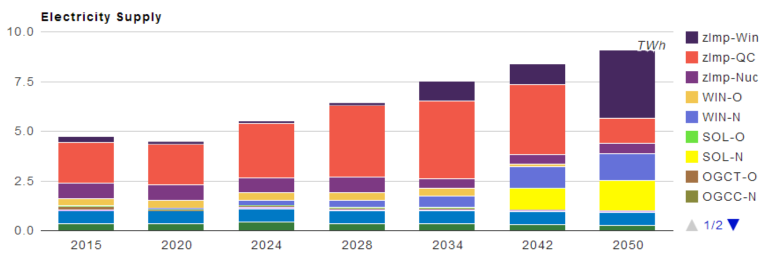


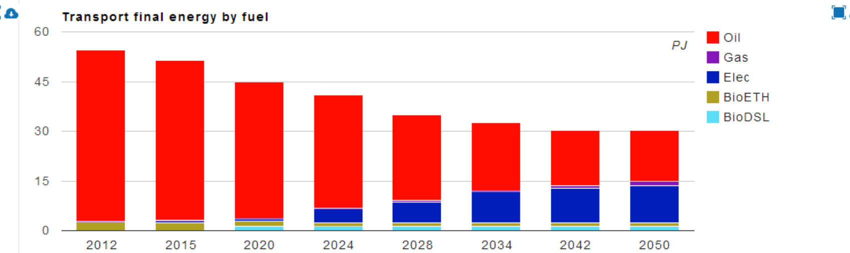


Tax 1000 - High biofuel prices

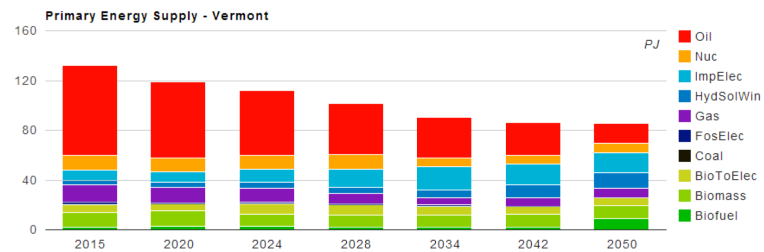


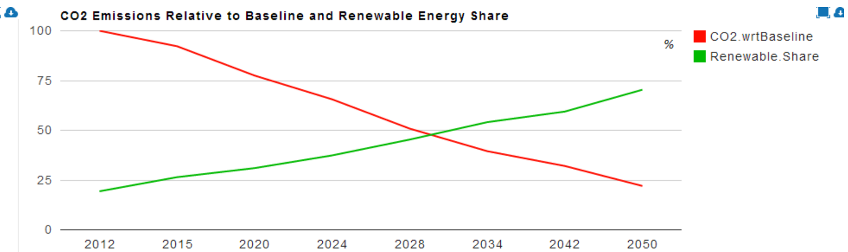


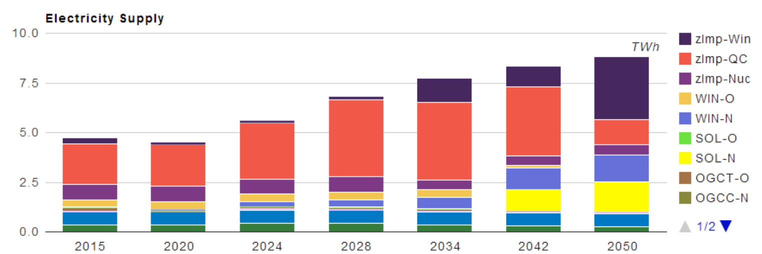


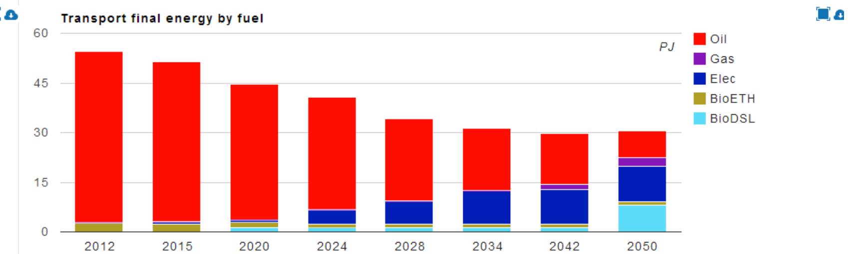


Tax 1250 - High biofuel prices

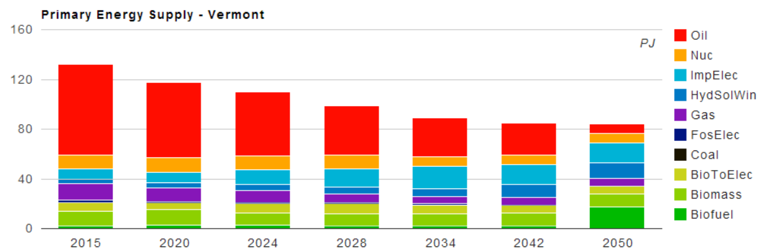


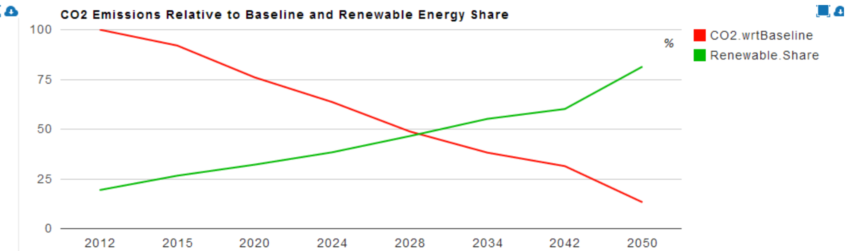


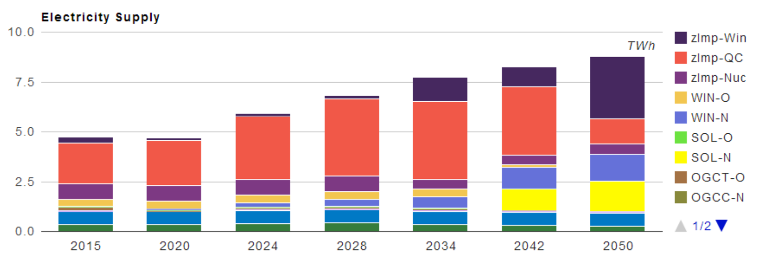


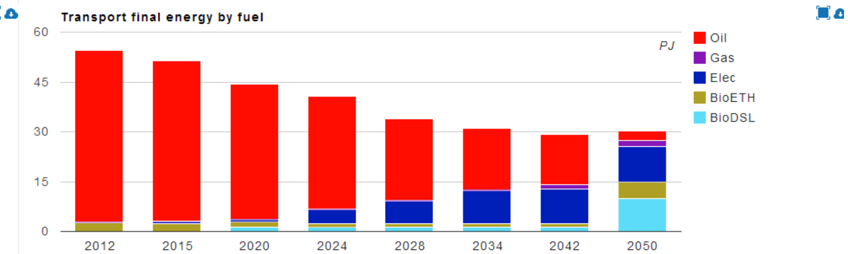


Tax 1500 - High biofuel prices









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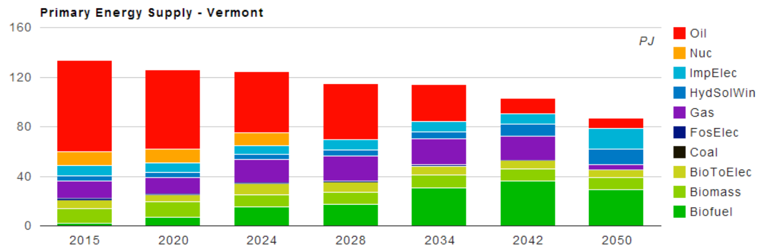
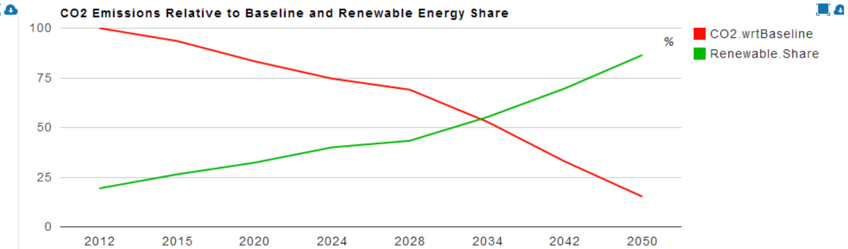
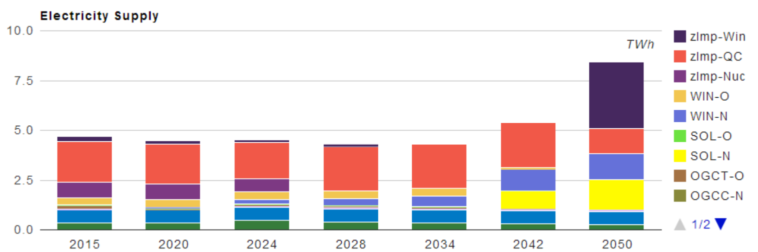
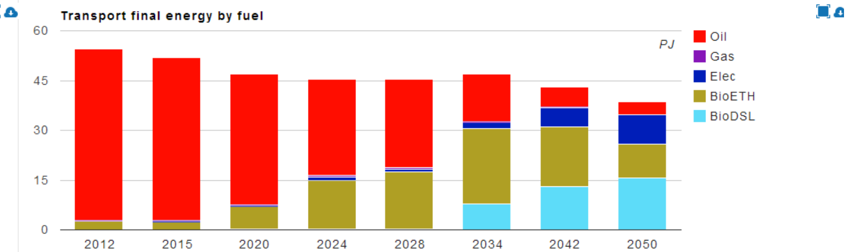
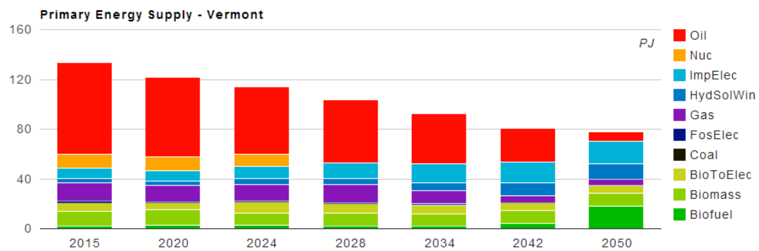


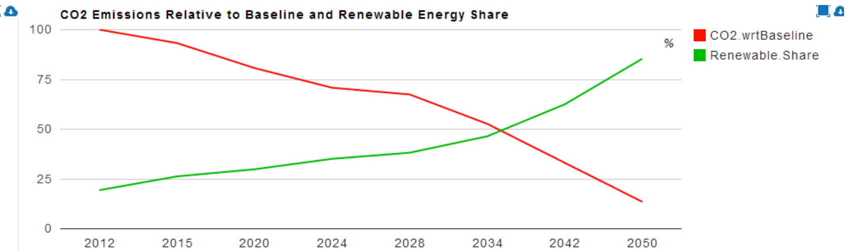


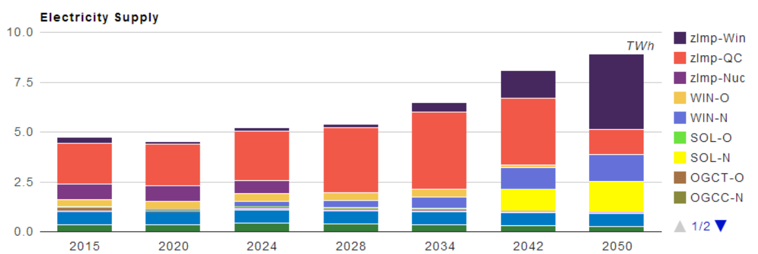


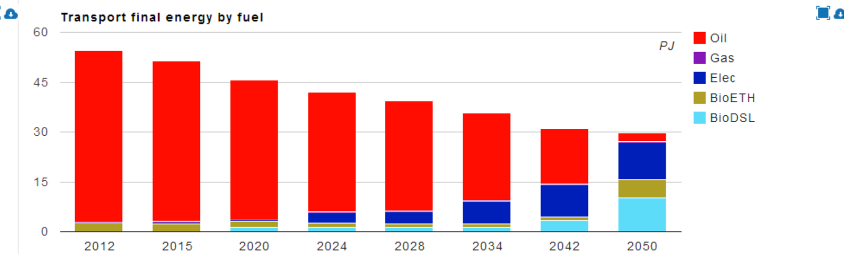


TREES - High biofuel prices

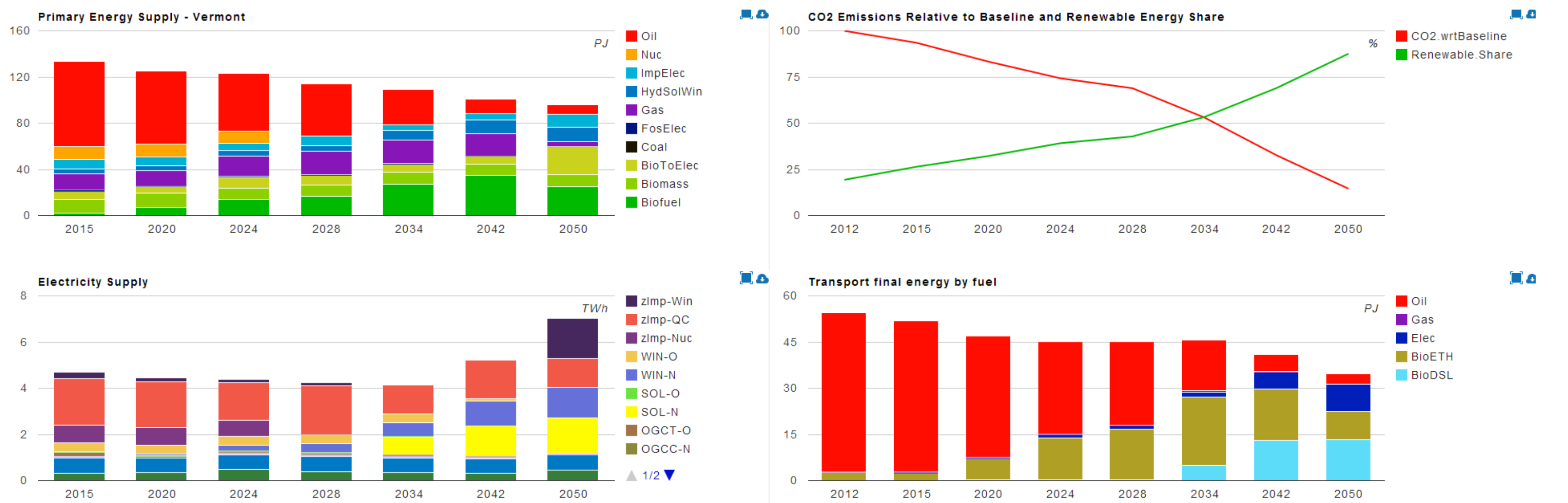




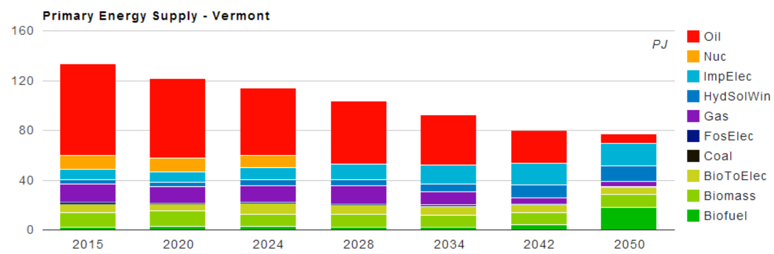


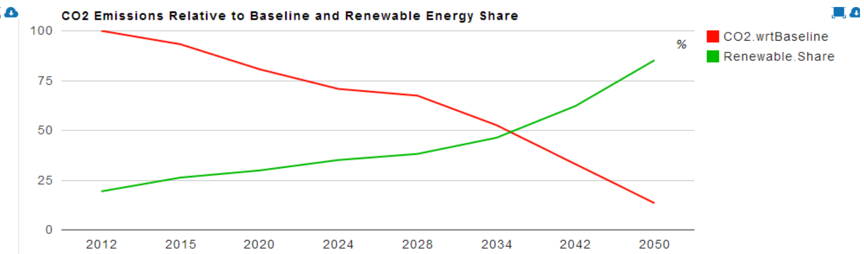


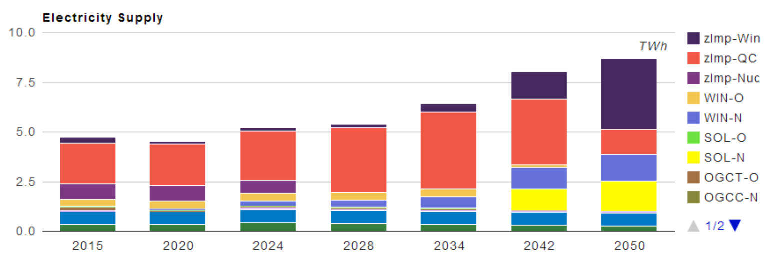
TREES local - Low biofuel prices

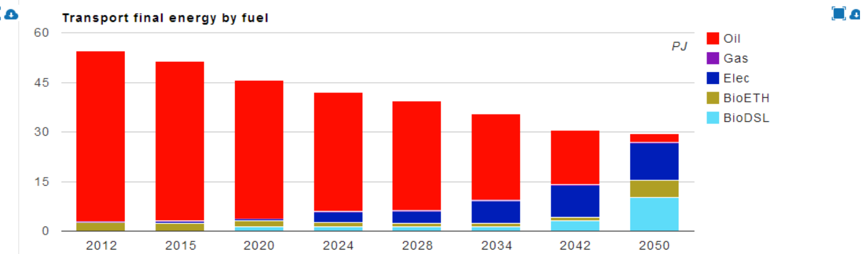


TREES local - High biofuel prices









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Economic Modeling Analysis of Total Energy Study Policies

Vermont Public Service Department

December 5, 2014

Contents

Executive Summary

The FACETS modeling done by Dunsky Energy Consulting (DEC) provided the Public Service Department (PSD or Department) with an informative view of the direct monetary costs associated with the pursuit of Vermont's energy and greenhouse gas goals through various policy pathways. Three different policy sets were modeled by DEC, each with a unique (though similar) trajectory of energy related costs: (1) Carbon Tax Shift, (2) Total Renewable Energy and Efficiency Standard (TREES), and (3) TREES with an additional local requirement.[1]

In the real world changes in the costs of meeting the energy needs of an economy also imply changes to a variety of spending flows that provide revenue to businesses and wage income to workers. The purpose of PSD's economic analysis of the Total Energy Study policy sets was to estimate the net impact that results from an increase in energy costs that must be met with an equal change in the amount of spending in the economy. To perform this analysis, PSD relied on the PI+ software developed by Regional Economic Models Inc. (referred to as "REMI"). Each of the REMI simulations constructed by PSD capture the interplay of four broad economic processes that characterize Vermont's energy transition under each policy scenario:

1. The rerouting of household and business fuel spending away from fossil fuel producing industries and toward renewable energy producing and energy efficiency industries.
2. A shift by households and businesses toward greater spending on equipment and efficiency improvements, and less spending on operation and maintenance costs.
3. The price response by consumers and businesses to increases in the cost of living and doing business due to rising energy prices.
4. The use of policy instrument revenue (either carbon tax revenue or TREES certificate revenue) to offset negative effects of this price response.

PSD's REMI simulations are intended to provide answers to two central questions about the economic implications of the FACETS results. Firstly, what is the magnitude and direction of the economic impact of the three examined policies, supposing that policy instruments perform as intended? Secondly, what can be learned from the variability in economic outcomes within and across policies?

Through the modeling effort described in this document, PSD found that each of the TES policy sets could be implemented so that the economy experiences beneficial increases in output, employment and income.[2] An economically successful Carbon Tax Shift policy results in an average yearly increase in Gross State Product (GSP), compared with the baseline or business as usual (BAU) case, of between \$139 and \$363 million (in 2014 dollars), depending on the price and availability of biofuels. An economically successful TREES Basic policy results in an average yearly increase in GSP of between \$123

[1] See DEC report, "Energy Policy Options for Vermont: Technologies and Policies to Achieve Vermont's Greenhouse Gas and Renewable Energy Goals" for details of their analysis and descriptions of each Total Energy Study (TES) policy set.

[2] PSD also modeled versions of the TES policy sets in which the policy instruments were assumed to be less effective. What follows are results from "effective implementation" versions of the policy scenarios. See Section 2 and 4 for an explanation of how policy instrument efficacy was treated in the Department's simulations.

and $238 million. An economically successful TREES Local policy results in an average yearly increase in GSP of between $140 and $246 million. Though positive, these changes are small relative to total GSP, representing between 0.23% and 0.69% increase over baseline levels. For employment, percentage changes above baseline are more salient, ranging from 0.44% and 1.26%.

These generally positive results require that policy instrument revenues—either carbon tax revenue or income from sales of TREES certificates—be used in such a way as to provide enough counter-stimulus to offset the effects of increasing unit costs of energy in each policy scenario. As described in section 4.1, policy effectiveness is especially important when the unavailability of low-priced biofuels constrains the suite of renewable energy options.

For a Carbon Tax Shift policy, the difference between effective and ineffective policy implementation policy could mean between $239 and $1,125 million in GSP a year (on average), depending on the price of biofuels. For TREES Basic, the analogous range is $341 to $1,383 million, while for TREES Local the range is $665 to $1,425 million. It is clearly important to strive for effective implementation.

The economic success of each of the policies is greater if other states pursue a similarly aggressive energy transition alongside Vermont, leaving relative energy costs between states unchanged. The economic benefit to Vermont of "going it together" is greatest when low-cost biofuels are not available. For the Carbon Tax Shift policy, "going it alone" would mean forgoing an average of $216 million in GSP per year. For TREES Basic, "going it alone" would mean forgoing $311 million per year. And for TREES Local, it would mean forgoing $375 million per year.

In each policy case, the expansion of employment and output in industries related to the supply of electricity and biomass is significant, growing by as many as 820 jobs per year (on average) in a "go it together" scenario when biofuel prices are low, and up to 2,500 jobs per year in a "go it together" scenario when biofuel prices are high. While ineffective policy implementation runs the risk of shrinking output and employment in a handful of large Vermont industries that do a large portion of overall business fuel spending, the majority of Vermont industries do not see significant net effects from any TES policy that is effectively implemented.

