Some Facts for Addressing Climate Change in Vermont

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Prologue

For those that follow climate science, we know that we have an urgent task to decarbonize our society to preserve the environment for our children and grandchildren. In the long run (roughly three decades), that means we need to electrify our energy system and replace fossil generation of electricity with carbon free generation of electricity. The same as with any complicated system that has a lot of built-in momentum (which definitely describes the climate system), it is clear that any beneficial changes we make today impact the final outcome dramatically more than making the exact same changes 5, 10 or 20 years into the future. It therefore matters a great deal about the *sequencing* of the changes we make. It also matters whether we make changes today, or make the changes in the future. Finally, it is very clear what changes are financially and technically viable today (in other words, how do we slash the first 10% of carbon emissions), and we should implement those changes today. Due to the rapid state of technological change and the massive investment in new climate technologies, it is much less clear how we will eliminate the last 10% of carbon emissions decades into the future. We should not try to look into the crystal ball and figure that out. Instead, let's get our facts straight and focus on the changes that are technically and financially viable today. Once we are in agreement, we can cooperate to find the solution

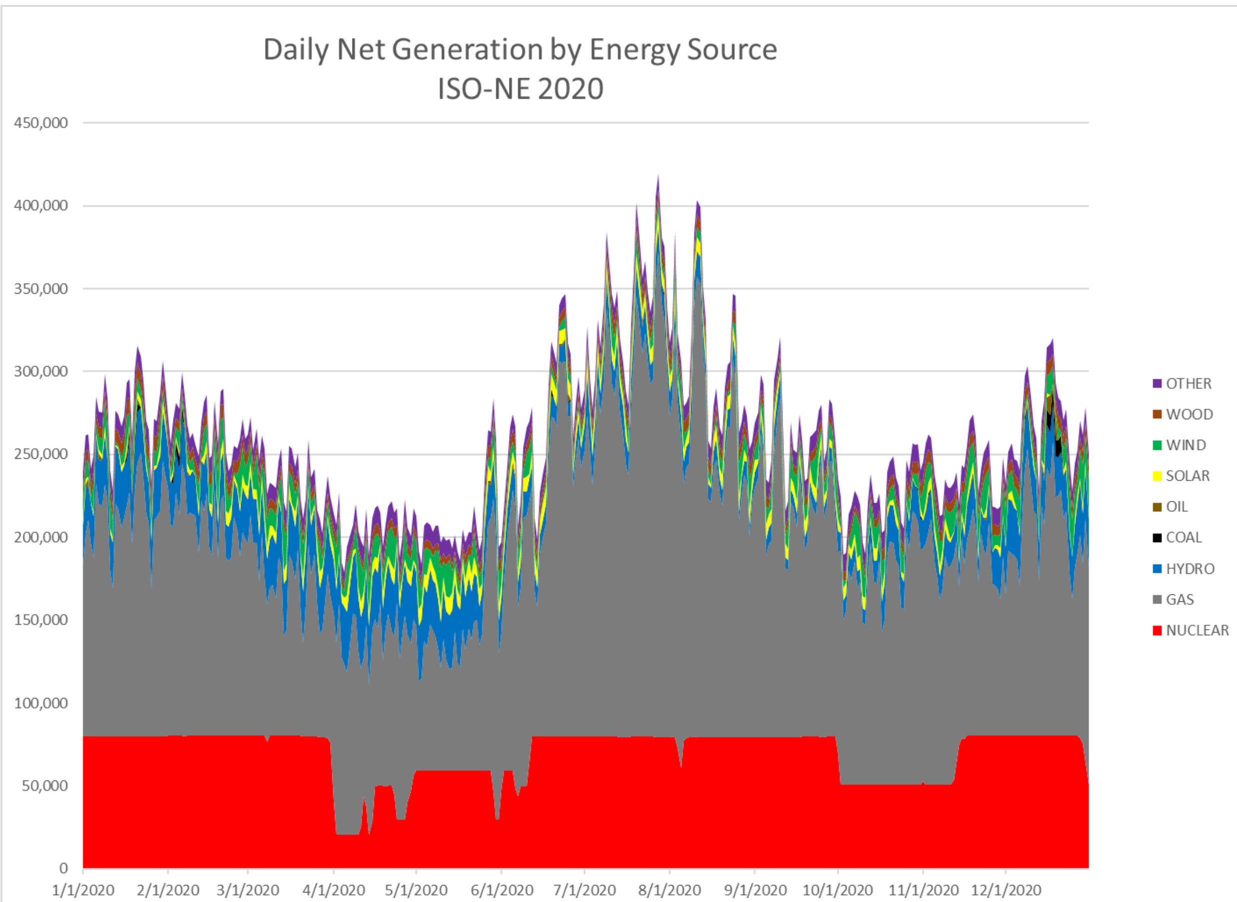
TAKEAWAY FACT: The marginal emissions of electricity production in Vermont significantly exceeds 900 lbs of CO_2 per MWh of electricity (see Fact #1, Reason #3).