Exhibit 1. Percentage Change in GSP Relative to BAU Levels

	Gross State Product			
Scenario	**2015-2025**	**2025-2035**	**2035-2050**	**2015-2050**
Carbon Tax Shift: High Bio	+0.17%	+0.87%	+0.83%	+0.69%
Carbon Tax Shift: Low Bio	+0.08%	+0.15%	+0.32%	+0.23%
TREES Basic: High Bio	+0.03%	+0.70%	+0.53%	+0.45%
TREES Basic: Low Bio	+0.11%	+0.11%	+0.34%	+0.23%
TREES Local: High Bio	+0.09%	+0.58%	+0.58%	+0.47%
TREES Local: Low Bio	+0.11%	+0.13%	+0.40%	+0.27%

Exhibit 2. Percentage Change in Employment Relative to BAU Levels

	Employment			
Scenario	**2015-2025**	**2025-2035**	**2035-2050**	**2015-2050**
Carbon Tax Shift: High Bio	+0.33%	+1.65%	+1.61%	+1.26%
Carbon Tax Shift: Low Bio	+0.15%	+0.32%	+0.67%	+0.44%
TREES Basic: High Bio	+0.18%	+1.10%	+1.23%	+0.90%
TREES Basic: Low Bio	+0.22%	+0.25%	+0.70%	+0.45%
TREES Local: High Bio	+0.23%	+1.01%	+1.14%	+0.85%
TREES Local: Low Bio	+0.20%	+0.24%	+0.84%	+0.51%

Exhibits 1 and 2 display the percentage change in average GSP and employment (compared to BAU levels) for each of the TES policies under both high and low biofuel price scenarios. These results reflect simulations in which, 1) other jurisdictions take equally strong action to reduce greenhouse gas emissions and adopt renewable energy, and, 2) policy instruments are assumed to be most effective in countering consumer and business price response to higher energy costs. See Section 5 for a discussion of differences between “go it alone” and “go it together” scenarios. See Section 4.1 for a discussion of differences between “effective” and “ineffective” scenarios.

1 Economic Modeling Approach

The first step in the Department's economic impact analysis was to translate the monetary costs of meeting legislative targets, as determined by DEC's energy system modeling effort, into specific energy related spending streams created by household and business purchases in four categories:

1) spending on fuel
2) spending on equipment
3) spending on operation and maintenance
4) spending on efficiency improvements

To perform its analysis, PSD utilized PI+, a regional economic impact simulation software developed and licensed by Regional Economic Modeling Incorporated, commonly referred to as "REMI."[3] In the model mechanics of REMI, each of the above spending streams provides a demand stimulus to the economy that contends with the negative effects of increased unit costs of energy. In PSD's simulations, the net economic impact from each policy reflects the interplay of four broad economic processes expected to occur over the course of Vermont's energy transition.

1. The rerouting of household and business fuel spending away from fossil fuel producing industries and toward renewable energy producing and energy efficiency industries.
2. A shift by households and businesses toward greater spending on equipment and efficiency improvements, and less spending on operation and maintenance costs.
3. The response of consumers and businesses to an increase in the cost of living and doing business resulting from the integration of renewables into the energy supply and the expense added to energy purchases by the policy instrument (either carbon taxes or TREES certificates).[4]
4. The use of policy instrument revenue to counter these price response effects. In Carbon Tax Shift scenarios, this is accomplished by fiscal policy. In TREES scenarios this is accomplished when income from certificates sales enables renewable energy producers to lower retail prices.

[3] The REMI model is structured around an econometrically-derived baseline projection of input-output flows between industries. Exogenous changes to the size of those I-O spending flows are resolved through gradual endogenous quantity adjustments (by both firms and consumers) back toward baseline levels. Technical information about the REMI model architecture can be found at http://www.remi.com/resources/documentation.

[4] For households, PSD modeled the policy-induced increase in energy costs as a proportional decrease in consumer purchasing power. Consumers respond to this loss of purchasing power by substituting toward cheaper goods and services, and, when cheaper imports are unavailable, reducing overall spending. For businesses, the increase in energy cost is modeled as a proportional increase in production costs. Businesses respond to this increase in costs by increasing use of cheaper production inputs, and, when unavailable, decreasing investment spending.

Exhibit 3. Cumulative Changes in Energy Related Spending (in millions of 2014 dollars) Relative to BAU levels (2015-2050)

	Carbon Tax Shift		TREES Basic		TREES Local	
	High Bio ($1,250)	Low Bio ($450)	High Bio	Lo Bio	High Bio	Lo Bio
Electricity	+17,624	+3,663	+13,510	+4,288	+12,479	+3,582
NG & LPG	-7,288	-3,103	-7,024	-3,043	-7,008	-3,264
Distillates & Residual	-1,944	-4,680	-1,845	-2,348	-1,853	-2,515
Gasoline & Diesel	-23,774	-31,280	-19,491	-29,259	-19,578	-28,485
Biomass	+1,716	+410	+1,236	+591	+1,355	+527
Biofuels	+9,309	+36,621	+15,142	+29,516	+14,694	+26,897
Total Fuel	-4,356	+1,630	+1,528	-255	+90	-3,258
Conservation	+2,186	+239	+1,569	+323	+1,629	+457
Equipment & Maintenance	+5,579	+73	+1,968	+1,429	+5,115	+1,818
Operation & Maintenance	-1,102	-308	-1,746	-393	-1,051	-340
Total Spending	+2,308	+1,634	+3,320	+1,103	+5,783	-1,323

Exhibit 3 displays the cumulative change in energy related spending (relative to baseline levels) taking place in each policy scenario over the entire projection period (in millions of 2014 dollars from 2015-2050). Each TES policy induces a shift toward higher levels of spending on capital and efficiency improvements, but lower levels of spending on operation and maintenance costs. When low cost biofuels are unavailable (i.e. in high biofuel price scenarios), these shifts are more pronounced.

Policy-induced changes in the level of total spending on fuel—whether greater or less than business as usual levels—do not respond uniformly to the price of biofuels. When biofuels prices are only available at high prices, it is the TREES policies that see more spending on fuel. But when biofuel prices are lower, it is the Carbon Tax Shift policy that sees more spending on fuel. These outcomes are explained by the larger quantities of renewable energy brought online in the TREES scenarios. In order to achieve a 90% renewable energy supply, biofuels become a necessary component of the energy supply regardless of price. Not being constrained by the 90% renewable goal, the Carbon Tax Shift policy achieves emissions reductions targets with less use of biofuels.

2 Policy Scenario Variations

For each of the three TES policy scenarios, PSD performed two different sets of simulations, each including separate high and low biofuel price versions. As depicted in Exhibit 4, the first set of simulations is defined by the assumption that Vermont pursues the policy independently of other states. In these "go it alone" simulations, other states do not take on the costs of building a renewable energy supply alongside Vermont. As a consequence, the competitive position of Vermont declines; businesses lose market share and consumer dollars leak increasingly out of state to cheaper sources of supply.

Left unchecked, this process (endogenous to the REMI model) would culminate in lower investment spending by business, lower employment levels, reduced income, and an overall decline in Vermont output. As discussed in section 4, PSD found there are several ways in which the TES policy instruments could successfully work to counter such a retrenchment in spending. This finding followed from the simulation of a range of policy scenario versions in which the policy instruments are assumed to be more or less effective at offsetting increases in energy unit costs. These "policy effectiveness" simulations are a subset of the "go it alone" simulations, represented for simplicity in Exhibit 4 as either "well implemented" or "poorly implemented" versions of each policy.

The second set of simulations performed by PSD is defined by the assumption that other states pursue comparably aggressive energy policy alongside Vermont. In "going it together," relative energy prices between states do not change, and thus there is no significant loss of competitive position by Vermont firms or leakage of consumer spending to other states[5]. As discussed in Section 5, REMI simulations show "going it together" to be the more economically beneficial course to take for all policies. Because there are no changes in relative energy costs in a "goes it together" scenario, no tests of policy effectiveness assumptions are possible in this set of simulations. The findings from the "go it alone" set of simulations regarding policy effectiveness are nonetheless applicable to a "go it together" context.

[5] A real-world implementation of "go it together" energy policy is unlikely to leave relative cost structures between states completely unaltered. For modeling purposes however, this assumption yields useful information about the potential economic benefits of a cooperative approach.

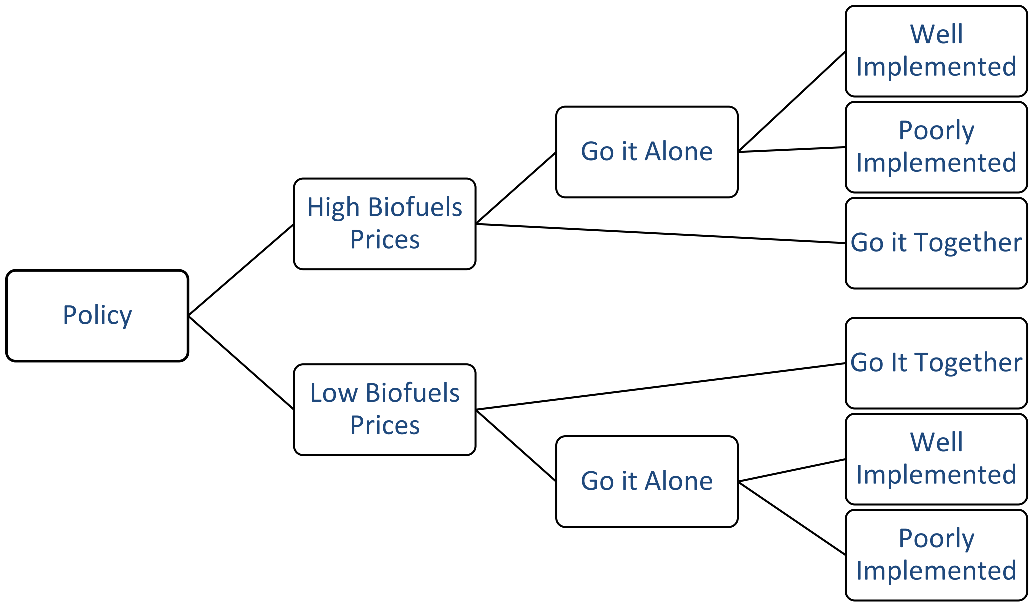

Exhibit 4. Organization of PSD's REMI Simulations. For each policy scenario, two sets of simulations were run. Each set included both high biofuel and low biofuel price scenarios. The first set is defined by the assumption that Vermont "goes it alone." In addition, a variety of second-order assumptions about the effectiveness of the policy instrument were tested. The second set of simulations is defined by the assumption that Vermont "goes it together."

3 Summary of Simulation Results

PSD's general finding from the various simulation exercises described in Section 2 above is that, with effective use of policy instrument revenues, each of the TES policies is conducive to a well-performing Vermont economy. As summarized in Exhibits 5 and 6 below, results for all simulations of well-implemented policies show Vermont experiencing a small but positive impact in the level of employment and Gross State Product.[6]

Across policies, the average yearly increase in GSP ranges from +$118 million (at the low end), to +$363 million (at the high end). These changes represent slight increases over baseline GSP levels of 0.23% and 0.69% respectively. The positive impacts on employment levels are slightly more salient, ranging from an average yearly increase of +2,200 jobs at the low end, to +6,400 jobs at the high end (representing increases over baseline employment levels of 0.44% and 1.26% respectively).

The majority of this growth in economic activity, though relatively small in aggregate, is driven by large expansions of output and employment in industries associated with the supply of renewable electricity, biomass, and to a lesser extent, efficiency services. Across policy scenarios, annual output and employment levels in the electricity-producing sector increase by 20 to 30 percent on average when

[6] Though not shown here or elsewhere in this document, results for measures of personal income follow similar trends as GDP and employment.

biofuel prices are high, and 5 to 8 percent on average when biofuel prices are low. The growth experienced by the biomass producing sector—a small player in Vermont's overall economy—is substantial enough in the high biofuels price scenarios to double baseline levels of sales and employment. When biofuel prices are low, biomass industry growth ranges between 40 and 60 percent above baseline values. Collectively, average employment over the entire 2015-2050 period in these two sectors scenarios grows by as many as 2,500 jobs a year if biofuel prices are high, and 820 jobs a year if biofuel prices are low. These results are consistent with the economy's increased dependence on electricity and solid biomass in each of the FACETS policy scenarios. In the TREES policies where liquid biofuels are heavily used, electricity and forestry related industries benefit somewhat less, while retail (which includes the distribution of liquid fuels) does somewhat better.

As discussed in section 4.2, the details of policy implementation are important in determining the economic performance of a handful of large individual industries. REMI simulation results show that the majority of Vermont industries are not likely to experience significant net effects from the TES policies. If policy is effective in balancing the increase in unit energy costs with appropriate counter-stimulus measures, the expansion of the emergent "clean industry" in Vermont need not come at the expense of established industries (very few of which are inextricably dependent on the production of fossil fuels for their existence). Fuel intensive industries, though not generally large employers in Vermont, could face difficulties for which policy instruments may struggle to compensate. Any energy transition of the scale contemplated by the TES is bound to prove disruptive to conventional business models predicated on access to inexpensive fossil fuels. However PSD's simulation results give no reason to expect that higher energy costs will necessarily undermine any major Vermont industry. More than any "creative destruction" that might take place along the way, the greatest risks and challenges of the TES policies lie in how the policy instruments can be most effectively used to distribute and offset the incremental costs of a growing renewable energy supply and increased implementation of energy efficiency.

Exhibit 5. Percentage Change in GSP Relative to BAU Levels

	Gross State Product			
Scenario	**2015-2025**	**2025-2035**	**2035-2050**	**2015-2050**
Carbon Tax Shift: High Bio	+0.17%	+0.87%	+0.83%	+0.69%
Carbon Tax Shift: Low Bio	+0.08%	+0.15%	+0.32%	+0.23%
TREES Basic: High Bio	+0.03%	+0.70%	+0.53%	+0.45%
TREES Basic: Low Bio	+0.11%	+0.11%	+0.34%	+0.23%
TREES Local: High Bio	+0.09%	+0.58%	+0.58%	+0.47%
TREES Local: Low Bio	+0.11%	+0.13%	+0.40%	+0.27%

Exhibit 6. Percentage Change in Employment Relative to BAU Levels

	Employment			
Scenario	**2015-2025**	**2025-2035**	**2035-2050**	**2015-2050**
Carbon Tax Shift: High Bio	+0.33%	+1.65%	+1.61%	+1.26%
Carbon Tax Shift: Low Bio	+0.15%	+0.32%	+0.67%	+0.44%
TREES Basic: High Bio	+0.18%	+1.10%	+1.23%	+0.90%
TREES Basic: Low Bio	+0.22%	+0.25%	+0.70%	+0.45%
TREES Local: High Bio	+0.23%	+1.01%	+1.14%	+0.85%
TREES Local: Low Bio	+0.20%	+0.24%	+0.84%	+0.51%

Exhibits 5 and 6 display the percentage change in average GSP and employment levels (compared to BAU levels) for each of the TES policies under both high and low biofuel price scenarios. These results reflect simulations in which 1) other jurisdictions take equally strong action to reduce greenhouse gas emissions and adopt renewable energy, and 2) policy instruments are effective in countering consumer and business price response to higher energy costs.

In addition to the simulations represented by the results in Exhibits 5 and 6, PSD modeled several other versions of the TES policies that entertained less optimistic assumptions about the effectiveness of each policy instrument. It is notable that even in the "ineffective policy" or "poorly implemented" scenarios (discussed further in section 4), the range of economic impact results remains small. Neither the high nor the low end of the results from these policy effectiveness tests reveal a large enough change in economic activity to significantly alter long term baseline growth rates in GSP (2015-2050). Compared to an annualized growth rate of 2.11% in the REMI control forecast (i.e. business as usual), the high end of this range (a perfectly effective policy) represents a long term growth rate of 2.13% while the low end represents a growth rate of 2.07%. It is notable that even in nonsensical scenarios, where the revenue generated by the Carbon Tax or by TREES certificates effectively disappears (i.e. fails to recirculate through the economy) the impact on the growth rate is still not drastically detrimental. Thus one of the most significant findings of the PSD's economic impact analysis is that even so large an energy transition as Vermont's goals imply does not necessarily also imply outsized impacts on the Vermont economy, in either positive or negative direction.

4 Insights from Policy Scenario Variations

4.1 Policy Instrument Efficacy

The intended effect of the policy instruments considered by the TES is to lower the relative end-use prices of renewable energy and efficiency improvements to levels at which renewable energy and efficiency become the most cost-competitive options for meeting energy demand. DEC's energy system modeling gives an informative view of how much more expensive fossil fuels would need to be in order to meet the State's goals. However, the costs that the TES policy instruments add to purchases of fossil fuels also constitute revenue streams that might cycle through the economy in any of a variety of ways not captured by an energy-sector cost-optimization model such as FACETS. PSD simulated a range of ways that policy instrument revenue could re-enter the economy after first being paid by producers and consumers of fossil fuels. Exhibits 7 and 8 below show results from these "policy effectiveness" simulations, comparing scenarios in which uses of policy instrument revenue was found to be most and least economically successful. They display the difference in economic performance between "perfectly effective" and "perfectly ineffective" versions of each policy. For all policies, there is a bigger difference in impact between "effective" and "ineffective" versions when biofuel prices are high.

Exhibit 7. Percentage Change in GSP: "Effective" Relative to "Ineffective" Policy

	Gross State Product			
Scenario	**2015-2025**	**2025-2035**	**2035-2050**	**2015-2050**
Carbon Tax Shift: High Bio*	+0.63%	+2.02%	+2.78%	+2.17%
Carbon Tax Shift: Low Bio**	+0.66%	+0.82%	+0.31%	+0.45%
TREES Basic: High Bio	+1.56%	+2.06%	+3.17%	+2.70%
TREES Basic: Low Bio	+0.36%	+0.43%	+0.79%	+0.65%
TREES Local: High Bio	+1.56%	+2.05%	+3.31%	+2.79%
TREES Local: Low Bio	+0.43%	+1.05%	+1.65%	+1.28%

Exhibit 8. Percentage Change in Employment: "Effective" Relative to "Ineffective" Policy

	Employment			
Scenario	**2015-2025**	**2025-2035**	**2035-2050**	**2015-2050**
Carbon Tax Shift: High Bio *	+0.51%	+1.71%	+2.36%	+1.73%
Carbon Tax Shift: Low Bio **	+0.86%	+1.21%	+0.67%	+0.80
TREES Basic: High Bio	+0.84%	+1.83%	+3.21%	+2.39%
TREES Basic: Low Bio	+0.41%	+0.48%	+0.86%	+0.69%
TREES Local: High Bio	+1.78%	+2.35%	+3.66%	+2.99%
TREES Local: Low Bio	+0.60%	+1.26%	+2.02%	+1.48%

***The Tax Relief approach is more economically effective when biofuel prices are high.**
****The Dividend approach is more economically effective when biofuel prices are low.**

4.1.1 Uses of Carbon Tax Revenue

In a Carbon Tax Shift scenario, the policy instrument revenue flows first to state government. DEC's energy system modeling did not capture how that revenue is then used by the state. PSD simulated two possibilities for how carbon tax revenue might be recirculated back into the economy after being collected by the state. In practice, some mix of these two methods could also be implemented.

1. *Revenue neutrality achieved through tax relief*. In this scenario, carbon tax revenue is used by the state to offset existing taxes paid by businesses and households. The effectiveness of the tax relief approach depends on the response by businesses and individuals to reductions in the cost of production inputs, consumer goods and other expenses that make up the cost of living and doing business in Vermont. Currently, the state collects more than a third of its revenue from property taxes, a third from various consumption taxes, a quarter from personal income tax, and around 5 percent from corporate income taxes. The effect of replacing some of these revenue sources with a carbon tax is that there will be a broad range of price reductions for a wide variety of intermediate and final goods that no longer have to be marked up to cover a tax bill. In REMI, firms and consumers will respond to this reduction in costs by increasing investment, hiring, and consumption. The tax relief approach would be an economic success then if the reductions in the cost of living and doing business effected by tax relief are impactful enough to counter the effects of higher energy costs.

2. *Revenue neutrality achieved through transfer payments*. In this scenario, carbon tax revenue collected from all sources (businesses and individuals both) is remitted in full to the household sector as a "household dividend." The economic effectiveness of the transfer payment approach relies on the stimulus provided by increased levels of consumer spending made possible by redistributive fiscal action. It is fundamentally a demand-side approach that attempts to offset the price response effects of higher energy costs by increasing households' spending capacity. In REMI, a successful transfer payment approach requires that any reduction in business investment and hiring induced by higher energy costs is outweighed by the increase in discretionary consumer purchases. This outcome is more likely if those receiving the income are apt to use it for consumption of locally supplied goods and services. It is estimated that less than half of Vermont demand is supplied by in-state producers.

PSD's simulations showed that the effectiveness of both the tax relief approach and the transfer payment approach depends on the cost at which biofuels can be added to the energy supply. As can be seen in Exhibits 7 and 8 above, when biofuels can only be obtained only at high costs (i.e. in high biofuels price scenarios), economic performance is best if revenue neutrality is maintained through the tax relief approach. That is, in a high biofuel price environment, remitting a "citizen's dividend" back to taxpayers was found to be insufficient stimulus to offset the loss of market share and purchasing power effected by higher energy costs. However when biofuels are less expensive, the resulting increase in cost of energy is small enough that an increase in consumption out of transfer payment income can compensate for the reduction in businesses and consumer spending related to energy costs. Thus in a low biofuel price environment the transfer payment approach does provide sufficient stimulus to offset price response impacts. One challenge for the design of a Carbon Tax Shift policy, therefore, would be to select the best method for returning tax revenue in the face of uncertainty about future biofuel availability.

The revenue from a carbon tax would provide the state with sufficient fiscal resources to more than compensate for the negative economic effects of any loss of market share or purchasing power that would naturally accompany an increase in Vermont's energy unit costs. If the costs of building a renewable energy supply are steep (i.e. biofuel prices are high), effective fiscal action will need to be directed more toward lowering existing tax burdens, in order to avoid loss of competitive position and leakage of consumer dollars to other states. In a world where renewable energy is less expensive, a demand-side approach could bring as much or more in benefits than a reduction in taxes.

4.1.2 Uses of TREES Certificate Income

For the TREES policies, the payment of the price of TREES certificates by energy distributors generates a revenue stream for the renewable energy and energy efficiency industries. The intent of the TREES policy design, in addition to raising the relative price of fossil fuels, is that this certificate revenue would lower the amount of revenue that renewable energy suppliers require from sales to end users, thereby encouraging the development of scale economies that result in lower retail prices of renewable energy. The extent to which this might take place in actuality is difficult to assess.

PSD simulated a variety of possibilities ranging from a “perfectly effective” TREES policy, in which every dollar earned on certificate sales by renewable energy producers translates into a dollar reduction in the retail cost of renewable energy, to a “perfectly ineffective” TREES policy, in which no reduction in the retail cost of renewable energy takes place, no matter how large the earnings on certificate sales. A “perfectly ineffective” TREES policy does nothing to offset the policy-induced increase in energy costs (an unlikely prospect), while a “perfectly effective” TREES policy does the maximum amount possible to contain the policy-induced increase in energy costs.

The TREES policy instrument differs fundamentally from fiscal policy in the means by which it can provide counter-stimulus to the economy. That is, certificate revenue can only act on the price of energy. Fiscal policy, in contrast, would act on the price of real estate (property taxes), the price of consumer goods (sales tax), personal income levels (income tax), and business costs (corporate income tax). A TREES policy instrument, in other words, by design, directs all of its resources toward lowering the unit cost of energy.

Exhibits 7 and 8 above show the difference in economic performance under a “perfectly effective” TREES scenario compared to that of the “perfectly ineffective” version of the policy. The comparative results provide a useful illustration of the importance of policy design to economic outcomes. For example, in the high biofuel price scenario, the benefits foregone by a TREES policy that completely fails to push down retail renewable energy costs, unlikely as that may be, could amount to as much as $1.3 billion dollars in GSP per year and 14,000 jobs on average for the whole 2015-2050 period. In a scenario where biofuels are cheaper, the loss of benefits in this unrealistic case is less extreme but still significant ($340 million in annual GSP and 7,400 jobs).