FACT #1: In Vermont, the marginal resource for electricity is natural gas.

This is a critical fact. If we add load to Vermont's grid (i.e. an EV or a heat pump), we use natural gas to produce that electricity. If we add generation to Vermont's grid (i.e. solar or wind), we turn off natural gas. This is the only comparison that matters from the perspective of the climate. The physical electricity must be produced somehow. Today, this extra electricity produces carbon.

Reason #1: *The electric generation of nuclear, wind and solar are nearly always fixed at full capacity.*

Figure 1: New England Electricity Generation



Nuclear is a base load source of generation. It is clearly seen from annual production data that this is constant all year round (see the red in Figure 1 above) except when the nuclear plants are refueling or there is a generation problem. Wind and solar are variable production sources that are dependent upon the wind and the sun. These always produce at the maximum capacity given the wind and the sun that is available. There is a minor exception to this for wind, which is sometimes curtailed in the spring or in remote regions with insufficient transmission capacity. Hydro production is somewhat variable in the short term, but annual production is essentially fixed based upon annual rainfall. Furthermore, it comprises only 6% of New England's electricity (https://www.iso-ne.com/static-assets/documents/2021/03/2019_air_emissions_report.pdf, page 3).

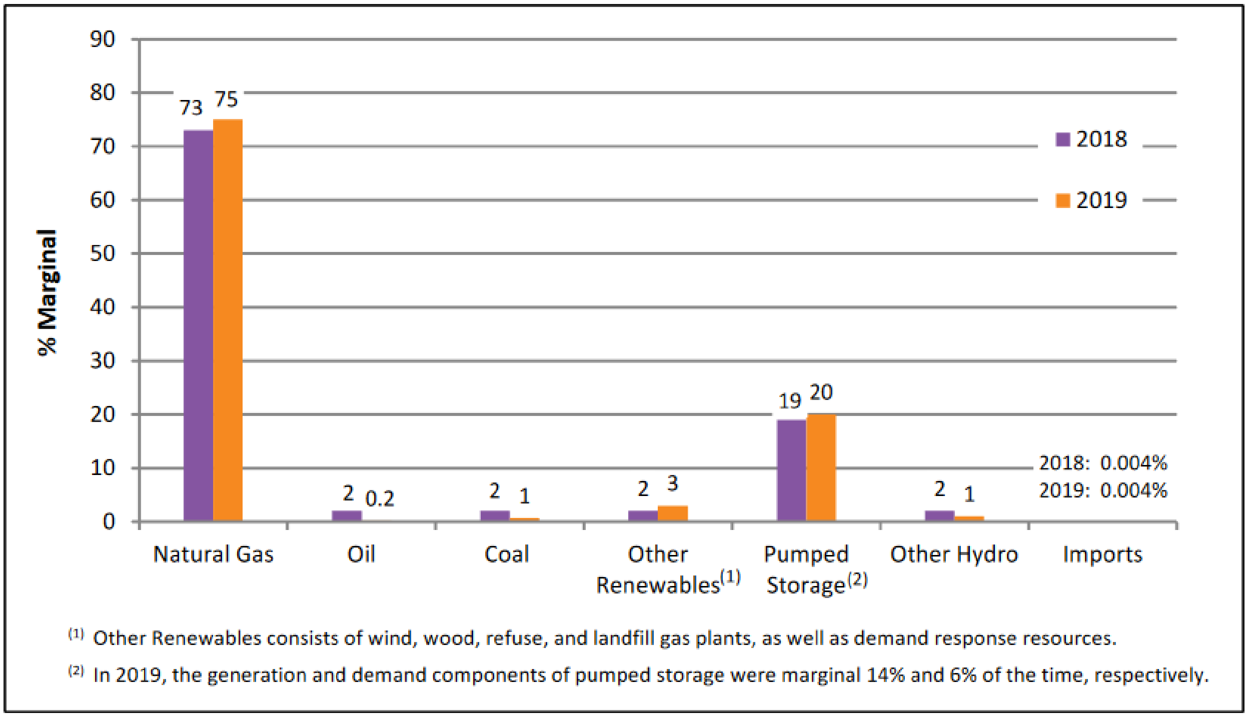
***Reason #2:** This is how New England electricity markets work.*