As with the FACETS model runs, the price of biofuels plays a substantial role in the results of PSD’s simulations. When biofuels can only be added to the energy supply at high cost, there is a more powerful price response that must be countered by equally impactful uses of policy instrument revenues. The economic performance of the TREES scenarios in the high biofuel price scenarios raises important questions about the limits that any of the TES policy instruments might encounter in providing sufficient counter-stimulus when some forms of renewable energy can only be acquired at high cost.

The difference between economic performance in high and low biofuel price scenarios suggests that a policy instrument that acts only on the price of energy, such as TREES certificates, may not provide sufficient counter-stimulus if biofuels are both necessary and available only at high cost. Other policy efforts to contain the effects of the price response may be required to ensure best economic outcomes. The broad-based tax relief approach, in targeting costs other than energy, does a better job compensating for the spending retrenchment associated with high biofuel prices. However some of the better performance of the Carbon Tax Shift policy in the high biofuel price scenario (compared to the TREES high biofuel price scenarios) is explained by the lesser amount of biofuels purchased when the 90 percent renewable energy goal is not constraining fuel choices. Thus it is difficult to say that high biofuel prices (and the prospect of high renewable energy prices generally) present more of a challenge to a TREES-like policy than they do to a tax based policy. The safer conclusion is that the effectiveness of either type of policy instrument is likely to be more limited when consumers and firms must pay very high prices for energy. PSD's results suggest there is a point at which an increase in energy cost can outstrip the ability of the TES policy instruments to sufficiently mitigate. And though PSD's high biofuel price scenarios do not exemplify such an outcome (rather only hinting at it), it stands as an important policy consideration that the effectiveness of the policy instrument does not necessarily grow in proportion to the energy bills that it must be used to offset.

Within the TREES policies simulations, PSD found that placing a premium on local renewable energy resources serves to contain some of the negative employment impacts associated with the purchase of high biofuel prices. In the TREES Basic scenario, "going it alone" without inexpensive biofuels results in an average annual loss of 1,600 jobs. But in the "go it alone" TREES Local scenario, the economy manages to add 290 jobs despite having to shoulder the high biofuel costs.

4.2 Implications for Individual Industries

The difference between the performance of the economy in "effective" and "ineffective" versions of each policy—measured in terms of GDP, employment and income—hinges to a large degree on the role played in Vermont's economy by some of the its larger industries, namely Construction, Retail and Wholesale, and Professional and Technical Services. Collectively these industries employ more than a third of Vermont workers. Simply because of their large relative size, they also account for a large relative share of overall spending on fuel by the business sector as a whole. As such, they are likely to face the greatest policy-induced increase in energy bills.

PSD's simulation results suggest that the economy performs better in aggregate when the policy instrument in question is effective in preventing this handful of industries from experiencing too large a net increase in costs. "Ineffective" policy tends to hamper the growth of these industries while "effective" policy need do little more than leave their costs unchanged on net. Other large Vermont industries, like Computer and Electronics Manufacturing, which spend less on overhead generally (and fuel specifically), are not as vulnerable to ratcheting energy costs.

However, leaving production costs unchanged (on net) for this group of larger high overhead industries proved difficult to achieve with the TES policy instruments when inexpensive biofuels were not available. Neither the tax relief in the Carbon Tax Shift scenario, nor the reduction in renewable energy prices in the TREES scenarios proved sufficient to offset a slight negative price response by these industries in a "go it alone" scenario. Small changes in the investment and hiring patterns of large industries can have outsize multiplier effects that policy design will need to take under consideration. It is possible, for example, that targeted efficiency services could save these industries enough energy expenses to leave their policy-induced production costs unchanged, even if expensive biofuels are the only way to meet policy goals. Likewise, tax relief or complementary energy policies may provide enough flexibility to accomplish this, as TREES alone acts only on energy prices.

5 Benefits of Cooperation

PSD evaluated the economic impact of joint action to reduce GHG emissions and increase renewable energy by simulating "go it alone" policy scenarios side by side with "go it together" scenarios. The comparative results shown in Exhibit 10 confirm that the Vermont economy generally performs better if policies are undertaken in cooperation with other states. For all policy scenarios, PSD simulation results show that "going it together" is an effective way of avoiding excessive retrenchment in consumer and business spending caused by a negative price response. The higher the cost of energy consumption in any policy, the more benefit there will be to going it together with other states.[7]

While economic success was not found to depend entirely on "going it together" for any policy, the results in Exhibit 10 do suggest that at least some level of cooperation with other states will be an important component of effective implementation for all policies. As an example, the benefits gained by going it together with a TREES policy could amount to as much as $311 million in GSP per year and 6,200 jobs per year (on average for the 2015-2050 period). In a scenario where biofuels are less expensive, the gain in benefits is less dramatic, but still significant ($33 million in GSP and 290 jobs). Thus "going it together" reduces the risk posed by the uncertain future price of biofuels.

[7] However it should be acknowledged that no part of PSD's economic modeling exercise was designed to capture the potential rewards, rather than just the risks, of being a first mover in the regional energy policy arena. It is not inconceivable that an aggressive energy policy that places large incentives on the standardization of efficiency services and the build out of renewable energy infrastructure could attract an influx of innovative and profitable enterprises to Vermont.

Exhibit 9. Long-Term Growth in GSP and Employment: "Go it Together" and "Go it Alone" Policy Versions

	Together		Alone	
	Δ GSP	Δ Jobs	Δ GSP	Δ Jobs
Carbon Tax Shift: High Bio	+0.69%	+1.26%	+0.28%	+0.41%
Carbon Tax Shift: Low Bio	+0.23%	+0.44%	+0.26%	+0.36%
TREES Basic: High Bio	+0.45%	+0.90%	-0.14%	-0.32%
TREES Basic: Low Bio	+0.23%	+0.45%	+0.17%	+0.39%
TREES Local: High Bio	+0.47%	+0.85%	-0.24%	+0.06%
TREES Local: Low Bio	+0.27%	+0.38%	+0.13%	+0.38%

Because the price of biofuels are the largest determinant of the overall cost of a renewable energy supply, "going it together" serves to minimize Vermont's economic exposure to the possibility that inexpensive biofuels will not be available to meet policy goals. In a "go it together" scenario, increased energy unit costs do not uniquely hamper Vermont cost-competitiveness relative to other states. In high biofuel price cases, it is the TREES policies that show the largest gains from cooperation. The greater volumes of spending attributable to purchases of expensive biofuels in the TREES scenarios actually provide a larger stimulus than under Carbon Tax Shift scenario.

6 Methodology

REMI PI+ is a structural model designed around the core theoretical assumption of General Equilibrium Economics that households and businesses will seek to minimize costs in order to maximize monetary gains. All changes to endogenous variable values made by users in a PI+ policy simulation are integrated into the model through a gradual quantity adjustment process by which the prices for labor, goods and services each find their own market clearing level. Within this framework, changes in levels of production and consumption are driven by changes in prices of substitutable options in markets for capital goods and consumer goods and services. For more technical information about the REMI model see http://www.remi.com/resources/documentation.

6.1 Mapping FACETS Results to REMI Input Variables

The FACETS modeling software characterizes its results as optimal strictly in terms of monetary cost. Policy requirements favoring production and consumption of renewable energy add relative costs to fossil fuel purchases and induce increased purchasing of renewable fuels that may not be cost-competitive without the policy. In an economic impact analysis, however, it is necessary to distinguish how those changes in costs translate into spending flows by households and businesses. In REMI, an exogenous increase in the costs faced by households or business—in the form of higher prices of consumer goods or factors of production—will cause an endogenous price response in which purchasing behavior substitutes away from the most expensive options. At the same time, an exogenous increase in spending or demand will flow through regional industry supply chains, providing sales revenue to businesses that causes an endogenous increase in investment and hiring spending, culminating in higher levels of output and employment.

One of the central purposes of an economic impact study is to estimate the net effect of these often countervailing processes. Thus what FACETS characterizes as costs must be represented in REMI also as spending streams that flow between different sectors and industries, providing income for business, governments and households. Some portion of those spending streams is attributable to changes in prices and should be treated as a specific monetary cost of the policy that will be met with an endogenous price response in REMI. This methodology section explains how these policy costs were differentiated from the spending flows that encompass them and entered into REMI as distinct variables.

6.2 Representing Policy Scenario Demand in REMI

The FACETS optimization results that the Department relied on to construct demand variables in REMI were organized into the following categories, originally construed by FACETS as costs, but reconceived here as spending flows:

Investment costs	→	Spending on equipment and capital
Fixed costs	→	Spending on operation and maintenance
Fuel costs	→	Spending on fuel

All data received from DEC was grouped into aggregations for Residential, Commercial, Industrial, Transportation, and Power sectors. The Department assumed that 90 percent of Transportation sector spending is done by the Residential sector and 10 percent is done by the Business sector.

Exhibits 11 through 13 below display how these native FACETS categories were mapped to specific demand variables in REMI. In Exhibit 13, Fossil Fuel spending includes spending on Natural Gas, LPG, Distillates, Motor Vehicle Fuels, Coal, and Oil Products. Biomass spending includes spending on Wood Chips, Wood Pellets and Cordwood. Biofuel Spending includes spending on Biodiesel and Ethanol.

Exhibit 10. FACETS Capital Costs Mapped to REMI Demand Variables

Investment Costs in FACETS Associated with:	Exogenous Demand variable in REMI
Electricity Consumption by Residential, Commercial and Industrial sectors	Final Demand: Electrical Equipment Investment Demand: Electrical Equipment
Fossil Fuel and Biomass Consumption by Residential, Commercial and Industrial sectors	Final Demand: Machinery Manufacturing Investment Demand: General Industrial Equipment
Efficiency Improvements made by Residential, Commercial, and Industrial Sectors	Final Demand: Repair & Maintenance Final Demand: Professional & Technical Services Final Demand: Electric Equipment Final Demand: Computer & Electronic Final Demand: Construction
Photovoltaic Electricity and Solar Thermal Energy Production by Residential and Commercial sectors	Final Demand: Computer & Electronic Final Demand: Machinery Manufacturing Final Demand: Electrical Equipment
Electricity Consumption for Transportation by Residential and Commercial sectors	Final Demand: Motor Vehicles, Bodies, Trailers, Parts Final Demand: Electrical Equipment Investment Demand: Electrical Equipment Investment Demand: Railroad Equipment
Fossil Fuel and Biofuel Consumption for Transportation by Residential and Commercial sectors	Final Demand: Motor Vehicles. Bodies, Trailers, Parts Final Demand: Electrical Equipment Investment Demand: Aircraft Investment Demand: Railroad Equipment Investment Demand: Electrical Equipment Investment Demand: Other Trucks, Buses Investment Demand: Light Trucks

Exhibit 11. FACETS Fixed Costs Mapped to REMI Demand Variables

O&M Costs in FACETS Associated with:	Exogenous Demand Variable in REMI
Residential and Commercial Transportation	Consumption: Motor Vehicle Repair & Maintenance Final Demand: Repair & Maintenance
Photovoltaic Electricity and Solar Thermal Energy Production by Residential and Commercial sectors	Final Demand: Repair & Maintenance Final Demand: Construction Final Demand: Professional & Technical Services

Exhibit 12. FACETS Fuel Costs Mapped to REMI Demand Variables

Fuel Costs in FACETS	Exogenous Demand Variable in REMI
Electricity	Industry Sales: Custom Electric Utility
Fossil Fuels	Final Demand: Oil & Gas Extraction Final Demand: Petroleum & Coal Products Manufacturing
Biomass	Final Demand: Forestry & Logging Final Demand: Agriculture & Forestry Support Final Demand: Wood Products Manufacturing

6.2.1 Treatment of Biofuel Spending in REMI

As in the FACETS optimization, the Department assumed that biofuel consumption is supplied predominately by outside-region exporters. All spending on biodiesel and ethanol was therefore represented in REMI as demand on the Retail Trade industry, a proxy for the local businesses involved with the distribution of biofuels to end users in Vermont. However, only 15 percent of the spending on biofuels reported in the FACETS results was included as demand on Vermont retailers. In effect, this assumes a 15 per cent markup by local distributors. The Department arrived at its 15 percent markup assumption based on an informal comparison with conventional fuel dealer markups. It should be noted that because of the large quantity of biofuels consumed in the FACETS optimizations—especially in the low biofuel price scenarios—REMI results are quite sensitive to assumptions about how much of this spending flows through the Vermont economy.

6.2.2 Building a Custom Electric Utility in REMI

REMI allows for the development of custom-built industries with user-specified intermediate inputs. The Department's analysis made use of this functionality in order to build an Electric Utility industry that enacts the quick transition toward a renewables-dominated power supply in each policy scenario. This was done because REMI's default Utility industry uses mostly inputs from fossil fuel industries with no large shifts in the supply chain projected.

Exhibit 14 below shows the percentage of all spending by the TES Custom Utility going to the purchase of each fuel type used to generate electricity, as well as the capital spending associated with the purchase and use of those fuels. When demand on the Custom Utility industry is increased in PI+, intermediate demand for industries supplying that fuel and equipment also increases (in line with the input shares shown in Exhibit 14). The percentages given in Exhibit 14 are averages for the entire projection period, 2015-2050. Note, however, that the Custom Utility industry was built with enough temporal detail to reflect the shifts in those shares that take place over the duration of the projection period. It is also important to realize that the percentages in Exhibit 14 represent the volume of spending undertaken to acquire the listed resources. These percentages are not necessarily proportional to the quantity of energy supplied by these resources. That said, a higher level of spending to acquire a resource is generally indicative of higher consumption of that resource for power production, even if the relationship is not exactly linear. The last row of Exhibit 14, labeled imports, includes electricity purchased by Vermont utilities from Hydro Quebec and nuclear generators located outside the state.

Because REMI does not supplant default Industries with user-specified Custom Industries, it was necessary to take a final step in each policy simulation to ensure that all endogenous intermediate demand for electricity was properly re-routed to the supply chain of the Custom Utility. This was done in an iterative procedure, in which a "second-to-last" simulation was run in order to determine the total quantity of intermediate demand for electricity taking place in the policy scenario. In the final simulation this "second-to-last" quantity of intermediate demand for electricity was prevented from flowing through to the suppliers of the REMI default Utility industry (using the "Nullify Intermediate Inputs Induced by Industry Sales" variable). In addition, this same quantity was entered into the final simulation as a new demand variable for the output of the Custom Utility.

Exhibit 13. Custom Utility Spending on Intermediate Inputs, Average Percentage for Projection Period

	High Biofuel Price Scenarios			Low Biofuel Price Scenarios		
	CT 1250	TREES Basic	TREES Local	CT 450	TREES Basic	TREES Local
Biomass Fuel Spending	27.85%	29.54%	29.89%	35.24%	35.66%	46.20%
Biomass O&M Spending	1.03%	1.13%	1.15%	1.41%	1.43%	1.87%
Farm Methane Equipment Spending	0.09%	0.11%	0.11%	0.13%	0.13%	0.14%
Farm Methane O&M Spending	0.14%	0.16%	0.16%	0.19%	0.20%	0.22%
Distillate Equipment Spending	0.15%	0.16%	0.17%	0.20%	0.21%	0.21%
Hydropower Equipment Spending	2.42%	2.66%	2.68%	3.25%	3.34%	3.43%
Hydropower O&M Spending	2.30%	2.53%	2.55%	3.10%	3.18%	3.27%
Landfill Gas Equipment Spending	0.66%	0.72%	0.73%	0.88%	0.91%	0.93%
Landfill Gas O&M Spending	0.27%	0.30%	0.30%	0.37%	0.38%	0.39%
Natural Gas Fuel Spending	0.26%	0.27%	0.27%	0.28%	0.29%	0.29%
Natural Gas Equipment Spending	0.53%	0.58%	0.59%	0.71%	0.73%	0.75%
Natural Gas O&M Spending	0.05%	0.11%	0.11%	0.12%	0.12%	0.12%
Solar Equipment Spending	1.12%	1.26%	1.27%	1.48%	1.56%	1.68%
Solar O&M spending	0.13%	0.15%	0.15%	0.17%	0.18%	0.20%
Wind Equipment Spending	12.32%	13.60%	13.74%	17.21%	17.45%	18.16%
Wind O&M spending	2.58%	2.83%	2.86%	3.76%	3.76%	3.78%
Import Spending	48.09%	43.91%	43.28%	31.50%	30.46%	18.34%

6.3 Representing Policy Scenario Costs in REMI

Some portion of the magnitude of the fuel spending flows described in Exhibits 11 through 13 is attributable to businesses and households paying more for the fuels they consume in each policy scenario. There are two inter-related sources of changes to the cost structures facing households and business in the Department's REMI simulation:

- Cost of purchasing renewable energy at higher relative prices
- Cost added to energy purchases by the policy instrument

Taken together these two categories comprise each sector's aggregate policy-specific increase in costs. In all scenarios, there are large efficiency gains achieved by households and businesses in reaction to high energy prices. To varying degrees (depending largely on the assumed price of biofuels), the decline in energy usage over time is large enough that the cumulative sum of spending on energy over the entire projection period is actually less than is the case for the BAU forecast. However this is not the case in all years of the projection period; the higher cost of a renewable energy supply generally causes more of a burden in the earlier stages of the projection period. In these early years the higher prices of renewable energy outweigh declining usage.

6.3.1 Costs from Policy Instrument Price

The first source of changes to the REMI economy's cost structure mentioned above is the prices of the policy instruments themselves, either the price of carbon in the Carbon Tax Shift scenarios or the price of TREES certificates in the TREES scenarios. In the case of the TREES Local scenarios, each sector's cost is determined also by the prices of the local supply credits, which are not present in the TREES Basic scenarios.

6.3.2 Cost from Higher Priced Renewable Fuels

The second source of changes to the REMI economy's cost structure is the higher relative prices of the renewable fuels that must be purchased in order to satisfy policy requirements. In effect, the presence of a carbon price or a market price for TREES certificates forces the purchase of more expensive biomass, electricity and biofuel options that are not otherwise taken up in the BAU scenario. In turn some of this increase in spending on renewable fuels is attributable to higher prices charged for biomass and electricity in the face of policy-induced increase in demand for renewable options (i.e. due to movements up the biomass and electricity supply curves).

6.3.3 Preserving FACETS fuel-switching

While REMI allows users to increase the price of a limited number of specific fuels (natural gas, electricity, and fuel oil), doing so in this context would trigger endogenous substitution responses that would distort the fuel-switching behavior implicit in the demand variable values transplanted from the FACETS output data. For this reason the cost burdens described above were entered into REMI as generalized increases in prices. For households this meant using the "Total Consumer Prices" variable, effectively reducing their purchasing power by the amount of each category of cost burden. For businesses, this meant using the production cost variable which increases the prices that each industry pays for its factors of production (labor, capital and fuel) in proportion to the industry's relative use of those inputs in the REMI control forecast.

The consequence of using these generalized cost variables is that no part of the price response by households and businesses will be determined by the cross-price elasticity coefficients programmed into REMI. That is, capital will not be substituted for labor, for example, nor will fuel oil be substituted for electricity. The endogenous effect on households will be a decrease in consumption spending, a greater portion of which will now go to suppliers outside the region offering cheaper consumer goods. For business, the effect will be a loss of sales by industries that have outside-region competitors with lower production costs. Both effects are part of a feedback sequence whereby investment, hiring, income and employment all adjust downward in response to a higher price environment.

To the extent that other states pursue similar policies that also compel the purchase of higher priced renewables by households and business, the loss of market share and consumer dollars to outside region business taking place in REMI will be overstated. This is because the price differentials between Vermont and the rest of the nation would not be so large in a reality where other states are also bearing higher energy costs. As described in Section 5, the Department performed a set of "go it together" simulations in which relative energy costs between Vermont and other states do not change.

6.3.4 Apportioning Policy-Induced Costs to Industries

For the business sector, the aggregate policy-induced change in energy costs—represented as an increase in production costs—was assigned to the various NAICS industries in proportion to each industry's individual share of the total spending on fuel by all regional industries. In order to determine these industry-specific fuel shares, it was necessary to first "regionalize" the national input-output table built into REMI so that it better reflects the specific makeup of intermediate demand by Vermont Industry.

This was an iterative process which involved running a "first-pass" simulation that included only the demand variables, as listed in Exhibits 11 through 13. From these results, the next step was to extract data on the scenario-specific output levels of each NAICS industry, which then reflected the spending patterns implicit in the FACETS optimization (but did not yet account for the changes in the REMI economy's cost structure). Next, the "first-pass" industry output levels were multiplied with the fuel shares contained in REMI's national input-output table. This gave an estimate of each regional industry's fuel spending in each scenario. The sum of those products was then used as the denominator for calculations of the specific share of the policy-induced costs borne by each industry. The greater the industry's share of total regional industry fuel spending, the greater the portion of the aggregate business sector costs borne by that industry.

6.3.5 Apportioning Carbon Tax Offsets to Households

In the Carbon Tax Shift scenarios, PSD simulated two different ways in which government might recycle carbon tax revenue back into the economy: the "transfer payment" approach, and the "tax relief" approach, both described in Section 4.1.1 above.

In the “transfer payment” approach, the entirety of the carbon tax revenue is directed to households regardless of which sector the revenue came from. This fiscal action directly increases consumer discretionary income. The extent to which this income is then spent back into the economy and thereafter re-spent by subsequent recipients is determined by REMI’s hard-coded coefficients for the household sector’s marginal propensity to consume. All else equal, in the REMI economy, a $1 million increase in transfer payments will generate more than $1 million in consumption spending.

In the “tax relief” approach, government uses of carbon tax revenue were assumed to offset existing taxes on households and business. Currently in VT, taxes paid by households comprise about three quarters of total state revenue. Using Tax Department data, PSD estimated that state revenue collected from households is divided approximately in thirds between Property, Income and Sales Tax. Tax relief to households in the REMI simulation was distributed accordingly, with each third of the Carbon Tax Revenue collected from households matched by reductions in each tax category. Even with the high price on carbon in the out years of the high biofuel price scenarios, offsets from the carbon tax revenue are never enough to reduce existing household taxes by more than 40 percent. Reductions in the sales and property tax categories are represented respectively as decreases in consumer prices and property prices. Reductions in household income tax were represented as increases in disposable income (using the Personal Income Tax variable).

REMI does not differentiate the spending behaviors of different income groups. For this reason REMI is an imperfect tool for modeling redistributions of income within the household sector. Many argue that the carbon tax is inherently regressive and should be implemented so to mitigate the disproportionate burden borne by lower income groups. PSD acknowledges that a full accounting of a carbon tax shift policy should address these distributional issues. However, PSD’s analysis looks at the household sector in aggregate and due to the limitations of REMI, does not attempt to represent the impact of any redistribution between income groups.

6.3.6 Apportioning Carbon Tax Offsets to Business Sector

Tax relief received by the Business sector was modeled as a reduction in industry production costs. Treating offsets to the business sector’s carbon tax in this way has the effect of mitigating the production cost increases attributable to the higher prices paid for both renewables and taxed fossil fuels. Currently in Vermont, taxes paid by business comprise about a quarter of total state revenue. The Department estimated that of these taxes paid by Vermont business, approximately 40 percent is Property Tax, 40 per cent is Sales Tax, and 20 percent is Corporate Income Tax. It is important to note that in both high and low biofuel price scenarios, there comes a point in the projection period when more Carbon Tax is being collected from business than would be paid if the current tax code was carried forward. This threshold is reached sooner in the high biofuel price scenarios than in the low biofuel price scenarios.

The implication of representing tax relief to business as a reduction in production costs that eventually exceeds the sector’s existing tax burden is that, beyond the thresholds mentioned above, offsets to the Carbon Tax on business would have to take the form of direct payments or subsidies to industry, such as an investment tax credit. The Department recognizes that whether tax relief or subsidies can be expected to reduce production costs and spur business expansion in the way modeled here is an open question. However REMI allows for limited options in representing corporate tax policy and standard practice is to treat corporate taxes as a cost of production. Incidentally, the Department observes that a given decrease in capital costs elicits a far weaker investment response than an equivalent decrease in production costs. All else equal, were business carbon tax offsets to be represented as a decrease in capital costs, rather than a decrease in production costs, results for GSP, employment, and income would all be lower than presented here.

6.3.7 Apportioning Carbon Tax Offsets to Specific Industries

Each individual Industry's share of the business sector's total carbon tax offsets—represented as a decrease in production costs—was determined by its share of the sum of all value-added across all regional industries. Value-added can be thought of as that portion of business revenue going to employee compensation and profits. Industries paying relatively higher amounts in salaries, wages and profits would see a relatively greater share of carbon tax revenues returned to them than industries with lower value-added. Thus in the Department's approach to modeling the carbon tax as revenue-neutral, it is those Industries that account for the highest shares of fuel spending but relatively low shares of value-added that will see the greatest increase in net cost from the policy. To the extent that a given Industry spends less on fuel than they spend on compensation and profit, their net cost will be either very low or completely absent, depending on the amount of tax collected in a given policy year. For example, in all policy scenarios the Truck Transportation industry is one of the largest spenders on fuel but ranks low in its share of value-added. On the other hand the Forestry industry does a relatively small amount of business fuel spending in each scenario but ranks higher in its share of value-added. So the net cost burden of the modeled revenue-neutral carbon tax would generally fall more on the Trucking industry than the Forestry industry.

6.3.8 Testing the Price Effect of TREES Revenue

In the TREES scenarios, there are no direct offsets to the increase in energy costs associated with the policy, as there is in the revenue-neutral carbon tax scenarios. However it can reasonably be assumed that revenue earned by originators of TREES certificates would be used in some degree to offset the supply costs of renewable energy producers and thereby mitigate the end-use energy costs facing households and business. The Department made no effort to empirically estimate what the magnitude of this price reduction might be. Instead, a variety of simulations were run testing a range of assumptions about the degree to which the revenue earned on TREES certificates would serve to mitigate the costs associated with the purchase of higher priced renewable fuels (see Section 4.1 above). For example, it can be assumed that none of the revenue generated by TREES certificates is used to reduce retail costs of renewable energy and energy efficiency services. This would mean that the effect of the TREES policy instrument is limited only to increasing the cost of non-renewable energy, an extreme and unrealistic assumption. Conversely, it can be assumed that all of the revenue generated by TREES certificates is used to reduce retail costs of renewable energy and energy efficiency services. This would mean that, in addition to having the effect of increasing the cost of non-renewable energy, the TREES policy instrument also has the effect of reducing the delivered price of renewable energy, a more plausible assumption. As shown in Exhibits 7 and 8, the results of these extreme "policy effectiveness" assumptions were treated as upper and lower bounds of the range of likely economic impacts associated with each policy.

Total Energy Study:
Public and Stakeholder Engagement Appendix

Contents

Legislative Report:

Public Comment Summary

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1 Introduction

The purpose of this Appendix is to provide a synopsis of comments on the Total Energy Study (TES) solicited and received from energy stakeholders and the public between June 21st and December 2nd, 2013. Commenters responded to various requests from the Public Service Department (PSD):

1. Energy stakeholders submitted written responses to the PSD's Request for Information regarding the Total Energy Study Framing Report.

2. Energy stakeholders participated in eleven focus groups during the summer of 2013. Some submitted written comments as a follow up to the discussions.

   One hundred and thirty two representatives participated from 79 organizations of varieties of businesses and their associations, local and national energy businesses and consulting firms, energy utilities, environmental and citizens advocacy groups, academics, financial institutions, philanthropists, transportation authorities, law firms, town energy committees, planners and other local, state, and federal governmental agencies. Refer to Appendix B for a list of participants.

3. The public and energy stakeholders attended a TES Public Meeting and Webinar on November 14th at the State House and on-line.

4. The public and energy stakeholders submitted written comments from November 14 through December 2nd.

All who provided input are invested in Vermont's future. All statements below were summarized from the summer focus group discussions, the public meeting, and written comment. No comments have been validated. Comments suggesting that a particular action should or should not be taken, should not be interpreted as evidence that the action has or has not already been taken.

This appendix is organized in the following fashion.

- Section 2 Energy Goals and Principles includes comments related to Vermont energy and greenhouse gas goals and methods used to measure energy demand, energy consumption, the renewables component, and greenhouse gas emissions. Section 2 includes comments related to the overarching statutory goals of Vermont's energy policies. Section also includes comments regarding how the public, the private sector, or the Legislature might drive or react to State energy policy.
- Section 3 End Use Demand Technologies & Services and Section 4 Energy Supply Technologies & Services include comments related to technology and service requirements, existing markets, and resources.
- Section 5 Energy Policy Development includes comments regarding priorities, pacing, evaluation criteria and other principles which energy policy analysis and development should consider

during the design of new policies. Section 5 also summarizes comments related to the five primary policy sets described in the Total Energy Study Legislative Report.

2 Energy Goals and Principles

2.1 Energy Goals and Their Measurement

The Legislature required that the TES analyze how to reach the currently defined State energy and greenhouse gas goals. Therefore, few commenters expressed an opinion for or against the current goals as set by the legislature. Many commenters did point out that in order to achieve these energy goals, massive change is needed and that we are entering a new energy frontier. One commenter stated that operating our society at current levels is incompatible with substantial greenhouse gas (GHG) reductions. A few commenters advocated for setting all energy goals such that their achievement directly supports meeting the GHG goals. A particular concern was expressed that if total energy consumption grows, Vermont might reach our renewable goals but not our GHG goals. One commenter advocated for moving beyond our goals to 100% renewables with near-zero GHG emissions as soon as possible.

Many commenters discussed data representations of Vermont's energy portfolio (e.g. pie charts of total energy by resource type) often calling for more clarity in how certain activities are measured and presented, such as the buying and selling of Renewable Energy Credits (RECs), reduction in demand, electricity feedstock resources , and energy losses (heat, transmission). Several commenters appreciated the PSD's more recent visual presentations of total energy supply which differentiate RECs that are sold. Several commenters requested that natural gas purchased through regional electric markets be quantified and shown in Vermont's representations of total energy consumption.

Renewable Energy Goals: Most commenters agreed that Vermont policy should prioritize reducing reliance on fossil fuels. Most commenters agreed that to reach Vermont's renewable energy goals, energy efficiency and conservation are critical primary strategies.

Measuring the Renewable Energy Component of Total Energy: Several commenters requested clarity on how energy savings from efficiency and conservation will be accounted for in the measurement and projection of declining energy usage. More specifically, will these savings be treated as demand reductions against total energy consumption or reductions in supply? Several commenters recommend the former.

One commenter stated that U.S. Energy Information Administration (EIA) data projections used in PSD planning are based primarily on expected demand, which is shown to increase through 2050. This person believes that EIA demand projections are overstated and recommends following biophysical economics methods to account for physical and economic constraints which are likely to lead to an inevitable fall off in consumption around 2030.

One commenter stressed that when measuring the renewable component of the energy mix, we should include the investment of fossil fuels needed to manufacture and install new technologies like electric vehicles (EV) and photovoltaics (PV). This person contends that relevant GHG measurement and policies should account for the embodied energy in all goods and services produced and consumed in Vermont.

Measuring the renewable resource component of Vermont's total energy supply requires that renewable and non-renewable resources are converted into common units. The standard practice is to convert power outputs from renewables to a British Thermal Unit (BTU) equivalent. One commenter recommends that kilowatt-hours be used as the common measure, given that a majority of Vermont's energy will most likely be derived from electricity in the future.

One commenter highlighted the issue that combustible fuels suffer a loss of heat that renewables such as wind, hydro, and solar do not. Therefore, the use of BTU equivalents will tend to overestimate heat loss from the renewable component of our energy mix. One commenter recommended that "source energy" measurement be more transparent and accurately show the "energy intensity" of Vermont's economy, methodologies for which the EIA has published research. This commenter urges that all efforts should be made to prevent waste in energy generation from being counted in the renewable energy component of our energy mix.

GHG Goals: Many commenters support exploring new and systematic approaches to address Vermont's energy goals. Most are deeply concerned about the impacts of global carbon emissions.

GHG measurement: Several commenters wanted Vermonters to understand that many GHGs will persist in the atmosphere for thousands of years. The timing of emissions reductions is important in meeting GHG goals due to multi-decade lag effects and positive feedback loops. The emissions rate must be less than the global absorption rate to slow or prevent climate change. If all GHG emissions stopped today, climate change would still cause substantial problems. To make better decisions in directing and pacing policy and technology pathways, GHG measures should be presented in terms of a carbon budget and account of compounding atmospheric effects. Many commenters supported the use of lifecycle analysis when measuring GHG emission, though all are aware of the accounting complexities and wide variability in measurement techniques. One commenter cited particular technologies: hydro dams are responsible for GHGs emitted in the decomposition of flooded biomass; intermittent renewable sources require more spinning reserves which emit GHGs; earthworks for new generation and transmission infrastructure clears carbon-storing vegetation; crop-based biofuels may require additional nitrogen fertilization; increased bioenergy production may reduce carbon sequestration benefits from existing land uses. One commenter requested that lifecycle analysis for bioenergy sources include all nonrenewable energy inputs used in their manufacture. Commenters were in general agreement that further dialogue is needed within Vermont regarding the right GHG measurement methodologies and that the terms "clean" and "renewable" should be applied with care.

Several commenters noted that planning documents need to include explicit discussion of research on natural gas GHG measurement. Some measures put lifecycle shale gas emissions near that of coal when accounting for shale gas infrastructure development and operation, including pipeline extension, well pads, access roads, large volumes of water, and release of fracking fluids that may not be recovered or rendered harmless.

There was frequent discussion among commenters about the on-going controversy over how to measure GHG emitted from bioenergy. Some experts consider bioenergy old carbon and thus carbon emitting. Other experts count bioenergy as new carbon and thus carbon neutral. A few voiced concerns over if and how lifecycle accounting would be applied. Will biogenic emissions be counted at-the–stack, when burned, or via lifecycle accounting? Will GHGs from cut firewood be counted? Well informed policy design on the accounting methods can shape reduction in net emissions.

2.2 Projecting the Future: Total Energy Study Modeling

One commenter clarified that the TES will not be a package of strategies but is part of an ongoing process to provide policy directions aiming to optimize benefits for customers, energy systems providers, and the general society. One commenter compared the process to piecing together a daunting puzzle, making a design out of much data, many pieces, and many ideas. One commenter would like to see more evidence that the State is following a systems approach when planning for change related to energy systems, global climate, economic, and social systems, including more information on the connections among policies proposed.

The TES modeling exercise involves comparing a baseline scenario to alternative scenarios comprised of different combinations of policies and technologies. Commenters agreed that TES modeling must distinguish baseline efficiency and conservation savings from new efforts. For instance, CAFE standards should be treated as baseline measures while the impacts from any new state policies to encourage efficient vehicle ownership should be counted as additional savings above the baseline. Several commenters expect that projecting the baseline current policies forward will show how dramatically far Vermont is from meeting its energy goals.

One commenter recommended that each TES Model run prioritize efficiency and conservation programs first and then apply renewable resources. The model should track and measure the impact of new, above baseline policies without counting demand reduction towards Vermont's renewable energy goal. However, another commenter noted that the model needs to dynamically compare the cost effectiveness of efficiency and renewables simultaneously. As renewable technology costs decline they are becoming more cost competitive than efficiency under particular conditions.

2.3 Statutory Goals

2.3.1 "adequate, reliable, secure and sustainable"

Refer to Section 4 Energy Supply Technologies & Services

2.3.2 "assures affordability" and "least cost planning"

Several discussions and written comments noted that forward looking energy planning publications and presentations need to include specific information on costs to residential and commercial/industrial consumers. There needs to be more discussion about consumer choice; consumers need the freedom to state their preferences for energy resources and technologies. One commenter stressed that consumers need opportunities to weigh in regarding their willingness to pay for carbon reduction programs and more renewables.

2.3.2.1 Least Cost Planning

One commenter noted that all energy planning documents listing Vermont's key energy statutes in their introduction should include 30 V.S.A. §202a(2) which requires least cost integrated planning by law.

Several commenters rallied for updating the least cost planning framework historically applied to the electric supply sector, to integrate both the supply and demand sides of the transportation and building energy sectors. Scenario analysis using least cost rules should be indifferent to the scale of projects within any sector; scale will be determined by the energy demand consumers. One commenter suggested another advantage of least cost planning is that an assessment of capital availability can be captured when levelizing the costs of ownership across technologies.

Commenters agreed that efficiency is most often the least cost solution.

Commenters discussed the lack of outcomes in the 2013 legislative session to advance energy policy. Cheap natural gas conflicts with long term efficiency and renewable goals. Some commenters said new legislation was stalled because citizens and legislators are not motivated given that new energy investments have large up-front costs and little if any immediate payback.

New wind energy development was commonly identified as the cheapest new renewable technology. One commenter stressed that consideration of transmission, integration, and environmental costs show wind to be less competitive, especially as costs fall for PV, hydro dam upgrades, and combined heat and power (CHP).

The integration of renewables requires new grid operations technologies and could require increased reliance on fast ramping, higher emitting natural gas plants, energy storage, and in the worst case, temporary curtailment of renewable generators. Several commenters raised questions about how these costs are accounted for when comparing technologies.

One commenter underscored the need to optimize the deployment of renewable generators and energy storage capacity. Energy storage costs are high in terms of capital and operation. Energy planners need data and models to assess the future optimum mixture of renewables that will minimize the need for energy storage and thus minimize total system costs. Data at the right resolution and frequency should be collected from wind, solar, and hydro resources at key locations across Vermont. New legislation and regulation might be needed to make this data available from operators.

Cost Benefit Analyses: Many commenters requested that cost effectiveness analyses and screening tools include total environmental and societal costs (including health impacts) of projects on a lifecycle basis or that the specific costs and benefits be considered under separate criterion. One commenter stressed that until there is consistency in the accounting of full costs and benefits, including insurance, subsidies, tax breaks, etc. across technologies and energy sectors, rational decisions cannot be made by consumers and politicians. While advancing these methods is beyond the TES, a forum for discussion should be defined.

Some commenters highlighted that cost benefit screening tools need to consider particular renewable technologies which become more cost effective as markets deliver lower prices due to economies of scale. For instance, in certain buildings solar can be more cost effective than efficiency measures.

Some commenters voiced the opinion that there are economic benefits to simultaneously developing efficiency and renewable markets in Vermont. Screening tools that give competitive advantage to low cost efficiency measures need to be strategically adjusted in tune with new policies that give greater weight to renewable technologies, especially as the relative installation and operating costs change. Screening tools should be designed to recommend efficiency and/or renewables for a building based on owner specified monthly or annual operating (and financing) expenses.

Energy Return: A few commenters suggested that all energy technologies and projects be evaluated in terms of energy return on energy invested (EROEI) and energy payback time.

2.3.2.2 Price Signals and Markets

Commenters discussed the impact of price signals. In order to adjust markets and influence consumers, energy price signals need to be large and consistent. One commenter contended that the magnitude of energy pricing adjustments needed to impact behavior would have to be effected at the federal level to be feasible. One commenter mentioned that without other dials to turn (e.g. funding), price signals need to be as high as European style energy taxes. Commenters discussed the need to avoid the “P-scream,” which happens when prices become too high and create backlash among consumers.

Commenters generally supported using transparent market mechanisms to influence energy systems. The true costs of energy production and consumption should be internalized, however lower income residents need to be protected via vouchers or subsidies. Some commenters stated that price signals are effective public relations campaigns and the right price signals will shift the culture toward lower energy consumption.

Other commenters noted that consumers often do not respond to price signals, new technologies, and markets as expected. Commenters said policies and programs need to be designed with careful consideration of human behavior. Consumer behavior needs to be studied. For instance, significant gasoline price increases and volatility have not lowered Vermont’s average Vehicle Miles Traveled (VMT) proportionally. One commenter noted that if gas prices incorporated the true costs of production and externalities, electric vehicle purchases and operation costs would be more competitive.

Commenters recommended tiered rates such that higher prices above standard thresholds are set to reward conservation and protect low-income households. Some commenters noted that tiered pricing for certain resources, such as gas or heating oil, has less potential to incentivize immediate behavior change, but would encourage behavior change for conservation or investment in less energy intensive technologies if phased in and maintained. One commenter recommended tiered pricing be applied to total energy use.

One commenter countered the concern stated by others to always protect the most “vulnerable” from policies that institute pricing mechanisms which are set to influence behavior. This person noted that at some point the government will not have the resources to provide on-going subsidies that encourage unsustainable behavior, for instance when gas moves to $6 per gallon.

2.3.3 "encourages the state's economic vitality"

Many commenters noted that the impact of energy policy on economic development is not discussed or analyzed with enough frequency or depth.

Commenters noted that Vermont's ability to attract and retain businesses and employees must be cultivated. Many commenters emphasized that price and rate competitiveness must be preserved. There is concern that Vermont's relatively high electricity costs put us at a regional and national disadvantage, although we remain competitive due to other factors, in particular quality of life. As energy transformation unfolds, these costs and existing competitive advantages need to be carefully balanced. One commenter stated that Vermont's energy goals, e.g. "90% by 2050", need push-back from PSD. Striving to reach the goals could raise energy prices sufficiently and cause harm to Vermont's economic development. Analysis is needed not just to study "how to reach the goals", but also to understand "how to mitigate the economic impacts of reaching the goals".

Many commenters held the view that prioritizing the development of in-state renewable energy resources will maximize local economic benefits by creating jobs and keeping dollars in-state.

Some commenters emphasized that the internalization of externalities would be most successfully implemented on a regional, national, or international basis.

Commenters stated that Vermont should be wary of locking-in technology that would make the state less flexible to adopt emerging technologies.

Several commenters noted that transportation and land use policies supporting Smart Growth principles and well designed local/regional transportation systems are beneficial for local economies. One commenter stressed that planners need to be better at concretely demonstrating the economic benefits of funds spent to implement Smart Growth principles.

2.3.4 "efficient use of energy resources and cost effective demand side management"

Refer to Section End Use Demand Technologies & Services

2.3.5 "environmentally sound"

One commenter stated that energy planning needs to broadly assess the cumulative effects of environmental impact; project-by-project assessment does not capture the full picture. For example, transmission build out to reach an array of distributed and remote generators can cause habitat fragmentation.

One commenter warned Vermonters to avoid environmental imperialism and prioritize using resources locally for our energy supply.

One commenter was against siting biomass district heat plants in the vicinity of homes due to concerns over air quality health impacts.

2.4 The Actors and Their Motivation for Action

Many commenters stated that to implement Vermont's energy goals, a sense of urgency is warranted by the Governor, citizens, and Legislature. Commenters stressed the need for significant immediate action sustained over decades; Vermont should not wait for easier conditions, lower technology costs, or broader public support. One commenter said that the need for massive change in our energy systems and the effort to get there needs to be communicated in a positive way rather than from a place of fear and scarcity.

One commenter was concerned that small municipal utilities do not have the capacity to manage the evolving complexity and transformation of energy systems. Their capacity needs to be addressed in planning and perhaps through new policies that help small utilities pool resources, following the VPPSA model.

2.4.1 The Public

Commenters emphasized that a sustained effort of public outreach and education is critical. Consumers need simple, credible messages. Myths need to be dispelled. Some commenters stated that consumers need to be empowered to make different choices about their energy consumption. Education on energy systems and climate change in schools is important.

Commenters stated that service providers need to speak a common language using standard definitions. Social-norming will permit neighbors to share comparable information. One commenter suggested that consumers might be more energy aware if they received one bill rather than multiple bills for energy costs.

Several commenters noted that consumers are sensitive to how they use energy (it's a lifestyle issue) especially with regards to how they heat or cool their living spaces and their reliance on cars. A human touch is needed when providing services to consumers. Service providers need to take the hassle out of mysterious projects and effort.

One commenter noted that Vermonters need to understand the complex trade-offs in all choices regarding our energy future, and be open to the benefits of home-grown energy sources which could include increased security and an improved quality of life.

Several commenters stressed that the public would experience a psychological shift to become more engaged as energy resources are localized, similar to the trends that have swept Germany. The "keep it local" buzz is effective.

2.4.2 The Private Sector

One commenter representing Vermont businesses noted that the private sector should "innovate and creatively partner" with the state government. Numerous comments took as their starting point that private businesses, such as energy providers, will be critical actors in any energy transition.

2.4.3 The Political Landscape for Action

Commenters felt it is important that the TES analysis be non-partisan. One commenter stressed that until least cost planning and cost benefit analyses assess the full costs of our energy choices consistently across technologies, state and local politicians will not be given the “lift” required to promote clean energy policies.

Several commenters suggested that energy stakeholder groups need to work together and avoid neutralizing each other in their approaches to influence legislative action. One commenter said politicians are motivated by cost issues, thus the most compelling message is that the right energy policies will result in lower costs; also that the Governor and leaders in the legislature need to stand behind Vermont’s energy goals, heed expert recommendations from studies, and lead from their platforms. One commenter suggested that politicians need to sell the benefits of energy independence and job creation. Commenters noted that policies with broad benefits are worth the effort to move through a potentially difficult political process. A few commenters expressed the need to take back the term “tax”. Good tax policy is an effective mechanism to shift behavior.

One commenter contended that the magnitude of energy market shifts required to motivate adequate behavior change must be enacted through proactive political action. However, it might take a crisis to spur such action, at which point the markets will have already dramatically adjusted.

3 End Use Demand Technologies & Services

3.1 Overarching Energy Efficiency & Conservation

Commenters agreed that lowering energy demand is critical. The cheapest energy is that which is never used. Demand side management should be applied across all energy sectors. One commenter suggested that the largest energy users in the Vermont should receive specific attention to help them reduce their consumption.

Behavior Change: A number of commenters discussed behavior change as an important opportunity for demand reduction. One commenter mentioned Vermont’s work to develop a Genuine Progress Indicator as a forum to broaden discussion regarding how energy choices align with quality of life. Planners also need data on how different technologies impact behavior; for example wood stoves favor zoned heating, solar hot water users schedule usage on sunny days, and low operating costs for electric vehicles might encourage higher vehicle-miles-traveled.

One commenter recommended that the State review all options for implementing energy efficiency programs, noting the Vermont Energy Investment Corporation’s track record, but remaining open to new administrative structures.

Rebound effects: Many commenters are concerned that reduced costs from increased efficiency and fuel or mode switching might cause consumers to use more energy. For instance, one commenter predicted that higher miles per gallon (MPG) cars or EVs that are cheaper to operate will encourage more driving. To prevent this rebound, a few commenters stressed that efforts to increase efficiency need to be coordinated with increases in energy prices.