The ISO-NE grid is a competitive market, with prices constantly varying depending upon supply and demand conditions. Nuclear, wind, solar and hydro all have marginal operating costs that are very low, and in the case of wind and solar are nearly zero. They will continue to operate at nearly any price above zero. However, this is not true for fossil generation of electricity (in New England, nearly all natural gas except very cold spells, when oil is a large component). To generate electricity from fossil fuels, there is an ongoing cost of fuel. These plants will not generate electricity once the cost of electricity is below the cost of the fuel to make the electricity. Therefore, it will nearly always be the case that natural gas plants will turn on and off to balance the financial ISO-NE markets, which in turn balances the supply (generation) and demand (load) of electricity.

***Reason #3:** This is the data from ISO-NE.*

ISO-NE, which runs the New England grid, calculated the marginal emissions and published it in their report *2019 ISO New England Electric Generator Air Emissions Report* (https://www.iso-ne.com/static-assets/documents/2021/03/2019_air_emissions_report.pdf). Their load-weighted marginal emissions rate for 2019 is 719 lbs of CO_2 per MWh produced (Table 1-2, page 4).

Figure 2: Annual Percentage of load for which various resources were marginal



(https://www.iso-ne.com/static-assets/documents/2021/03/2019_air_emissions_report.pdf, page 21)

On further inspection, we can see that this number is too low. From Figure 2, we can see that in both 2018 and 2019, fossil fuels (Natural Gas plus Oil plus Coal) were the marginal resource for 76% of the load, and renewables (including hydro) were the marginal resource for 4% of the load (Other Renewables plus Other Hydro). Pumped storage was the marginal resource for 19% (2018) or 20% (2019) of the load. However, in Footnote 14 on page 11 of the ISO-NE report, it is stated that the marginal heat rate (and therefore the marginal emissions) for both pumped storage and for imports of electricity into New England are assumed to be zero! How do you pump water into a storage reservoir without using electricity, which in turn comes from the marginal resource (i.e. fossil fuels)? In addition, pumped storage does not have perfect 100% efficiency, so you actually use MORE fossil fuels for electricity from pumped storage than directly from the fossil powered generation facility. Therefore, it is safe to assume that for 96% of the load in New England the marginal resource is fossil generation. Thus, the 719 lbs/MWh number should be 908 lbs/MWh (719 * 96%/76%). ISO-NE also reports that the load weighted marginal emissions rate for emitting units (e.g. fossil fueled electricity generation) was 943 lbs/MWh in 2019. 96% of this is 905 lbs/MWh, an almost identical number. This number does not account for fugitive emissions of methane from the production, transportation and distribution of natural gas. Methane is a far more potent greenhouse gas than carbon dioxide, so these emissions are a significant *underestimate* of the actual emissions from New England electricity generation.

In calculating the impact of any climate policy, it should be assumed that adding or reducing electric load has a MINIMUM impact of 905 lbs of CO2 per MWh of electricity. Actual emissions are certainly much worse due to ISO-NE imports, and fugitive emissions (leaks) of methane in the production, transmission and distribution of natural gas.