3.1.1 Building and Industrial Energy Efficiency

Most commenters support continued investment in weatherization as a critical pathway; this is a mature technology. Policies, standards, education for consumers, and certification for building trades are needed to prevent sub-standard new construction and renovation. Other New England states are doing a better job than Vermont.

One commenter emphasized that there is lot of efficiency left to capture but in residences of people who need public assistance. All the major efficiency work in the commercial and industrial sectors is complete.

Commenters noted that State funds for all current building efficiency incentives are collected from electric sector charges. There is a need to align Efficiency Vermont's (EVT) electric and thermal goals with higher level goals in Vermont's 2011 Comprehensive Energy Plan (CEP). There is a lack of clarity from the PSD on how to adjust EVT goals.

Several commenters emphasized that larger commercial and industrial entities have the expertise and capacity to strategically design and carry out progressive projects to lower their energy demand. These entities want to self direct their efficiency investments. Several commenters mentioned that the Energy Service Company model is not evolving because companies don't want to commit to long term contracts. One commenter mentioned that energy efficiency spending requirements need to be visible to corporate headquarters (which may be located outside of Vermont).

Building Energy Codes, Net Zero Buildings: Building to Net Zero standards does not cost much more than building to current efficiency standards. Commenters noted that in order to analyze the potential of Net Zero building technology, data collection is key. Data needed includes time series data of new construction per year, the state of current building stock, estimates of energy usage per square foot. One commenter asked whether Net Zero should be defined based on energy usage or carbon emissions. One commenter suggests that a better term for the standard should be Net Neutral, signifying the inclusion of building owner investments in renewable generation.

There is a need to identify buildings that are patched together and therefore extremely expensive to retrofit. A decision needs to be made as to whether those buildings will be exempt from new standards or eligible for more lenient standards.

Most commenters noted that the enforcement of building energy codes is critical. One commenter noted that code enforcement is effectively voluntary now but that incremental change is in the works. The issue is very local. Neighbors are known to encourage each other to cut corners to reduce up-front capital costs. Education about savings and other benefits is widely needed.

Several commenters noted that standards need to specify appropriate building sizes based on the structure's function. One commenter suggested that generation on-site be required for a building or complex of buildings that exceed specified energy consumption standards set for their building function, e.g. for residential, and commercial categories.

Some commenters want buildings to meet a minimum efficiency standard at the time of sale. Other commenters warn that restrictive policies like mandatory efficiency upgrades before sales will be insurmountable in terms of administration and will hamper the real estate market, especially when the market is strained.

Building Efficiency Labeling/Scoring: Many commenters support implementation of building efficiency labels or scores, similar to the Environment Protection Agency's MPG rating for cars. Vermont can start with a voluntary effort. One commenter suggested that the efficiency label be required at the time of sale. Some commenters want scores to include locational efficiency measures which evaluate a building user's transportation energy requirements (e.g. food, schools, medical, and recreation).

Scores need to reflect the cost effectiveness of both efficiency measures and the use of renewable energy supply for heating and electricity. A baseline standard for building efficiency is needed. Vermont needs to formulate policies on sharing building score data; a body of knowledge is needed to direct programs, but privacy must be protected.

Building Trade Training: The pace of technology development is out-running contractor knowledge. More young people need to be recruited and educated.

Consumer Service: Commenters emphasized that consumers need guidance and hand-holding to implement the right solutions. Along with building efficiency certification and licensure for tradespeople, a system of referrals (clearinghouse) is needed to encourage consumers to hire contractors who are trained and up-to-date on the most current technologies. Trades people need to refer each other. Realtors have expertise in both guiding and hand-holding consumers.

3.1.2 Transportation Efficiency and Mode Switching

Commenters requested information on the percent of single occupancy vehicle travel that makes up the total energy use in the transportation sector and what portion is commercial in nature.

Several commenters noted that work place transportation demand management is the surest means to influencing how most people travel. Vermont needs effective regional associations of employers and transportation providers.

Transit services to key regional and metropolitan areas need to be improved. Several commenters noted that public transportation has attracted ridership with wireless internet. Employers are recognizing telecommuting in transit.

Transit Buses & Shuttles: One commenter stated that good design for transit services includes scheduled stops every 15 minutes at each point. Another stated that we need to shift to community oriented transportation (e.g. small shuttles loops, route shifts upon request). One commenter recommended that Vermont coordinate bus routes statewide so that schedules and stops allow for convenient transfers.

Rail: One commenter recommended reestablishing overnight service to New York City. Vermont could collaborate with Amtrak to survey potential riders and plan the best schedules to improve ridership. Another commenter stated that Amtrak is not the answer and believes there is tremendous opportunity to reduce VMT and build the economy with a state-owned commuter train between Bennington and Burlington. One commenter supports the transfer of non-perishable freight by rail instead of trucks.

Smaller Electric Vehicles: One commenter asked that planners include in discussions and modeling the potential to replace car use with smaller vehicles including electrically powered neighborhood vehicles, bicycles, and scooters. Smaller vehicles are effective for commuting.

Some commenters recommended that a transportation data group be convened to devise measures and goals for keeping VMT flat. Information is needed at a more granular level of resolution. We need to understand the impact of Smart Growth on VMT and how to build barriers against reliance on single occupancy vehicle trips.

The discussion of transportation demand reduction continues into the next section on Land Use Practices.

3.1.3 Lowering Energy Demand with Land Use Practices

One commenter described that the "Quintessential Vermont" is a mix of forest, farms, homes, quaint small towns, and more-affluent recreation/tourist destinations. Many commenters pointed out that current preferences for choosing residences in rural areas add to the challenge of meeting Vermont's energy goals. Several commenters noted that affordable housing needs to tie in with access to jobs and transportation. One commenter mentioned that Vermont's aging population requires special consideration for town and transportation designs.

Commenters acknowledged there are good land use policies in place but they are not being consistently executed by local governments. Another commenter questioned whether local and regional planners are supporting Smart Growth principles; there is a lack of funding. One commenter noted that many towns lack zoning altogether or have zoning laws that encourage dispersed development.

Several commenters noted that community development efforts are needed to encourage people to live in mixed-use community centers. As we approach 2050 businesses should be increasingly located near existing urban cores. One commenter expressed a vision for walkable and bikeable town centers that would include locker rooms and showers for employees and safe sidewalks and bike route systems. Commenters suggested creating more car-free areas. One commenter noted that parking requirements for buildings are often inflated and this encourages reliance on car travel.

One commenter was concerned that Smart Growth policies will receive back lash from the public, many of whom prefer living in suburbs or exurbs. Another commenter noted that people are leaving Vermont to live in dense mixed-use communities. Another commenter noted that because of a lack of growth pressures in Vermont, Smart Growth policies are not receiving attention in the political arena.

3.2 Load Shifting and Demand Response

Commenters agreed that after optimizing investments in energy efficiency, energy systems need to shift from managing loads to optimizing demand response.

Smart Grid: Commenters noted that smart grid technology allows both grid operators and building owners to reduce thermal and electrical energy consumption, permits distributed generation and renewables to be safely connected to the grid, and can reduce investment in new utility infrastructure (by shifting loads to off peak). The costs of smart grid upgrades are covered by these savings.

One commenter noted that Vermont is a national leader in deploying Smart Grid technology with 90% of Vermont electric customers having smart meters.

3.3 Fuel Switching

Commenters actively discussed the electrification of the building energy and transportation sectors. Also, bioenergy technologies provide opportunities for switching off fossil fuels.

Some feel that the electrification pathway is in synch with Vermont's least cost energy planning directives. One commenter believes that technology advances will offer opportunities to electrify many segments of energy use. Of particular note is the potential total energy savings from switching from petroleum fuels to electricity via air-to-air heat pumps and electric vehicles. One commenter suggested that Vermont can learn from electrification programs being successfully implemented in other states such as California, and abroad, such as Israel.

One commenter emphasized that renewably generated electricity will not be able to replace all energy derived from fossil fuels. Also, some biofuels have lower energy density than petroleum fuels.

Several commenters stated that industrial entities have limits in their ability to replace fossil fuels with renewable resources for processes requiring very high temperatures; electrical supply cannot generate such high temperatures cost effectively. They mentioned that CHP could work. One commenter noted that for lower temperature processes, there is potential for fuel cell technology where the source energy originates from natural gas, or propane and perhaps hydrogen for sites beyond natural gas pipelines.

3.3.1 Transportation

Electric Vehicles: Many commenters support policy directions that promote the electrification of transportation through the deployment of light-duty EVs and electric vehicle charging equipment (EVCE). One commenter noted that EVs are three times more efficient than conventional vehicles. EVs are entering the market more quickly than hybrids were at a comparable stage of market development. One commenter noted the limited lifetime of current EV batteries.

One commenter noted the Drive Electric Vermont website as the state resource about electric vehicles. At least one guide about EVCE siting and installation is available for local governments from the Chittenden County Regional Planning Commission.

One commenter stated that the expense of buying an EV makes the technology beyond reach for moderate and low income people. A few commenters mentioned that three year EV leasing programs are becoming competitive with those for conventional cars.

One commenter stated that electrifying transportation could save Vermonters almost $1 billion a year in annual energy costs and could result in lower utility rates. One commenter is concerned that the global economic system will not have the capital resources (due to rising raw material and manufacturing costs) to manufacturer EVs in the quantities required.

Other Fuels: One commenter pointed out that because diesel accounts for only 18% and gasoline accounts for the bulk of Vermont's transportation fuel use, the primary challenge for meeting Vermont's transportation energy goals, is to move away from gasoline-powered vehicles.

Several commenters support aggressive policy to replace some uses of gas or diesel with biofuels produced locally, especially for on-farm use.

Several commenters were cautious about investing in EV infrastructure, mentioning that fuel cell technology may still have potential and natural gas vehicles are already on the market. One commenter stressed that fuel cells are not an energy source but are energy carriers that will require renewable resources to generate hydrogen in order to stay on target with renewable energy goals. One commenter stated that fuel cell technology is not likely to reach a favorable EROEI when efficient production, hydrogen storage, and transportation are all accounted for.

Another commenter suggested that Vermont incentivize the purchase of flexible fuel vehicles.

Heavy Duty Vehicles: One commenter suggested that fueling stations offering biofuels and natural gas for heavy duty transportation (freight, transit busses) should be exempt from carbon pricing.

3.3.2 Building and Industrial Energy

Water Heating: One commenter noted that converting hot water heating is one of the more cost effective efforts available in building efficiency and suggested an analysis be done comparing solar hot water heating to air-to-air heat pumps powered by PVs.

Space Heating: Many commenters agreed that policies encouraging fuel switching or equipment upgrades should be prioritized and linked to building retrofits.

Several commenters promoted policy development for aggressive adoption of bioenergy technologies for space heating, including district heating for town centers and building complexes, pellet boilers for small residential and commercial buildings, as well as advanced woodstoves for rural residences. The solid biomass technology and markets are mature. Cold climate Europe has adopted these heating technologies. Several commenters suggested homes switch from fuel oil or gas to wood pellets.

Several commenters emphasized that fuel dealers should be key partners in related programs.

One commenter noted that heat pumps cost effectively harness renewable sources of electricity. And efforts should be made to alter Act 250 mechanisms which have discouraged electric heat.

Several commenters support aggressive adoption of air-to-air heat pumps; this technology is proven, cost effective, and can be cost competitive with natural gas. One commenter noted that heat pumps are applicable in commercial settings for water heating, and clothes drying.

One commenter was particularly against air-to-air heat pumps. Space heat loads have a significant impact on peak and could require load shifting from on-site energy storage. In order to keep space heating prices affordable, buildings would require near-zero energy construction or retrofits. In the past, consumers have viewed electric heat as uncomfortable.

A number of commenters requested more discussion of geothermal or ground-source heat pumps in energy planning discussions and related documents. One commenter detailed the costs and benefits of geothermal technologies for Vermont buildings.

Passive Solar Design: Several commenters suggested that passive solar design is a proven technology and should always be included in discussions and analyses of building efficiency policies. One noted that passive solar design can be a significant contribution to space heating and the design has the best return on investment over heating fuels.

4 Energy Supply Technologies & Services

Commenters requested that Vermont carefully analyze the economic benefits and other tradeoffs of developing in-state resources versus purchasing out-of-state resources on the market or via long term contracts. Commenters noted that due to Vermont's size and environmental policies, we should continue to plan for out-of-state resources. Long term contracting mechanisms and standards (size, environmental impact, emissions, etc.) can help Vermont meets its goals.

One commenter recommends that Vermont prioritize in-state resource investments in order to ensure the greatest economic benefits and long term control over our energy resources.

One commenter stated that long-distance energy distribution systems, including transportation infrastructure, produce energy losses, overloads, accidents, and vulnerability. One commenter supported local distributed electric generation and biofuels production and stated that these local resources could supply much of Vermont's residential demand. Several commenters looking long range added that competition for energy resources could become extreme in the future and cause energy exporters like Hydro Quebec and wind farms in our neighboring states to limit export supply. Vermont may not have the economic leverage to compete for well priced long term contacts, especially with metropolitan areas. Several commenters stated that renewables alone will not make up for declines in conventional energy resources.

Some commenters asked how TES is viewing utility business models. One commenter stated that the current Energy Efficiency Utility (EEU) model is a patch on a utility system that is no longer meeting our needs.

4.1 Electric Supply and the Grid

Several commenters noted that if the regional grid can supply lower cost and cleaner power as compared to in-state resources, Vermont should take advantage of it. One commenter predicted that if the rest of New England enacts similar renewable energy goals, electric prices will climb higher faster. Another commenter stated that because Vermont is small and nimble, we will be able to advance toward our renewable goals more quickly. One commenter added that ISO New England (ISO-NE) treats efficiency as a demand resource; it is accounted for and paid in the market as a generation source.

Distributed Generation: Several commenters noted that with distributed small-scale generation, the framework for utility regulation needs to adjust to new relationships between the utility, suppliers, and customers. Some commenters stated that distributed generation systems will be increasingly called to replace the role of centralized systems, including ancillary services. One commenter surmised that when energy users have a more intimate role with producing energy they are more prone to conservation. Local and at-home generation fits Vermont's do-it-yourself traditions. Another commenter believes that distributed generation will filter into the landscape over a long time, a hundred years.

One commenter noted that distributed resources minimize environmental harm and reduce transmissions costs/losses. However, other commenters posed that distributed resources will lead to more landscape and habitat fragmentation.

Several commenters stated that commercial and industrial entities will increasingly integrate rooftop PV and energy storage technologies.

Large Scale Generation: Commenters noted concern regarding the build out of large scale renewables in advance of grid improvements which are needed to pair demand response with improved energy storage to manage intermittency. Several commenters noted it is important that renewable resources are tracked and associated with the original generating unit.

Energy Siting: Several commenters acknowledged the work of the Energy Generation Siting Policy Commission. One commenter noted that grid interconnection was overlooked in the report.

Transmission and Distribution: One commenter requested that planning efforts specifically address the need to modernize the grid in-state and under the ISO-NE. Commenters noted that distributed in-state generation is already causing constraints requiring grid upgrades, but these upgrades will be less costly than those needed if all of Vermont's power was imported. A number of commenters stated that commercial and industrial entities who own equipment which is sensitive to power dynamics are concerned that the reaction of distributed PV to voltage disruption could trip off a cascading effect across the grid.

Energy Storage: Some commenters proposed that Vermont encourage construction of energy storage in strategic areas. One commenter speculated that significant investments in energy storage will be needed in the next ten years. One commenter questioned how energy storage development will interact with the Sustainably Priced Energy Enterprise Development (SPEED) and net metering programs. Some commenters requested that future documents include more specifics about Vermont's plans and the costs to invest in energy storage technologies.

Several commenters noted that the potential of EVs as a dynamic energy storage facility is promising but is not likely to be widely available for some time. One commenter suggested that planning for vehicles powering the grid should always include designs for using vehicles as local backup energy storage, e.g. buildings, micro-grids.

Electrification: The impact on load from heat pumps and electric vehicles was frequently discussed. Several commenters estimate that the increased electric load, peak demand, and related transmission and distribution upgrades for these uses is a concern and thus electrification should not be a major policy option. One commenter noted that increased load from electrification is a distribution system issue, not a transmission issue. One commenter predicted that growing constraints in natural gas supplies will impede Vermont's progress toward electrification.

In dispute, other commenters stated that the increased load from electrifying the transportation sector can be offset by electric demand reductions resulting from continued electric efficiency work. Several commenters referred to study findings that show Vermont could electrify a large portion (up to 50%) of its cars without adding new electric supply. One commenter noted that without the right rate structures, EV charging can cause new peak loads (e.g. evenings when commuters arrive home). Time of Use utility rates, as well as special EV rates, can help manage load from charging EVs. One commenter noted that EVs charge from the grid and generate energy efficiency systems charges like any other electric appliance.

There has been some concern regarding if/how EVCE owners can collect fees for charging EVs at public EVCEs without falling under electric utility regulations. Several commenters pointed out that EVCE owners can avoid fees based solely on electric usage and instead set fees based on the duration of use or by session.

Wind: Many commenters recognize wind as a viable and important technology pathway for Vermont. One noted wind has a favorable EROEI. Several commenters stressed that siting wind turbines in-state requires careful deliberation. Several commenters identified existing alternative or potential out-of-state wind resources which Vermont should consider. Working with New England Governors to procure off-shore wind could advance wind development. The potential of off-shore wind needs more attention in analyses, given that Vermont's access to those resources could require transmission investment.

One commenter contends that Vermont's preoccupation with wind development is severely hampering Vermont's efforts to move ahead on other renewable resources. Wind power is not a viable in-state resource – all sizes of wind turbines are causing problems for neighbors and communities are divided. The wind industry has overestimated the availability of good wind sites, wind capacity and grid constraints will make development and operations more expensive, and turbines cause tremendous environmental damage. Another commenter noted that Vermont should consider landscape impacts in other states as well as in-state.

One commenter requests that opposition around aesthetic and environment impacts of wind siting be considered in light of how other types of energy generators and commercial uses of energy impact Vermont's ridgelines, such as ski resorts and logging. Vermont should focus on the larger benefits of protecting the whole of Vermont's habitats from GHG climate change impact. Also noted is the comment that many people find views of wind turbines in the landscape acceptable and that the majority of Vermonters support wind development as a direction for State energy policy.

Solar: Many commenters state that installing residential and commercial rooftop PV and PV covering Vermont's built landscape (e.g. parking lots) should be a policy priority. One commenter requests that key policies discourage large solar fields on agricultural lands until opportunities on the built landscape are maximized.

Hydro Power: A number of commenters said existing dam sites should be developed across the state; these sites should be considered low-hanging fruit. Several commenters support more development ecologically responsible run-of-river hydro and requested that these projects be identified as a distributed renewable technology. One commenter suggested that any hydro system with a good EROEI and minimal environmental impacts be considered for Vermont's electric portfolio, whether in-state or out-of-state. One commenter identified specific alternative out-of-state low impact and run-of-river hydropower operations which Vermont should consider. One commenter suggested that we consider energy from TransCanada as local energy.

Nuclear Power: One commenter noted that the TES Framing Report did not mention nuclear power as an option although the study is meant to leave everything on the table.

One commenter recommended that Vermont ramp up to install 100 mega watt (MW) Liquid Fluoride Thorium Reactors (LFTRs) paired with Vermont Electric Power Company (VELCO) substations. With LFTRs and renewables, town centers could become energy net zero and power EVs.

4.2 BioEnergy Supply

Commenters agree that Vermont needs to develop its limited bioenergy resources with great caution so as not to adversely impact Vermont's landscape, food prices, or other value added uses of these resources. Most commenters agreed that Vermont's forest and farms need to be managed for sustainability. Bioenergy resources should be used as efficiently as possible.

Many commenters support that bioenergy resources are best utilized for space heating. One commenter stated that even though biomass does not yield fast carbon benefits, it can replace fossil fuels at 100% in many applications, and thus there is a strong policy justification for using biomass resources, at scale, for space heating.

Experts stated that Vermont has potential to produce energy crops from carefully selected grass species in specific pockets of Vermont as a primary crop or incorporated more widely to optimize farming practices for food production and land use. Examples of such practices include planting energy crops on marginal soils, along buffers, or as beneficial rotational crops. The cost effectiveness and EROEI of energy crop farming needs to be analyzed based on yield (tons per acre) and should include transportation costs. One commenter stated that switchgrass is not viable when evaluated for EROEI. More research is needed about current energy crop varieties and those not yet grown in Vermont. There is a need to establish best practices for cost effective bioenergy production while maintaining and improving food crops production, and land use planning to identify sites that are best suited for energy crops, food crops, or both.

Some commenters explained that Vermont needs to carefully monitor bioenergy resources across the region. For instance, how is the new 75 MW Berlin NH biomass electric plant impacting wood prices and supply for Vermont residential customers and businesses?

Experts noted a number of Vermont based research publications and projects that provide a wealth of knowledge in the field of bioenergy production, with specific topics including costs of production, grass fuel, on-farm biodiesel, algae, soybeans, canola, and sunflowers for biodiesel, oil and meal extraction.

Solid Biomass: Commenters noted that the limited woody biomass supply from Vermont forests should be used to optimize Vermont economic interests through value-added wood products as well as for affordable energy production; these uses must be carefully balanced. All commenters stated that sustainable harvesting is critical. Some commenters consider that biomass use for heating and certain CHP applications, and replace fossil fuels, will reduce carbon emissions and have favorable EROEIs. Most commenters support that biomass resources should not be used to produce liquid fuels or purely for electric power because these energy conversions are extremely inefficient and wasteful.

One commenter stated that our forests should be managed by professional foresters who prescribe thinning and harvesting of mature trees about every 20 years, followed by grazing (domesticated or wild animals). Due to climate change, increasing drought, fire danger, and invasive species require updated forest management protocols in Vermont.

Combined Heat and Power: One commenter recommended that CHP plants be incentivized for year-round heat capture; those that utilize heat only seasonally would receive partial incentives. One commenter was against large plants located near residences due to concerns over air quality impacts on the health of neighbors.

Methane Digesters: One commenter noted that digesters should be supported as a key technology for Vermont sized dairy farms. Burning bio-methane for energy has a number of environmental benefits.

Liquid Biofuels: Commenters discussed a vision for producing more liquid biofuels in-state and whether we should think more aggressively than the 25x25 Alliance recommendations. Commenters stated that farmers need technical assistance and access to technology to make “good” biodiesel on farm. To diversify Vermont should explore commercializing algae biodiesel production so as not to rely on soy biodiesel. And farmers should investigate farm cooperatives for production. Another commenter said Vermont should encourage research and development but not pay for it. One commenter noted that good marketing is needed. For instance, Vermont could run a campaign that promotes biofuels as a local Vermont grown energy resource and emphasizes that trucking costs are reduced. Another commenter noted the challenge is completion with commodity crops from elsewhere are produced at a much larger scale. This commenter questioned whether growing biodiesel is good use for Vermont agricultural lands.

Commenters noted the chicken and egg problem. Until there is more demand for biofuels in Vermont's market, more proximate production facilities will not attract investors. One commenter mentioned that a nearby facility is producing 100,000 gallons per month now and there is a plan to build a 7-million gallons per year plant. Also, demand will be limited until vehicle and equipment manufacturers accept higher blends under their warranties. Some manufacturers are now allowing up to a 5% blend.

One commenter stated that a national heating fuel goal is to have B100 replace fossil heating oil by 2040.