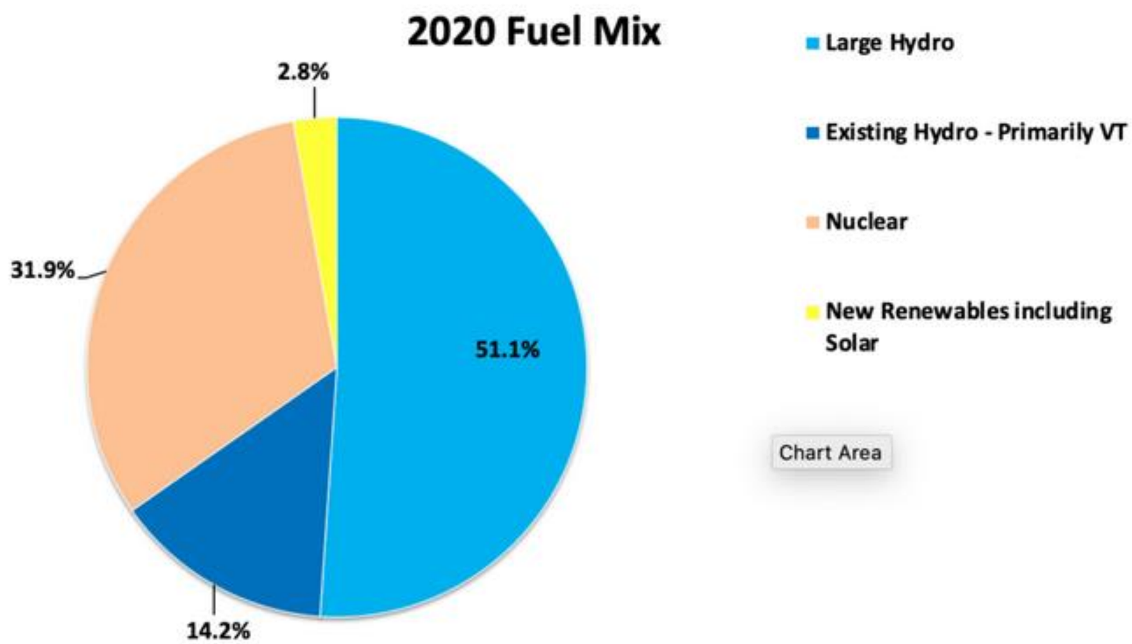
Reason #4: *The price says it all: it is a scam*

I will make this offer to anyone in the Public Utilities Commission or the Vermont Department of Public Service: Send me $780 in unmarked $20 bills, and I will deliver to you a brand-new car worth $40,000. Although I have made this offer several times, no one has taken me up on it. Why not? It is such a great deal! Obviously, it has all the hallmarks of a scam: the price is too good, there is no contract, the bills must be unmarked and in twenties only, there is no time limit, etc., etc. Anyone with an email account has a good sense of fraudulent offers. This is *exactly* the deal being pawned off on Vermonters: we will sell real RECs (Renewable Energy Credits) from *new* solar and wind projects to Massachusetts and Connecticut, and buy *fake* RECs (they are not RECs; they are "environmental attributes" because RECs must be from relatively new facilities that are actually reducing greenhouse gas emissions) from HydroQuebec for 1.8% of the price of the *real* RECs sold ($780 is 1.8% of $40,000 in the above example). The price says it all: these "attributes" are so cheap because they are not recognized by any entity that is seriously trying to address climate change. Twentieth century renewable facilities are great to have and we should not shut them down, but they do not address climate change because *nothing changes*. We need to build NEW renewable facilities that create honest RECs and displace natural gas in order to address our climate emergency.

FACT #2: The fastest solution to climate change is to build a LOT of renewables immediately.

Reason #1: *20th Century renewables do NOT solve climate change.*

The Vermont Department of Public Service (in correspondence with TJ Poor, Director of Planning) admits that natural gas is the marginal resource in the short term. However, Mr. Poor argues that "in the long-term, policy and programs development should account for the utility portfolio." Furthermore, he states that "the added load of a heat pump, in the long term, is met from resources in line with a utility portfolio." That is precisely the problem. The graph below shows the Green Mountain Power portfolio. Only 2.8% of this portfolio is new renewables; nearly everything else is from 20th century facilities.