Experts support further research studying which varieties of grass species are cost effective and beneficial for the Vermont agricultural economy. One commenter recommended that policy mechanisms should be analyzed to encourage farmers to grow biofuels to power their farm equipment. One commenter supported continued research for cost effective liquid biofuels production and distribution to supply space heating.

One commenter noted that planning discussions should explore the potential of producing Renewable Natural Gas from landfills, wastewater treatment facilities, and farms.

4.3 Natural Gas Supply

Commenters were concerned that cheap natural gas is causing people to ignore efficiency. Several commenters noted that natural gas may be riskier than expected with pipeline congestion and volatile prices showing up as consequences of growing popularity.

A number of commenters are not comfortable with declarations that natural gas is a valuable bridge fuel. A common concern is that infrastructure investment would "lock-in" this technology beyond its optimum timeframe as a bridge to renewable technologies. Several commenters stated that natural gas will not be a bridge solution for any longer than 15-30 years. One commenter cited known supply challenges with existing reserves and concluded that production will peak in a few years. Several commenters noted there is increasing competition for natural gas supplies across New England and in foreign markets. Prices are likely to rise due to this demand. One commenter noted that pipeline constraints have caused some price spikes in the electric market. Another commenter considers that pipeline expansion investments will be difficult to recoup. Several commenters stressed that before Vermont adopt policies establishing natural gas as a bridge to transition from higher carbon fossil fuels to renewable fuels, we need independent research analyzing natural gas pipeline infrastructure costs, long term natural gas price stability/volatility, and lifecycle emissions and costs of shale gas, and ethical considerations given Vermont's ban on fracking.

4.4 Fossil Fuels Supply in General

A few commenters noted that fossil fuels dominate because of their superior power and energy density, historically high EROEI, and scale. Several commenters noted that certain industrial processes will continue to require fossil fuels, especially when high temperatures are critical. One commenter noted that because businesses make expensive long term investments in equipment, they are not as flexible to purchase new technologies in the near term. There is a multi-trillion dollar infrastructure supporting their continued use. Useful fossil fuels will be burned. However, a number of commenters predict that petroleum prices will escalate and will drive the move away from fossil fuel use.

A number of commenters stated that the ten percent of resources that will remain nonrenewable should be reserved for critical purposes that cannot be met through conservation, efficiency, or renewables. One commenter recommended that Vermont not waste petroleum on materials that have organic substitutes, such as cellulose insulation, organic fertilizers. Petroleum consumption should be conserved for critical applications such as lubrication and pharmaceuticals.

One commenter stressed that shale from hydraulic fracturing needs more regulation on chemicals, pressures allowed, well monitoring, and sanctions. Wyoming and Colorado and Environmental Defense Funds are good models for regulation.

5 Energy Policy Development

Many commenters favor a systems approach to developing and analyzing policies. A systems approach will drive change in the overall structure in which energy consumption decisions are made. Cross sector policies are imperative in order to meet our energy goals efficiently. One commenter stated that while reviewing alternative policy options, energy planners should be aware how different suppliers and consumers in different economic sectors require different approaches and how federal and other New England states initiatives impact VT's efforts.

Several commenters visualized effective long term policy as carrots (funding, financing), sticks (regulation, fees), and tambourines (education). One commenter identified four types of policies that could lead to reduced energy consumption and therefore lower GHGs: 1) increase energy costs, 2) decrease the derived utility of an energy resource, 3) decrease access to energy resources, and 4) enforcement of lower consumption by an external agent. One commenter asked State energy planners to consider how to apply currently successful energy policy and programs more broadly within or across energy sectors by adapting, adjusting, supplementing, or altering priorities.

One commenter stated that individuals and organizations may be unable to achieve energy goals without public policies and programs that remove barriers and support individual action. The efforts of committed individuals and organizations are impeded by limited funding resources and uncertainly regarding which actions are most effective. One commenter stated that policy mechanisms and impacts need to be translated into tangible descriptions and metrics which average people can understand and implement in their everyday lives. Some commenters recommended that the best means to communicate energy policies and their impacts with the public is to present data in terms of average household expenditures.

Some requested that all energy policies be intelligently designed and coordinated to achieve Vermont's GHG goals. One commenter warned that policies not get hung up on targets and measuring exact emissions each year.

5.1 Energy Policy Priorities and Pacing the Change

Commenters discussed the long range of the CEP & TES planning periods. We have thirty-seven years to 2050. Looking back as far, who would have predicted the rapid deployment of the internet, ultra small computers, and wireless communications? One commenter said technology will improve many times over during the course of the 2050 timeframe and these advances will be big steps forward environmentally, sustainably, and economically. Thus in setting policies to evoke change, policies need to be flexible and responsive to technology improvement and cost reductions. One commenter noted that we should expect the process will not be smooth and that there will be many policy changes.

Many commenters emphasized that the public and communities need to understand a vision for good energy policy along with the cost of inaction. The benefits of action need to be well articulated. The public needs to be given and understand the value associated with alternative pathways in terms of economic impacts, GHG, and non-energy benefits. Consumers and communities need to be educated to understand the relative costs of energy choices and thus how their energy consumption is measured.

A number of commenters noted that the key to gauging successful policies is to systematically track progress toward meeting energy goals. This effort requires policies that establish prescriptive methods for measuring total energy consumption, renewable energy resources, and GHGs. Several commenters emphasized that the original energy sources need to be identified for accurate accounting of renewables, especially for out-of-state resources.

Commenters offered that significant change in policy directions can be phased in, stepping up targets and charges through 2050. However, many commenters stressed that GHG reductions need to be realized as soon as possible to reach our goals. Several commenters emphasized that a sense of urgency is required. Some commenters suggested that prices be adjusted to include societal costs on less desirable technologies in addition to focusing policies on incentivizing desirable technologies. One commenter contends that energy costs will rise faster than income, thus investment in energy development will be less expensive now relative to the future.

Several commenters mentioned federal policy as the biggest barrier to supporting community scale investment and a change in the current political climate is not likely. State vision is needed on this front. Commenters requested a deeper understanding of what will give capital markets support in order to attract private investors to fund a new energy system. Investors need confidence in contract structures. Many commenters supported passage of a Renewable Portfolio Standard. Also they supported rate design to drive down demand for electricity. Most commenters supported near-term investment in residential building energy efficiency as critical. Several commenters emphasized that Vermont also give more near term priority and specification to strategies that promote switching to efficient thermal renewable energy, such as heat pumps, biomass, and solar. Another commenter noted that conversion of hot water heating to renewables is a low hanging fruit.

Many discussions and written comments noted the work of the Thermal Efficiency Taskforce (TETF) and expressed disappointment with the lack of outcomes during the 2013 legislative session with regards to legislative action on the TETF recommendations.

Many commenters stated that Vermont's transportation sector needs more momentum in the formation of energy policy and should be given more immediate priority. Several commenters emphasized that consumption and emissions from the transportation sector should be tackled aggressively. One commenter noted that transportation consumes 34% of the Vermont's total energy use and contributes 59% of our total GHG emissions (EIA).

Many commenters view that long term Vermont's energy will be primarily sourced from electricity. The movement of people will be met through compact communities and electric vehicles. Building heating needs will be met through weatherization, heat pumps, biomass, and solar hot water. Electric needs will be met through efficiency, conservation powered by renewable generators.

Many commenters requested more emphasis on fuel switching to biodiesel for use in vehicles and to heat buildings.

One commenter stressed that PSD policy development and publications should balance analyses of community-based decentralized generation, micro-grids, and other distributed energy infrastructure, more equally with analyses of large-scale generation. The most promising policies provide models and incentives to communities to build community-based energy rather than policies that divide community and give utilities, developers, and large investors an advantage. Local energy control will encourage more personal responsibility.

Some commenters suggested that in order to advance Smart Growth and transportation demand management (TDM) policies, planners and policy makers should tie in the needs of Vermont's aging population for community level transportation and denser communities with accessible services.

Several commenters emphasized that Vermont will need to respond to national energy market changes rather than be the driver. Other constraints on the pace of change are funding, technology advancement, and time for infrastructure build-out; however inelastic cultural norms may be the biggest constraints. One commenter stated that reductions in energy consumption might only come as a result of economic systems not being able to supply affordable energy. The charge of public policy is to smooth the transition to an energy system that is affordable.

Commenters consider that Vermont's collaboration with regional and national partners is important on many fronts. One commenter noted that Vermont is no bigger than a mid-sized city and cannot take on major changes that require cooperation of whole industries.

A few commenters are convinced that fossil fuels will have a sustained allure in terms of energy density, convenience, and the might of existing infrastructure. Also higher consumer efficiencies make abundant marginal fuels more tolerable. Therefore fossil fuels will be burned globally as long as they are economically available. Even with extremely aggressive conservation, significant climate change can only be delayed 10-15 years. Thus, policy should focus on climate adaptation as the key outcome.

Commenters discussed the need for the State to develop a vision and lay the ground work for moving energy policy, regardless of federal politics. Federal funding for energy development is plausible. It is possible that fossil fuel subsidies will be reduced in the next two to three years. One commenter stated that federal action is not likely to address progressive energy goals or tax reform in the near future. Small tax tweaks are possible.

Some commenters suggested that the State's role is not to pick "winners and losers" but is to support a framework for technology-neutral market mechanisms to operate. The State should make sure there is access to capital, measure, and judge externalities, and make sure good information is available to empower smart decisions by consumers. One commenter added that to the extent that tax policy is used to drive energy markets and consumption, the State should not let such policies outpace technology or the ability to capitalize advances in technology.

5.2 Policy Evaluation Criteria

Several commenters requested a clearer definition of the ultimate goals in Vermont's energy decisions, because some directions seem to be in conflict. For instance, a priority is to keep dollars in-state by favoring in-state energy resources, yet the State and utilities are committing to and sometimes expanding long term contracts with Hydro Quebec.

Most commenters expressed value for locally produced generation. They asked whether the term "local energy" implies local within a town, region, watershed, or other designations. Several commenters requested clear definitions for the terms "distributed generation" and "community-owned".

Given that currently the majority of Vermont energy arrives from out-of-state, all commenters agreed that Vermont policy and technology pathways need to be analyzed in the light of long term views regarding regional energy demand, and regional and national market trends, as well as opportunities to influence policy directions beyond Vermont.

One commenter emphasized that in order to address GHG in the near term, policies chosen need to be designed for quick implementation.

Several commenters stated that the TES evaluation of policy and technology options must provide a reasonable assessment of economic benefits.

Several commenters suggested that Vermonters should use the same evaluation criteria to consider in-state and out-of-state resources, such as wind and hydro.

One commenter emphasized that the results of cost benefit analyses should be regarded with priority when evaluating policies and technologies. This practice will attract the participation of businesses and industries. Most commenters requested that all aspects of equity be considered in policy development and cost benefit evaluation, with special attention toward protecting low income people from increased costs, disincentives, or regulations dictating particular actions.

Several commenters emphasized that policies need to be simple to understand and implement. Costs to administer policies should be evaluated. One commenter suggested that transaction costs for regulators and regulated entities should be reasonable. This person noted that large overhead costs for managing complex administrative functions favor implementation solely by large organizations.

Several commenters emphasized that policies should allow flexibility in how commercial and industrial entities plan, finance, and implement energy investments. They warn against narrow or prescriptive State policies that would incentivize smaller impact projects over larger projects with broader or longer term benefits.

One commenter stated that maintaining Vermont's small rural communities and prioritizing community benefits, and community sized development are the most important criteria when evaluating long term energy policy. One commenter noted that community resilience is highly valued. We should avoid a top down approach to implement Vermont's energy goals.

All commenters agreed in principal that policies which are flexible to changes in markets and technologies are preferred. One commenter suggested that diversifying risks with an eye on total energy costs over the long term is the most important evaluation criteria.

A number of commenters recommended adding a criterion to rate policies by their expediency to be passed in legislation and to be implemented with legislative action, as well as their potential to be overturned. Also policies should be identified as revenue generating, requiring public funds or payments, or revenue neutral.

5.3 Priorities for Climate Adaption and Mitigation

One commenter stated that taking steps to address the environmental and human welfare crisis posed by climate change is a moral obligation.

A couple of commenters described flaws in the prevailing logic that fossil fuels will be largely replaced with increased renewable resources and energy efficiency. One presented this explanation. Because renewables have a lower EROEI than fossil fuels and their increased use will results in lower utility for the cost and this will result in lower consumption and pressure on society. As lower EROEIs and shortfalls occur in liquid fuel production, addressing societal needs will be prioritized over climate change. Worldwide energy and economic pressures dominate policy choices, thus the burning of ever more expensive fuels from marginal sites will continue to be deemed important. Attempting to appropriately address energy transformation to reduce GHGs would be political suicide. A solution through technology innovation is false but is likely to win because it appeases economic and environmental interests. The only solutions are mitigation and the reservation of valuable resources in the economy to preserve essential goods and services.

One commenter calculated that Vermont's reduction in fossil fuel use will simply make more fossil fuel available elsewhere. Vermont is but a speck contributing less than 0.03% of world GHG. If Vermont stopped all GHG emissions today the world would only be 4 days better off come 2050.

5.4 Funding & Financing Principles

Commenters agreed with the TES Framing report's emphasis that in order to meet Vermont's energy goals, stable long-term polices need to be backed by adequate funding. One commenter noted that the TES economic analysis needs to bring forward how affordable alternative pathways are in terms of sustained investment in infrastructure and institutional capacity. Commenters agreed that where appropriate, Vermont should invest in programs that permit broad deployment of chosen technologies, such that declining costs result from economies of scale, creating a feed-back loop that quickens deployment of new technologies. Several commenters support incentives and financing programs that are prescriptive and performance based.

One commenter stated that because we have delayed so long to adequately fund the energy transformation needed to address climate change, now the initial investment will be large (and unattractive). However, if we invest appropriately now, the long term benefits will be enormous.

One commenter stated that as technology advances, investments cannot be recapitalized; only a small number of people and a smaller number of businesses will be able to continually upgrade. Taxes cannot provide the revenues needed to capitalize technology investments in order to reach our energy goals. Attempts to rely on taxes to reach energy goals will likely be overturned in legislation later.

Many commenters discussed the need to collect more and better energy efficiency and renewable energy project data. The treatment of energy savings needs to be standardized. Without better information those making financing decisions, such as commercial/industrial executives and bankers, cannot accurately project energy savings and risks, or perform rigorous comparisons across projects. With the data these decision makers would be more secure regarding the benefits of proposed energy projects. Several said a statewide database is needed of state loan project performance. One commenter stated a concern that due to the size of Vermont's market, we will not have enough data.

Several commenters requested more flexibility with constructs in place for commercial and industrial entities related to their Energy Efficiency Charge (EEC) and EEU programs. Several suggested that EEC opt-out provisions be more widely available. Some said a portion of their EEC could continue to feed the EEUs, but that the remaining should be solely in their control given their internal expertise to finance. One commenter noted that Massachusetts had allowed op-outs from their EEC but that over time companies realized they were saving more by paying into the fund and participating in the program.

Several commenters noted that larger commercial and industrial entities have access to capital. They are primed to use internal financing for cost saving energy investments, especially those with a two and a half year payback. Also, these entities prefer to carry out larger projects which blend investments with short and long term payback. One commenter explained that because large investments in equipment and production facilities are long term (e.g. 40 years) they are not as flexible to adopt technology innovations as they appear in the market. Several commenters noted that businesses are having to simultaneous address many competing costs, including health care.

Some commenters had concerns with governmental agencies offering financing. The State's role is to make markets work and to ensure there is access to capital.

Several commenters held that there is plenty of private funding available. Creative public-private partnerships, such as the Vermont Business Energy Conservation Loan Program, are great avenues for advancing energy policy in both commercial and residential applications. One commenter noted that Vermont can set models which other states and nations can emulate. These partnerships invite the private sector to champion programs and could be a key organizational structure for achieving energy goals.

Commenters discussed the need for rate and regulatory certainty in order to build transaction size and volume and to attract sufficient capital. Then capital markets can be leveraged with support from State sponsored incentive programs. Several commenters believe that financial incentives are effective in motivating behavior change. One recommended that all policy sets for the residential sector include incentive and interest-rate buy-down programs and stressed that these programs need to have predictable incentive levels over the long term; transitions in the programs rattle consumer confidence, delay projects, and are disruptive to vendor businesses and banks. Some commenters recommended a State funded loan loss reserve account. One commenter suggested propping up leasing programs.

Some commenters expressed a preference for the socialization of investments in energy distribution infrastructure, including energy storage. One commenter conveyed a strong position that the private sector, rather than government, should be called upon to build out a public EVCE network when the market is ready. One commenter noted that EVCE installations are now eligible under the Property Assessed Clean Energy (PACE) financing program.

Commenters noted that regardless of financing availability, consumers are not borrowing. Available financing is not necessarily the primary barrier. The majority of the public is not yet aware of, does not fully understand, or is not sold on the benefits of new energy technologies. One commenter observed that customers who are financing energy upgrades are interested to invest and install in both efficiency and renewable technologies at one time.

Commenters noted that consumers are wary of up-front capital costs. Consumers understand monthly payments. When people buy a car they don't think about the term or details, rather they ask "Is it a payment I can handle?" Lease and on-bill financing programs show immediate savings on monthly statements. One commenter suggested creating a one-time bond issue with a cafeteria plan to raise significant funds for deep incentives.

Some commenters discussed crowd sourcing and cooperatives as attractive avenues for community ownership or small jointly owned and scaled projects.

Commenters mentioned that the market has no solution for people with low credit ratings. Credit guarantees and similar mechanisms are not a clean solution.

Some commenters mentioned that public serving institutions can't use tax credits and thus must depend on tax equity financing.

Many commenters consider that monetized RECs are effective incentives for supporting local energy development.

Several commenters noted that the electric sector is funding electric and thermal efficiency programs, while the thermal sector is not contributing. One commenter offered specific values for funds spent to save energy by efficiency programs – over $76 million is spent by energy efficiency utilities, $27 million is spent on transportation demand management, and over $9 million is spent on thermal efficiency programs (from the Regional Electric Greenhouse Gas Initiative and the Weatherization Assistance Program).

5.5 Primary Policy Sets

5.5.1 Nearly-Revenue-Neutral Carbon Tax Shift

Carbon pricing was actively discussed as a promising foundational mechanism that has leverage across the economy and deserves serious consideration as a primary strategy. One commenter noted that carbon pricing through taxation will lead to decreased consumption, resource sharing, purchase of more efficient technologies, and perhaps a change in living patterns if it is implemented long-term. Some transportation stakeholders agreed that a carbon price would change behavior leading to the adoption of Smart Growth principles.

Commenters understood that Carbon Tax Shift policies involve charging a carbon price for wholesale purchase of petroleum fuels. The policy would be mandatory and implemented for the long term. Although there is complexity in determining where in the value chain to apply the carbon price and how to price carbon relative to different energy resources, a carbon price is somewhat invisible (easy to administer) at the level of the energy consumer and producer. One commenter requested clarification regarding whether a carbon price would be charged solely on carbon dioxide (CO2) emissions or whether other more potent GHG emissions, such as methane and sulfur hexafluoride (SF6), would also be included.

Keeping in mind Vermont's conservative tax policy, a Nearly-Revenue-Neutral Carbon Tax Shift was generally regarded as having merit because revenues would directly lessen economically harmful taxes like income and/or sales tax. One commenter noted that voter education would be critical in order to explain that the Carbon Tax Shift would reduce taxes overall.

Some commenters suggested that carbon pricing would motivate all sectors of society to invest in efficiency and renewables, including consumers, energy producers & sellers, the finance sector, and government. Many commenters noted that with recent history in mind (gasoline price increases), a price on carbon would need to be large in order to shift consumer behavior. One commenter suggested that to inspire shifts in vehicle purchases and VMT, a $100 per ton tax which equates to about $1 per gallon of gasoline, would be reasonable. This commenter noted that Vermonters are already paying for GHG impacts through expenses for disaster recovery and climate adaption, and that these responses are not organized, systematic, or equitable; carbon pricing offers a long term systematic approach.

Some commenters representing the broad business sector were wary of an outcome that a Carbon Tax Shift would result in even higher energy costs and would put businesses' ability to manage costs at risk. One commenter was particularly concerned about the impact on the few VT corporations that use large quantities of fossil fuels. How would a Carbon Tax Shift reduce their GHGs? Would the tax motivate them to leave VT?

Some commenters discussed a carbon price range of $80-$100 per ton as potentially effective. One commenter requested background on how a carbon price would be derived. Commenters asked how the State would determine which taxes would be reduced from carbon revenues and what the impact of those reductions would be. Some commenters thought that reducing the gas tax would cancel the desired effects. One commenter suggests that the gas tax not be lessened with carbon revenues because that would certainly stall Carbon Tax Shift policy.

Several noted that a Carbon Tax Shift would only be possible if implemented at the federal level. Many commenters considered the discussion of a Carbon Tax Shift to be moot because it is politically infeasible.

A Cap and Trade mechanism was not favored by commenters due to the challenges of tracking emissions and trade at a retail level. One commenter noted that a Carbon Tax Shift would have a more immediate impact on behavior.

5.5.2 Total Renewable Energy and Efficiency Standard (TREES)

Note: In previous documents and discussions this policy set was named the Clean (Total) Energy Standard.

Commenters were intrigued in discussions of a TREES policy but the program design was not clear. Several commenters noted that a well designed TREES policy would be more effective than combinations of sector-specific policies. Some felt that TREES would be more politically feasible in legislation than a Carbon Tax Shift.

Several commenters thought that policies based on renewable targets could be extremely complex to administer across all energy sectors, however if the policies are not applied across all sectors entities would design operations around policy loopholes. Which entities would be regulated and how would enforcement work? Some commenters recommended that TREES should impose responsibility on energy suppliers. Such policies should offer flexible approaches to those suppliers through credit trading and targeted outcomes can be achieved quickly and efficiently.

One commenter noted that tracking renewable targets is especially difficult for unregulated fuels. This commenter requested a concrete illustration of how TREES would evaluate efficiency and renewable contributions to insure a level playing field for these technologies, yet with an “efficiency first” priority. Managing offset credits is notoriously difficult.

One commenter suggested that this policy start with low targets across sectors and ratchet up the targets in a predictable fashion. Current electric sector targets which are relatively high should not be lessened. This commenter warned that TREES should be equitable for residential users or their energy dealers; that is that the required level of investment or credit offsets purchased need to be consistent with their level of responsibility for GHGs. One commenter emphasized that it should be apparent as to how these policies and any uses of any revenues generated result in lower GHGs.

One commenter expressed that incremental expansion seems appropriate. The State should consider that because transportation comprises the greatest proportion of Vermont’s energy consumption, this sector should not be left for last. Dealing with the non-regulated fuels is more difficult, but it is also more important.

One commenter considered the challenges of administering annual accounting of the baseline energy demand upon which TREES fees and incentives are set. Rather than accumulating and computing the past years efficiency and renewable energy investments and resulting savings, an administratively daunting task, the recommendation (mimicking RPS alternative compliance payments) was to set in-lieu fees per energy user for the year forward. Fees would be set based on energy savings from a prescribed level of efficiency or renewable investment. Each user would choose to pay the fee or prove that they made appropriate investments. All fees collected that year would fund other users who wish to make such investments. The commenter noted that this process would operate in a fashion similar to a Carbon Tax Shift.

5.5.3 Renewable Targets with Carbon Revenue

One commenter suggested this hybrid of the Nearly-Revenue-Neutral Carbon Tax Shift and the Total Renewable Energy and Efficiency Standard (TREES) policy sets may be more politically feasible.

A good number of commenters agreed with transferring a portion of carbon revenues to fund energy programs. They said that Vermont needs to support alternatives to paying higher energy prices that make the impacts of higher prices more equitable, especially for low income people. Even if the carbon price signal is low or does not impact markets as expected, funneling a portion of revenues from a Carbon Tax Shift to efficiency programs would compound the impact to lower Vermont’s total energy consumption.

Several commenters were concerned with the challenges of administering any policies that require particular actions or payments based on renewable targets that are, especially those that are cross sector. Read more regarding these issues under the TREES comments above.

Several commenters noted that Vermont's electric supply contributes a small portion of our total GHG emissions and policy mechanisms to incent renewables are in place, thus the electric sector does not need as much attention in the development of new policies. One commenter recommended that renewable targets should be set to drive fuel switching in the transportation and heating sectors.

Another commenter asked whether Vermont has enough big GHG emitters to raise enough revenues from a carbon tax under this policy structure.

5.5.4 Market and Business Model Innovation Policies

Most commenters noted that energy policy needs to allow long term flexibility to support the adoption of innovation in new and existing technologies.

One commenter mentioned that 15 years ago a primary energy innovation was the development of the efficiency utility model but today the innovative models to be tested will integrate efficiency and renewable energy programs either within a utility structure or a market structure which seeks sustainability and energy neutrality, rather than energy efficiency alone. Commenters considered if and how new business models for energy utilities can develop. Rule changes are needed to allow the models to evolve. Can utilities be the voice for total energy, efficiency, technology choices, and financing?

One commenter wondered if the public would be attracted to invest in energy development through umbrella cooperatives. Such structures could generalize the utility model and reduce NIMBY resistance. Cooperatives could be run by local governments. Commenters discussed the German energy transformation which has been successful in attracting public investment. Although the German model results in higher energy prices, these are offset by direct income received by individuals who have invested.

One commenter recommended creating funding programs that incentivize and reward the collective efforts of organizational members, while also providing technical assistance and low cost financing options to members.

One commenter stated that the best market lever is to feebate everything and use feebate excesses to lower other taxes. The administration of such policies should be transparent. There should be an intention to leave something for younger generations. These examples were offered:

- Tax carbon, rebate carbon free
- Tax feedlots, rebate grass-fed
- Tax distances transported
- Tax gas guzzlers, fund "lottobates" to divvy up the annual kitty for EV purchases with earlier buyers getting bigger rewards

Many commenters held that the CEP goal of 25% of vehicles powered by renewables by 2030 will be achieved primarily through electrification. This goal requires a bold and innovative approach. Several commenters emphasized that least cost integrative planning should be applied across the transportation sector. One commenter stressed that the providing adequate electric supply for EVs is not the issue; rather the issue is to design regulatory structures to allow efficient use of electricity.

One commenter proposed that EV related policies and vehicle-to-grid policies be integrated with renewable electric policies and opportunities to experiment be explored. One commenter suggested incentivizing EV purchases by creating battery share agreements.

Several commenters recommended that sector-specific regulations impacting EEUs be loosened to allow effective cross sector programming aimed at reducing overall energy consumption. One commenter suggested that funding for studies be moved to support Public Purpose Energy Service Companies.

Another commenter recommended that the TES modeling effort closely analyze the seamless integration of EEU funds and efficiency programs for electric sector savings now administered under the Demand Resource Plan and for thermal sector savings now administered under the Heating and Process Fuels Plan. All current and new EEU entities such as EVT, the Burlington Electric Department, and Vermont Gas Systems would operate under this integrated framework. EEUs should not be constrained by a sector-specific resource approach and should be allowed to support programs that increase total energy efficiency across sectors for greater societal benefits. Currently under these constraints, EVT is finding it cannot assist customers to maximize their total energy savings. The impact of these constraints is contrary to State energy goals.

That commenter expanded the issue of constrained services, describing that the deployment of Smart Grid technology now opens additional untapped potential to work with customers and utilities on time of use rate design and choosing appliances and usage behaviors that are most efficient, including those that run on or generate renewable resources.

In addition, this commenter recommended that efficiency utilities work directly with the PSD, VELCO, and distribution utilities (electric, gas) to maximize the benefits of distributed resources in-state and regional transmission and distribution planning and to manage peak load.

5.5.5 Energy Sector-Specific Policies

A number of commenters suggest that the promise of implementing policies specific to each energy sector should be evaluated in terms of how well they complement larger policies and trends. One commenter suggested that there be an equal balance between incentives for renewables as for energy efficiency. One commenter recommended that sector-specific policies should be implemented in combination with carbon pricing. A concern is that sector-specific policies should be equitable for all end users.

Building Efficiency: One commenter suggested that the State reinitiate deeper energy reviews of Act 250 applications for commercial development. Another commenter suggested the State, utilities, and commercial entities put renewed attention toward developing utility and company contracts to require investments efficiency or renewable generation. Several commenters requested that commercial and industrial entities be permitted to utilize electric resistance heat as a backup, in particular when very cold weather causes heat pumps to become less efficient or fail.

Commenters requested policies that support financing and funding for more efficient multi-family housing. Make these buildings simpler to construct. Favor smaller projects (e.g. 15-20 units). Larger projects (e.g. 80 units) often involve complicated partnerships. Requirements for supporting urban density need to be higher. For low income housing, there needs to be a willingness to spend public funds. One commenter recommended that the Home Performance with Energy Star program incentive levels be propped up and consistent for a long time in order to increase participation numbers again.

Small Scale Renewable Incentive Program (SSREIP): One commenter requested long term funding for SSREI in order to maintain consistent incentive levels with no delays in approval; SSREIP has had three transitions in the past year and these have resulted in disruptions for both customers and vendors.

Net Metering: One commenter emphasized that many businesses in the renewable electric supply chain are reliant on Vermont's net metering program. One commenter asked what the limitations are on total net metered capacity in terms of grid management for small municipal utilities. One commenter would like homeowners with renewable generators to be allowed to sell excess electricity to utilities. One commenter recommends the State subsidize solar that is net metered and is used to charge EVs.

SPEED and Standard Offer: Some commenters warned that Vermont should carefully consider the scale and cost-effectiveness of resources eligible for the Standard Offer. In other states with aggressive Standard Offer programs, certain benefits such as deferred upgrades have not always resulted and sometimes greater investment is needed to handle intermittent generation from distributed renewables. Other commenters wish that the SPEED program be expanded further as a key to increasing renewable installations in-state. One commenter recommended that SPEED be customized to meet geographic needs and opportunities.

Many commenters were deeply concerned and disagree with the double counting of RECs under the SPEED program. One commenter asserted that RECs are already discounted due to the uncertainty of Vermont's REC system in light of new limits placed by other states.

Several commenters disagree with the structure of current subsidies which give greater reward to developers, leaving little voice and benefit to local communities and creating opposition to projects based on aesthetics.

One commenter noted that in 2016 the Business Energy Investment Tax Credit is set to expire and federal action is uncertain.

Permitting: One commenter supports a "thoughtful but progressive" permitting process but is concerned that the current process is too drawn out. Vermont's attainment of long term renewable goals is at risk unless the permitting process is streamlined.

Agricultural Sector and Methane Digesters: One commenter suggested that GHG goals should cover Vermont's agricultural sector in addition to the traditional energy sectors (residential, commercial & industrial, and transport) because methane makes up notable percentage of Vermont's GHGs. Also agricultural programs at both the state and federal levels are underfunded or understaffed. This commenter recommended that Vermont provide more funding or a tax credit for installing methane digesters which have proven effective on farms to generate electricity and heat.

Electrification: One commenter stressed the need to develop new institutional coordination across energy sectors between electric grid planning and operation organizations and those preparing for the roll out of thermal and transportation electrification technologies. A shared vision among these organizations will help ensure effective policies and infrastructure investments. Adequate coordination can drive and respond to the new technology adoption, prevent impediments to adoption and avoid risks to the electric grid (e.g. reliability, security). One commenter recommended that the State appoint an "Electrification Officer" to coordinate across State agencies and key players in the private sector, as has done in the telecommunications and health care industries and in Oregon for electrification.

One commenter recommended subsidies for heat pump and EV purchases but requiring product "green tags" to insure they are powered by clean electricity. One commenter recommended tax incentives for ground-source heat pumps similar to other states.

One commenter noted that efforts to optimize non-residential charging infrastructure should follow sitting criteria that compliments other State goals such as Smart Growth and economic development. Another commenter suggested that building energy codes include requirements for multi-family dwellings and public building owners to add a minimum number of EVCEs. One commenter suggested socializing the demand charge on Level 3 EVCEs; this would permit new business models.

Fuel Cells: One commenter suggested that Vermont adopt incentives for fuel cell technologies modeled after those in New York and New Jersey.

Biofuels: Ideas offered from commenters include incentivizing farmers to grow and use local biofuels, tax incentives or cost saving mechanisms for companies investing in biofuels production or mixing equipment, increased support for in-state blending facilities, mandating the State vehicle fleet and buildings use biofuels, tax credits or discounts for bioheat and vehicle uses of biodiesel, developing a regional biofuels network to provide technical assistance for converting vehicles, voluntary or mandated targets for fuel companies to produce or sell specified blends of biofuels.

Fossil Fuels: One commenter recommended that Vermont should produce fossil fuels locally where possible, encouraging renewables and well regulated oil and gas drilling.

Transportation: Many commenters do not support the institution of special fee structures and incentives that would further diminish transportation infrastructure funding which is already at risk (due to vehicle efficiency standards) in favor of fuel switching. One commenter stressed a need to reconcile the fundamental conflict between current infrastructure funding mechanisms and current VTrans policy goals to reduce transportation energy consumption (through mode and fuel switching).

Several commenters stated that alternative fuel vehicles should be treated equitably along with conventional vehicles. Several commenters recommended tax credits, lower insurance premiums, and other financial incentives for purchases of EVs and other alternative fuel vehicles. One commenter recommended a near-term Cash for Clunkers program to exchange sports utility vehicles for EVs. One commenter recommended rebate programs for fuel efficient vehicles, noting France's as a model. Another commenter was concerned that policies that disincentivize larger conventional personal vehicles could work against the many people in Vermont who need vans or pick-up trucks for work (more efficient technologies are not yet available for those vehicle types).

Many commenters felt that EV adoption needs to be paced and placed to match expanded renewable electric capacity. A few commenters supported subsidies paring EVs with PV installations, especially for residential customers. One commenter suggested funding prototypes to test vehicle-to-grid technology.

Another commenter views that setting electrification as a primary strategy at this time falsely assumes Vermonters will adopt EVs and that other vehicle technologies will not surpass the potential of EVs. Several emphasized that the overall cost to Vermont economy of converting to an electric fleet is a significant obstacle.

One commenter suggested that similar to the electric sector's geotargeting initiatives, transportation stakeholders should identify and focus funding on existing and emerging (e.g. the Jay Peak area) TDM hot spots across the state. Local plans should be revised to capture TDM incentives for employers and communities. One commenter recommended public-private partnerships to assist businesses of 50+ employees with operating shuttles between park and rides and businesses.

One commenter suggested that employers report data on employee commuting GHG emissions. Tax credits could be offered to performing employers and would incentivize travel by transit, carpooling, or telecommuting. One commenter mentioned a goal of reaching 50% of commute trips done by walking or biking.

Other policies mentioned include programs support eco-driving and carsharing. One commenter recommended incentives to buy back second cars in order to encourage alternate modes of transportation as well as car/vanpooling and carsharing.

Land Use Policy: Several commenters noted that Smart Growth as a key policy to support both economic development and the environment by fostering infill development, multi-modal transportation, and cut vehicle trips. What policies with "real teeth" will support Smart Growth principles to become integral in planning and zoning at the local level?

Commenters discussed some critical needs. Local planners need technical assistance for planning and design including visualization tools to better convey how desirable a denser and mixed use built environment can be. Future densities could mimic densities that existed in the early 1900's. Several commenters suggested that town center densities reach 8 units per acre. These designs need to integrate all infrastructure services including transportation, water, sewer, flood management, etc. Funding for sewer systems is critical to allow denser communities. Building height regulations need to be readdressed. One commenter stated that good community design allows for a 20 minute walking zone and frequent transit stops every 15 minutes.

One commenter suggested incentivizing developers to build in dense areas. Vermont should allow for growth in our existing hamlets; suburbs need to be repurposed. Industrial sites could also be considered as growth zones, if they are served by critical infrastructure or strategically placed in other ways.

One commenter suggested diverting health care funds to promote walking and biking. Some commenter suggested that parking requirements be set based on a maximum rather than a minimum, especially for employers. Funds saved can be invested in enhanced transit services.

One commenter suggested that Smart Growth policy should explore measures of location efficiency. One commenter recommended raising property taxes a fraction of a percentage for residences located far from centralized communities. Another mentioned that high gas prices will be the biggest driver. While transit, carpooling, and telecommuting are good, these modes can work against Smart Growth policy. Another commenter raised the issue that affordable EVs will likely create barriers for support of Smart Growth principles.

5.5.6 New England Regional Energy Policy Focus

Commenters generally agreed that regional collaboration is essential on many fronts. One commenter stated that all policies listed in the TES Framing Report would require some degree of regional coordination to be effective. Energy planners should consider the opportunities for collaboration and resource sharing. Vermont is small and nimble to drive innovation, this is an opportunity other states do not have. Also other New England states are more constrained by their heavy reliance on natural gas.

Regardless, commenters stressed that Vermont should learn from work in process by other states. Regional collaboration can support new policies in each state separately as well as coordinated efforts. One commenter noted that non-governmental organizations with chapters in New England states and a mission to lessen climate change impacts are able partners to drive policy in other states. Another commenter asked if other states are in fact interested in energy policy collaboration what current efforts are underway.

One commenter mentioned that Vermonters are already doing a lot compared to other areas of New England, especially relative to major cities where over consumption is common. There is concern that Vermont’s interests could be overshadowed by the metropolitan areas. Another commenter noted that Vermont’s accomplishments could be offset if our efforts drive Vermont jobs and emitting activity to neighboring states, with the additional potential that products are transported back in-state, causing additional emissions.

Many comments believe carbon pricing and clean energy standard policies will not work without an RPS and regional collaboration. One commenter noted that Vermont cannot price externalities in cost-benefit screening tools without similar action across New England.

Many commenters support passing an RPS. One suggested promoting high EROEI technologies and energy sources through the RPS. One commenter noted that an RPS will drive up energy prices but the short term impacts have longer term benefits. One commenter suggested that if Vermont adopts an RPS, REC sales could be fully dedicated to investment in renewable energy programs, including the Clean Energy Development Fund.

Certain energy resources outside Vermont dwarf our in-state resources. Thus Vermont needs to be part of multi-state partnerships planning large scale siting and transmission requirements, with careful consideration of environmental consequences.

Transmission: Several commenters noted that regardless of Vermont's accomplishments on energy goals, trends of increasing demand in other ISO-NE states will result in Vermont paying for expensive transmission reliability upgrades. Vermont needs to actively advocate for transforming federal and state systems and regulations that discourage non-transmission alternatives (such as efficiency, renewables, and energy storage). Vermont also needs to advocate for equitable treatment in transmission financing. One commenter identified other ISO-NE grid management practices which are counter to Vermont's energy goals, including day-ahead spot market purchases of natural gas can result in curtailment of large renewables, load forecasters are not allocating resources to adequately project load growth and reliability issues related to potential thermal and transportation electrification. A full review of grid management policies is needed in light of distributed and renewable generation, net metering, and electrification of other energy sectors.

Several commenters stressed the need for regional biomass harvesting, procurement, and biomass carbon accounting standards to ensure fair trade and stewardship. Trends in solid biomass trade in the region need to be carefully monitored.

Transportation: One commenter suggested that Vermont join with other states to lobby Congress and automakers to expand fuel efficiency standards to include larger vehicles. Vermonters drive heavier vehicles, such as pick-up trucks, vans, and four-wheel drive vehicles, to handle large loads and rural conditions.

One commenter recommended that Vermont incentivize transportation fuel switching by setting a market value on compliance with a set level renewable fuel production or consumption, by utilizing and expanding the federal Renewable Identification Number system. One commenter was skeptical of the potential for a low carbon fuel standard (LCFS) to be a successful policy in New England. There are few sources of liquid fuel in New England and it is not clear how a LCFS would help promote the adoption of EVs.

Several commenters support institution of a VMT tax to encourage modes of transport other than single occupancy vehicles. One suggested the VMT tax could be imposed through odometer readings at the annual vehicle inspection. One noted that a VMT tax will be the best way to affect behavior, but a gas tax is more feasible politically. One commenter noted that a VMT tax is good in concept, however it would penalize people who have long commutes or have family circumstances that require long trips (e.g. for medical services). Some commenters stressed that reliance on a VMT tax for revenues would be out of synch with the implementation of Smart Growth principles which work to reduce VMTs.

Legislative Report:

Energy Stakeholders Participating in Focus Groups

The following stakeholders participated in the Public Service Department's Total Energy Study (TES) focus groups during the summer of 2013. The people and organizations below have diverse opinions. Their participation in no way implies their support or disagreement with the TES Legislative Report.

- Adam Sherman – Biomass Energy Resource Ctr.
- Al Teague – Rock-Tenn Missisquoi Mill
- Amanda Beraldi – Green Mountain Power
- Amy Milne-Allen – Vt. Chapter, Appraisal Institute
- Andi Colnes – Energy Action Network
- Andy Boutin – Pellergy
- Andy Shapiro – Energy Balance
- Ann Ingerson – The Wilderness Society
- Annette Smith – Vermonters for a Clean Environment
- Arthur Berndt – Maverick Lloyd Foundation
- Avram Patt
- Barry Bernstein – Better World Engineering
- Ben Walsh – Vt. Public Interest Research Group
- Betsy Ide – Green Mountain Power
- Bob Hedden – Hedden Company
- Brian Dunkiel – Dunkiel Saunders
- Brian Shupe – Vt. Natural Resources Council
- Bryan Mornaghi – Northern Power Systems
- Charles McKenna – Sierra Club
- Chris Granda – Granda Associates
- Cullen Meves – Windham Regional Commission
- Darryl Mays – Go Juice
- Dave Snedeker – Northeastern Vt. Development Association
- David Blittersdorf – All Earth Renewables
- David Hallquist – Vermont Electric Coop
- David Mullett – Vt. Public Power Supply Authority
- Doug Smith – Green Mountain Power
- Elizabeth Courtney – Vt. Natural Resources Council
- Ellen Kahler – Vt. Sustainable Jobs Fund
- Emily Levin – Vt. Energy Investment Corp.
- Frank Blake – Price Chopper
- Gabrielle Stevins – Renewable Energy Vermont
- Gaye Symington – High Meadows Fund
- Gus Seelig – Vt. Housing Conservation Board
- Guy Page – Vt. Energy Partnership
- Hantz Presume – Vt. Electric Power Company
- James Moore – Sun Common
- James Sullivan – Bennington Regional Planning Commission
- Jamison Ervin – Waterbury LEAP
- Janet Doyle – IBM
- Jason Van Driesche – Local Motion
- Jeff Forward – Richmond Climate Action Committee
- Jeff Wolfe – groSolar
- Jim Hand – Hand Motors
- Jo Bradley – Vt. Economic Development Authority
- Johanna Miller – Vt. Natural Resources Council
- John Hulbert – PBM Nutritionals
- Jon Erickson – UVM Gund Institute
- Jonathan Dancing – Building Performance Professionals Assoc. of Vermont
- Josh Castonguay – Green Mountain Power
- Julie Campoli
- Karen Glitman – Vt. Energy Investment Corp.
- Karen Horn – Vt. League of Cities and Towns

- Kate McCarthy – Vt. Natural Resources Council
- Ken Gagnon – Gagnon Lumber, Inc.
- Ken Nolan – Burlington Electric Dept.
- Kevin Jones – Vt. Law School
- Leigh Seddon – Energy Action Network
- Lisa Ventriss – Vt. Business Roundtable
- Luddy Biddle – NeighborWorks of Western Vermont
- Lukas Snelling – Energize Vermont
- Luke Shullenberger – Green Lantern
- Mary Powell – Green Mountain Power
- Matt Cota – Vt. Fuel Dealers Association
- Maureen Hebert – Vt. Technical College
- Meredith Birkett – Chittenden Co. Transportation Authority
- Michael Dworkin - Vt. Law School
- Michael Zahner – Vt. Chamber of Commerce
- Michelle Boomhower – Chittenden Co. Regional Planning Comm.
- Michelle McCutcheon-Schour – UVM Transportation Research Ctr.
- Mike Raker – Agricultural Energy Consultants
- Nils Behn – Aegis Wind
- Owen Bradley – Vt. Gas Systems
- Patricia Richards – Washington Electric Co-op
- Paul Cameron – Brattleboro Climate Protection
- Paul Costello – Vt. Council on Rural Development
- Paul Hutchins – Rock of Ages
- Paul Zabriskie – Central Vt. Community Action Council
- Peter Adamczyk – Vt. Energy Investment Corp.
- Peter Gregory – Two Rivers-Ottaqueechee Regional Planning Commission
- Peter van der Hoof – Casella Waste Systems
- Phillip Mosenthal – Optimal Energy
- Richard Faesy – Energy Futures Group
- Riley Allen– Regulatory Assistance Project
- Robert Chamberlin – RSG, Inc.
- Sam Swanson – Pace Energy & Climate Ctr.
- Sandra Levine – Conservation Law Foundation
- Sarah Carpenter – Vt. Housing Finance Authority
- Sarah Galbraith – Vt. Sustainable Jobs Fund
- Sarah Hoffmann - New England Conference of Public Utilities Commissioners
- Scott Harrington – Vt. Gas Systems
- Scudder Parker – Vt. Energy Investment Corp.
- Steven Letendre – Green Mountain College
- Stu Slote – Navigant Consulting
- Tim Maker – Community Biomass Systems
- Tom Buckley – Burlington Electric Department
- Tom Evslin – NG Advantage
- Wayne Nelson
- William Driscoll – Associated Industries of Vermont

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State and Federal Government

- Alex DePillis – Agency of Agriculture
- Beth Pearce – Vermont State Treasurer
- Billy Coster – Agency of Natural Resources
- Brian Woods – Dept. of Environmental Conservation
- Dale Azaria – Agency of Commerce and Community Development
- Dick Valentinetti – Dept. of Environmental Conservation
- Dylan Giambatista – Office of the Treasurer
- Elaine O'Grady – Dept. of Environmental Conservation
- Gina Campoli – Agency of Transportation
- Harmony Wilder – Dept. of Buildings and General Services
- Jacob Smith – Office of Senator Sanders
- Jeff Merrell – Dept. of Environmental Conservation
- Jon Kaplan – Agency of Transportation
- Ken Jones – Agency of Commerce and Community Development
- Margaret Cheney – Vermont Legislature
- Michael Snyder – Dept. of Forest Parks & Recreation
- Paul Frederick – Dept. of Forests Parks & Recreation
- Ron Shems – Vt. Natural Resources Board

Public Service Department Staff

- Christopher Recchia, Commissioner
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- Asa Hopkins, Director of Energy Policy and Planning
- Kelly Launder, Assistant Director, Planning and Energy Resources Director
- TJ Poor
- Karin McNeill
- Edward Delhagen
- John Woodward

Public Comments in Response to the Legislative Report

1 Introduction

This document provides a synopsis of comments on the Total Energy Study (TES) Legislative Report solicited and received from energy stakeholders and the public between December 15th and January 23rd, 2014. The total number of comments received was 436, including 41 emails originally authored and 395 form emails.

The narrative below is a synthesis of all the comments. Sections 1-7 relate to assumptions and policy and technology selection for the TES modeling, while Section 8 relates the State process for carrying out the TES.

2 Measuring Energy Goals, Costs, and Benefits

Policies aimed at greenhouse gas (GHG) reduction should be advanced. Vermont's needs to understand and model lifecycle emissions; this will inform the best energy choices, policy approaches, and investments. Note that 10 V.S.A. §578(a) goals are to reduce GHGs from "outside the boundaries of the state that are caused by the use of energy in Vermont." GHG calculations for fuels extracted from shale fracking and tar sands should account for emissions from extraction processes. Fugitive methane is not accounted for in burner-tip treatment and methane is so potent a GHG. This must be studied prior to further development of policies and strategies that include natural gas (NG) use.

For bioenergy, Vermont should rely on EPA GHG methods in order to avoid participation in this debate.

Vermont's GHG progress is inconsequential relative to other states.

One commenter requested that the cradle to grave GHG emissions of energy equipment (renewables specifically) be accounted for. Another noted that conventional GHG accounting measures are influenced by the status quo investment in fossil fuel powered global economic systems and are even at work in venues such as the IPCC.

Eliminate counting Vermont SPEED renewable energy credit (REC) sales as renewable resources.

The TES model cost/benefit analysis need to compare energy technologies using a true Levelized Cost of Energy done on a societal cost basis over the lifetime of the asset (typically 25 years minimum). Because current programs, do not customers are given incentives for more efficient oil burners but not receive incentives for switching to renewable heating systems.

The cost/benefit analysis should assign the right value to biological systems and natural resources such as Vermont's wild lands, forest lands, water resources, agricultural soils, and recreation areas in order to effectively compare technology pathways. Also social capital and health externalities should be internalized.

Cost benefit analyses should account for the substantial non-energy benefits of efficiency and renewable projects. Also, conservation can improve well-being by lowering expenses and debt, increasing leisure time, physical activity, health, and community interaction…

Modeling needs to account for indirect costs and test an electric load/rate "death spiral", such as synchronous condensers needed to reduce wind curtailment, local subtransmission upgrades, greater use of spinning reserves from NG generators, costs to alleviate impacts of shifting summer peak due to solar penetration (storage, control technologies), cost increases to other customers when entities reduce electric load by switching to trucked CNG or LPG or due to expansion in net metering (increased electric load from heat pumps could mitigate this), the cost to train more master electricians.

3 Statutory Goals

Scenarios should include ample funding for energy efficiency and renewable energy projects in affordable rental housing units. Low income housing services seek to mitigate the impacts of higher energy prices by building and retrofitting housing to meet energy efficiency standards and locating housing near jobs and services.

One commenter stated we can't offset costs for those who cannot afford higher energy costs if that requires doubling costs for others.

4 End Use Demand Technologies and Services

Vermont should invest more in efficiency and conservation. Incorporate the TETF recommendations. Retrofit programs should be fully funded.

Americans need to use 1/10th our energy consumption to get back to 350ppm. The TES Legislative Report page 30 states there is likely a need to reduce Vermont's total energy use through conservation and efficiency by factor of 2 by 2050. One commenter stated that goals to increase energy productivity and the need to potentially reduce energy demand by a factor of 2 or more by 2050 may be in conflict.

Another commenter stated that that level of conservation will cripple Vermont's economy and prefers to see emphasis on increasing renewable supply and GHG free sources, rather than on decreasing aggregate demand. Don't make reducing energy use (inc. vehicles-miles-traveled, VMT) an end in itself. Avoid simple terminology "use less energy" in favor of phrasing such as "dramatic increase in the energy productivity of the state's economy" and "increasing the productivity of energy use".

Do not support do-it-yourself weatherization programs; for beneficial returns, weatherization must be done by experts.

In the industrial sector, in-house engineers have more expertise than EVT regarding efficiency measures in their businesses.

Encourage converting street lights to LEDs.

Encourage passive solar and passivhaus building standards in five years.

Electric vehicles (EV) are not practical for Vermont (cold weather) and are too expensive. Vermont should not count on EV penetration soon enough to meet GHG goals. Don't build large wind in anticipation of broad EV adoption.

Subsidize heat pumps. Legislators are skeptical regarding carbon savings with heat pumps. One commenter stated that heat pumps may be good for new construction but not for existing homes because they are too expensive, not compatible with steam and forced-hot-water systems, and are not recommended for hot water heating where temps fall below 40 degrees.

5 Energy Supply Technologies and Services

Supply modeling needs to assess and inventory the renewable economic and technical potential of each technology (generators, storage, power controllers) and their integration mapped on to the Vermont landscape and include the complexities of mixing electric resources stationed in faraway places (Midwest or off-shore wind). Energy return on energy investment (EROEI) analysis must be the basis for assessing the potential of each technology and geographic placement. Supply modeling will inform which locations and jurisdictions should be incented to produce an optimal share of Vermont's energy supply.

Vermont should build out in-state renewable generation/production with large and small-scale installations. Highlight reduced energy losses due to replacing combusted fuels with renewable electric resources. Don't load build to make electric technologies cost effective e.g. solar.

The electric grid should be upgraded to be more resilient to storms. Build locally powered power islands for each neighborhood/community. Each island would be detachable and linked so communities can back each other up. This will reduce the need for high-tension lines. Using smart meters and connections, during emergencies customers could reduce demand choosing priority equipment to power.

Canadian imports could be lower cost than in-state resources.

As suggested on pg 33, the priority for the use of combustible fuels should not be - heat-led combined heat and power (CHP); heating only; transportation; electricity led-CHP; and electricity only". The electrification of heat and vehicles will result in substantial GHG reductions even if the electric source is primarily from NG plants. Also, flex-fuel electric generation and demand response will be essential to balance the grid. Therefore, heating only and transportation applications should have a lower priority.

Biomass and biofuels resources are limited, must be sustainably harvested, and have health implications.

- Abandon biomass use for electricity only or for low efficiency CHP applications.
- CHP has limited potential in Vermont based on the amount of manufacturing. For CHP projects, we need to model the CHP technology's potential for efficiency contribution of distributed generation, carrying winter loads, and the displacement of grid power, while letting efficiency control the supply choice. Vermont needs to address regulatory and permitting barriers.
- A cap on biomass will be set not based on requirement for sustainable harvesting but on the low energy content of this heavy fuel, with consequent large transportation costs, and the debated concerns regarding public health and carbon neutrality.
- Biomass plants do not reduce GHGs. Based on EPA, data coal plants have lower GHG emissions. E.g. The Springfield Vermont biomass plant has allowable CO_2 emissions (2,668lb CO_2/MWh) 2 ½ times greater than the proposed EPA standard for fossil fuels (1,000lb CO_2/MWh).
- Prime agricultural soils need to be protected for growing food.

- Used of forest resources for energy needs, to be balanced with the sequestration value of those resources.

GHG goals and Vermont agricultural policies are in conflict. State approved practices and technologies promote conventional dairy farming, petroleum based fertilizers, and fallow fields. Larger farms receiving methane digester subsidies, put savings into new capacity, thus adding to the feedback loop favoring the paradigm of continually expanding conventional dairy farms. Instead, small organic farming practices and technologies should be favored.

A number of commenters requested that NG not be considered in Vermont's energy future. The TES report mentions policies and technologies that include NG uses – HDV, industrial processes, electric generation. The driver of NG use is price; the driver of Vermont energy policy is climate change. NG should be approached with skepticism so the right questions remain open.

Do not approve NG pipelines (extensions). Any NG use should include offsets and mitigation to reduce overall use going forward. Begin charging NG a GHG fee. Vermont should reveal the secondary environmental and health impacts from fracking. NG price volatility impacts should not be undervalued. Renewable sources offer price stability and are becoming lower in long term costs. Expanding NG infrastructure locks Vermont in and pipelines will be hard to later abandon. Treating NG as a bridge fuel is false –

> Energy prices will not remain comparatively cheap; EROEI is falling; global demand is growing; lifecycle GHG regulations will change price dynamics; NGs methane emissions are high and expert consensus rates methane's 20 yr global warming impact at 80 times that of CO_2.

A number of commenters requested that nuclear not be considered in Vermont's energy future. A couple of commenters requested that the newest generation of nuclear technologies be explored as well as the developing Low Energy Nuclear Reactions (LENR) technology.

6 TES Scenario Selection and Pacing

Some respondents believe Vermont should stand out as a leader with aggressive policies. Vermont's uniqueness does allow us to be out front, but Vermont needs to be wary of risks/reward. Some respondents are concerned that exploring innovative overarching policies could have many unintended consequence. Don't be "out there alone". Pathways need more analysis before this risk/reward context can be likewise flushed out.

With a high pace of technology innovation, Vermont should be flexible to adjust pathways to meet goals. The pace of transition will be set by the end-of life turnover of older technologies; there will be no buy-back program for old technologies. Leaders should be wary of those who hold on to or push technologies as motivated by self-interests.

PSD should test combinations of the policy sets identified in the TES Legislative Report. At least on one of the TES scenarios should analyze a carbon tax. At least one TES scenario should analyze carbon pricing mechanisms. Some suggested Vermont should not institute a carbon tax or other pricing mechanisms unless there is a national movement, or a regional movement. Some are concerned with how the regulation would be perceived by Vermont's broader business community.

Carbon tax/pricing should not be the sole policy used to meet energy goals. There are market barriers other than price. There is a great deal of literature on barriers to end use efficiency and transportation alternatives. One barrier to respond to is the mismatch between the long time horizons and lower discount rates at play in decision making for large supply-side infrastructure versus short time horizons and higher discount rates for consumers when they make energy demand choices.

Due to the cumulative effect of GHGs, PSD should analyze how of different pacing in scenarios impacts GHG reductions.

The primary importance of Vermont's energy planning is the fight against global warming, however it will be the changing economics of energy services favoring renewables that will motivate behavior; thus policy should be simplified to focus on facilitating the shift to renewables.

Eliminate policies with voluntary targets and credit sales for renewables. These policies have no penalty for missing GHG goals and do not provide appropriate incentives. Mandates are needed. For example, Vermont SPEED creates only an illusion of moving toward goals. Utilities selling RECS must be required to buy RECS to meet renewable energy obligations.

Sector specific policy work can begin now. Most agreed that some sector specific policies are best directed in Vermont while others require regional collaboration. Many commenters stated that sector specific policies need an overarching policy, otherwise there is too much complexity and several commenters had concerns about costs. Also, energy sectors have been separated in energy bills, through regulation, policy, technology, and markets. Going forward, conservation, efficiency, and renewables must be integrated across energy sectors. A few commenters stated that sector specific policies working in tandem with regional efforts can work without overarching policies.

While regional collaboration is desired on certain policy fronts, Vermont should not let regional consensus be a defining feature of our energy pla. Do not let working regionally impede Vermont's ability to move forward toward meeting our energy goals.

Scenarios should address all market failures including irrational (other than cost based) consumer behaviors. Therefore, public outreach and education programs should be included. (See Section 8.)

Scenario construction should solve and/or output the impact on transportation infrastructure funding.

7 Legislative Primary Policy Sets

This section highlights specific issues raised about each of the primary policy sets and includes specific policy sets and goals proposed by respondents.

7.1 Nearly-Revenue-Neutral Carbon Tax Shift

A carefully crafted carbon tax could be the most effective policy mentioned in TES. It should be flexible to new information. A carbon tax must be imposed throughout the energy markets and priced high enough to value the damage done by the emissions. This needs to be enacted as soon as possible. One commenter noted that complementary programs to the carbon tax listed in the Legislative Report are very complex.

Use the term fee rather than tax. Use a "fee and dividend" model and don't just reduce other taxes. Dividends are most effective in motivating ordinary citizens [this is especially true for lower income people].

Carefully analyze the level of carbon tax needed to reduce carbon use. Price carbon based on the appropriate value to reach GHG goals and not based on needed energy program revenues. If there is a revenue short fall to fund energy programs, offset other taxes to meet specific revenues and compensate energy programs. Focus offsets on taxes that disproportionally impact low income people and have broad consumer impacts, e.g. sales tax.

The cost per ton of GHG reduced will be greater through this policy than the other policies, unless some revenues go to low cost GHG reduction measures that face market barriers other than price. It has been shown that carbon pricing on power resources is 7-9 times greater than cost per ton GHG for efficiency investments. This issue needs further analysis for the thermal and transportation sectors where similar results are expected.[1]

7.2 Total Renewable Energy and Efficiency Standard (TREES)

Any scenario testing TREES policies should include policies that address other non-pricing barriers to a least cost solution. Such a scenario needs to capture all the cost-effective efficiency resources, spur transmission access to low cost out-of-state renewables, support flexible generation and demand response technologies to optimize the grid, and address social and other barriers to reducing VMT. TREES does not address how the policy would result in lower fossil fuel consumption/GHG emissions.

The TREES credit structure could borrow the credit paradigm used for energy efficiency - set deemed credits for simpler measures, develop credit algorithms for somewhat more complex measures, and design custom credit protocols for truly complex measures. This credit structure would be refined over time as evaluation results shed light. Continue to pay clean generation credits at generation and efficiency credits over the life of savings; efficiency credits should be set via evaluation-based assumptions.

Efficiency is the least-cost solution but faces more market barriers than renewables development which is more expensive. Therefore to meet TREES obligations, it is not appropriate to set limits on the amount

[1] This issue arose in the recent GHG calculation done for the CEDF FY13 portfolio.

of efficiency added in order to insure a minimal amount of renewable energy is supported; rather there should be limits on renewables to ensure enough low cost efficiency is captured.

An important disadvantage of TREES is the creation of a single market clearing price for clean energy. There will be a wide range of costs for building efficiency, fuel switching, transportation efficiency and renewable generation measures. With TREES, as described, the most expensive measure would set the annual clearing price and consumers would then pay more for certain resources than if acquired through direct obligations. This has been an issue for standard offer efficiency programs in the US and white certificate programs in Europe.

Avoid the situation where both TREES credits and SPEED credits are at play in markets.

The application of TREES to the transportation sector needs in-depth analysis and consulting expertise. How would one gain credit for a transit service or for lower energy land use design [location efficiency has other social and cost benefits beyond transportation – water systems, communication systems].

One commenter was concerned about "double counting" evident in the description on page 23 of the Report "If energy efficiency measures are awarded lifetime credits, it could mean that the overall obligation could rise above 100% (e.g. achieved through 30% lifetime efficiency – saving 2% annually for 15 years – and 75% renewable supply)". The goal is 90% renewables not 75%.

Renewable Energy Vermont does not favor commodity trading of RECs because the REC markets lead to price fluctuations and uncertainty for businesses. Rather, REV members favor Feed-in-Tariffs.

7.3 Renewable Targets with Carbon Revenue

Why was this hybrid approach proposed for renewables without one for efficiency? Efficiency is more important. Europe came close to its binding GHG and renewable energy goals, but fell short in efficiency due to the lack of binding goals. One commenter noted that program described to be funded with carbon revenues are too complicated, appear ineffective, and damaging.

A benefit of this policy is greater flexibility for energy providers than is evident with a carbon tax or TREES.

7.4 Energy Sector-Specific Policies

Also refer to Sections 4 and 5.

In the list of sector policies include aggressive building energy efficiency codes with net zero requirements for new construction by 2030, mandatory labeling and disclosure for buildings at time of sale/rent/lease and mandatory minimum efficiency levels for buildings. Evolve these building energy policies to promote distributed renewables and transportation efficiency via requirements for renewable-ready buildings, and energy rating credits for renewables and location efficiency.

As to whether fuel dealers are sophisticated enough to respond to and support thermal efficiency regulations, Energy Futures Group estimates 15% of dealers are or have committed to becoming retrofit service providers and these are generally the larger firms.

Ideas for transportation policies:

- Add a VMT property tax based on miles away from compact communities or transit hubs.
- Lower the maximum speed limit to 55 mph. Meanwhile, enforce current limits with increased police patrols.
- Increase the gas tax and fund public transit, including rebates for those without access to transit.
- Include sector policies to address transportation electrification.
- Transition to NGVs until they can be replace by EVs; ask businesses to turnover fleets in exchange for not raising diesel tax.

Land use policies to drive growth to downtowns in compact communities and restrict growth to other areas are essential to reduce transportation GHGs and create more mobility options close to home and work. The modeling needs to explore diversification in Vermont's transportation system and alternatives to SOVs.

7.5 New England Regional Energy Policy Focus

Include collaboration with Canadian provinces. Regional collaboration is necessary to leverage markets and promote regional procurement.

Policies that absolutely rely on simultaneous action regionally to be successful are a concern. With this Regional Focus policy front, how would Vermont insure we meet our state energy goals. How can we insulate Vermont from regional collaboration on policies that could result in Vermont interests being overwhelmed by larger states like MA and CT?

Work regionally to modify the electric capacity market to place great value on flexible resources for grid control; this is needed with increasing penetration of non-dispatchable renewables (e.g. demand response, quick/frequent ramping).

Regional standards are needed for biomass harvesting and procurement, and pellet production

A VMT fee would have to be implemented at the federal level.

7.6 Specific Policy Sets or Goals Recommended by Respondents

Akin to feed-in-tariffs[2] the TES could test policies which assign prices designed to reach specific CEP objectives, e.g. GHG reductions through specific means, increased building efficiency, fuel switching, decreasing VMT. Let the market determine how many of these "goods" are purchased. Reset the prices to refine the market action as progress is made or not made. This policy differs from carbon tax by giving positive incentives to encourage goals are met. Incentives are more effective than penalties. Feed-in-tariffs can be designed to meet certain objectives where a carbon tax cannot. Difficulties with this approach include funding and the challenge of setting prices per objective.

A legislative mandate is needed to drive and track conservation in order to reduce fossil fuel consumption. For example, before a renewable installation goes on-line, a commensurate unit of fossil fuel consumption must be eliminated. Vermont will not reduce fossil fuels by adding renewables and increasing efficiency. Efficiency does not necessarily reduce overall consumption. Several TES sections describe that efficiency promotes more spending and economic growth. The economic multiplier effect could nullify or reduce gains from adding renewable resources; this should be considered a market failure. Spending and growth increase consumption, therefore, only conservation reduces consumption.

Legislate a VMT fee with added factors for vehicle weight and possibly number of axles; this needs detailed study. A nonlinear formula makes sense for projecting road wear from vehicle weight and number of axles. To measure VMT, record odometers at the time of annual inspection.

A sector specific achievable immediate path forward is:

- Reduce transportation footprint: decrease VMT, increase ride-sharing, invest in transit, encourage efficient vehicles, switch to EVs only where they are powered with photovoltaics (PV)
- Weatherize homes
- Replace oil and propane with wood and grass pellet heating
- Encourage solar hot water
- Continue to encourage low-impact small distributed electric generation; raise net metering cap; Encourage PV especially with dropping prices

Two central policies can drive the change: 1) a GHG fee for damages to finance the program, and 2) a renewable energy production plan to support in-state production where models show the best geographic and political potential:

1-Renewable energy funding via a CO_2e GHG fee for damages based on the federal Social Cost of Carbon and third-party derived lifecycle accounting would fund administration, low-income rebates, and investment capital for build-out of renewables. Low carbon renewable energy from out-of-state will not be charge fees but will not be eligible for investment capital or fee rebates.

[2] "For insight on how this might apply to resource objectives other than renewables, see the following paper on the concept of a feed-in-tariff for efficiency: Neme, Chris and Richard Cowart, "Energy Efficiency Feed-in-Tariffs: Key Design and Policy Considerations", 2013 ECEEE Summer Study Proceedings, pp. 305-315."

2-A comprehensive renewable energy production plan will place responsibility on the entire Vermont community on a pro rata basis. This supports local control and benefits. Capital is given for investment and fees are charged if the a “fair share” of investment is not carried out. Communities and Vermont as a whole could be an exporter of energy services. The highest capital support and fees would be in early years encouraging rapid build-out and taper off as fossil fuel use declines. Accounting and regulation for energy production should be separated from grid services. Electric utilities should be responsible only for grid services such as T&D, should be treated equally with other renewable energy production project owners. Vermont should adopt CA’s model for interconnection standards.

Vermont could export excess renewable energy; go above 90% to 150-300% renewables. The way we account for and treat out-of-state resources in policy requires serious analysis and debate. Planning for a “100% energy island” within Vermont enhances the benefits of localization. This will eliminate the potential future where Vermont will have to outbid other locales in competition for energy resources.

TES modeling should look at the rate at which sustainably harvested Vermont forests can serve home heating coordinated with efficiency measures, and then assess how remaining heating demand can be served by electricity.

8 Comments Pertaining to the TES Process

Public-private partnerships can be hampered by constraints in how public or quasi-public organizations deliver assistance or funding. The Public Service Department (PSD) and other top level regulatory agencies should develop administrative processes from the top down to maximize flexibility within state agencies and partners.

Vermont needs an energy czar at the cabinet level and a regulatory body that can facilitate the renewable energy plan, its implementation, and accelerate approvals across state agencies, the PSB, and other regulatory panels.

Addressing climate change is a moral necessity. Leaders need to educate the public. Vermont can sustain its energy needs and prosper with locally owned and controlled distributed renewable energy. Other benefits are sustainable local food and agriculture, sustainable jobs, sustainable land utilization. Vermont’s landscape must show visible signs of energy infrastructure and production. We need a radical campaign to explain this need. Need to confront the status quo that resists this change. We need strong convictions, will, and diverse champions to overcome resistance to change.

We need to move the public discourse to efficiency initiatives in thermal and transportation and away from the over focus on renewable electric generation issues. Cease framing non-SOV travel modes as alternative.

We need qualitative modeling to promote benefits to be accrued equitably to Vermonters so they understand the renewable energy vision and its promise. This vision needs to be told from many perspectives, large and small, every day. Energy costs and impacts need to be carefully explained to the public; the public has been given conflicting information. The legislature should mandate an education/outreach campaign to inform all Vermonters of the need for energy conservation with materials and method for tracking individual progress in lowering consumption. State educational curricula should include courses on energy conservation.

Vermont should study and legislate for product labeling which would note the energy impact/savings of products.

PSD should track which sectors and technologies result in increased use of fossil fuels. One commenter suggested retiring the term clean energy (eliminate NG and nuclear in the portfolio) and use the term renewable. Renewable energy includes critical components – efficiency, demand-side management, storage, and energy carriers – electricity, hydrogen, methanol, ammoniac, dimethyl ether and biofuels as long as carriers use renewable energy as the primary energy source.

PSD needs to include in each policy/strategy discussion which includes NG as an energy resource, an obvious articulation that the study of NG lifecycle emissions was not undertaken, but that such a study has potentially signification information.

TES modeling could initiate a decades-long effort to model demand and supply/production. Assumptions and methods should be explicitly described. Independent entities should be allowed to use the model and test their own assumptions. One entity should coordinate consistency in data inputs which are take from peer reviewed and official independent bodies, excluding studies funded by pro fossil fuel, anti-wind, or anti-biomass money.