These facilities have been serving load for at least 40-50 years, and some have been serving load for over 100 years. If the generation or renewable attributes from these facilities is shuffled with pieces of paper, the load they have previously served still needs to be met somehow. The additional resource to meet this load is natural gas even in the medium term.

Reason #2: We use a LOT of fossil energy

New England used 117 TWh (Terawatt-hours) of electricity in 2020 (https://www.iso-ne.com/isoexpress/web/reports/load-and-demand/-/tree/net-ener-peak-load), of which 46.7% was generated from fossil fuels. We thus need to replace 54.6 TWh of electricity from fossil fuels just to meet current load. If we electrify our transportation and heating sectors, we will need to at least double the total amount of electricity we consume, so we need an additional 117 TWh of electricity generated from renewable sources for New England. Thus, we need over

170 TWh of electricity from NEW renewables in less than 3 decades. This is required to reach our goal of a fully decarbonized energy system. Vermont's share of this is 7.3 TWh.

Reason #3: HydroQuebec is not a solution

Of course, the best sites for dams in Quebec have already had dams constructed. It might be thought that additional hydro dams in Quebec could provide additional renewables to New England. The current construction project is the Romaine complex, started in 2009 and slated to be finished in 2022 (https://www.hydroquebec.com/projects/romaine.html). This will produce an extra 8 TWh of electricity. Electricity consumption in Quebec in 2021 was 175.2 TWh in 2021 (https://www.hydroquebec.com/about/financial-results/annual-report.html), while it was 165.3 TWh in 2009 (HydroQuebec Annual Report 2012, page 2). Thus, during the time period that the Romaine complex has been constructed, the Quebec electricity consumption increased 25% more than the production from the new dams. The construction of new dams by HydroQuebec is not meeting Quebec's needs, and should not be counted upon to provide the NEW electricity required for New England.

Reason #4: We can't efficiency our way to zero

Vermont has had a 5-6% efficiency tax on electricity for years, dramatically higher than any extra costs from solar construction. This, and building new renewables, have been the primary effective responses to climate change in Vermont. We should continue to drive efficiency, but there is absolutely no evidence that we can solve the climate problem through efficiency gains alone. We have to manage both demand and supply.

Reason #5: Offshore wind has been the salvation for more than 15 years

Vermont regulators tout offshore wind as the climate solution. However, Cape Wind was approved by the Massachusetts Energy Facilities Siting Board in May, 2005, and was projected to produce as much as 454 MW of electricity. After a protracted battle, the project was abandoned in 2017. Offshore wind is approximately twice as expensive to develop as onshore wind, and despite many hopes and promises, very little has actually been developed in northeastern US waters. In spite of this, offshore wind is still the salvation according to Vermont officials.

Reason #6: Offshore wind is not sufficient for New England's needs

A 2010 New England Wind Integration Study (https://www.iso-ne.com/static-assets/documents/committees/comm_wkgrps/prtcpnts_comm/pac/mtrls/2010/nov162010/newis_iso_summary.pdf) examined the difficulty of integrating from 1 to 12 GW of wind into the grid, calling 10-12 GW of offshore wind as "Extra-high wind penetration" (page 5). There are 15 GW of wind proposals in the ISO-NE Interconnection Queue (https://pjm.com/-/media/committees-groups/stakeholder-meetings/ipsac/2021/20210604-ipsac-ny-ne/20210604-item-04-2-iso-ne-osw-development-update.ashx, page 6). Only a small portion of this will be built in the most optimistic scenario, and this would require a massive investment in transmission infrastructure. In the "New England 2030 Power System Study" (https://www.iso-ne.com/static-assets/documents/committees/comm_wkgrps/prtcpnts_comm/pac/reports/2010/economicstudyreportfinal_022610.pdf), published in 2010, the high end wind case was 12 GW of wind, including 7.5 GW of onshore wind and 4.5 GW of offshore wind (page 2). As recently as February, 2022, New England senators have expressed reservations:

"We recognize the potential for our states to produce significant clean, renewable energy and to harbor a new industry and workforce through responsible development of offshore wind off our shores," the senators wrote in a letter to Bureau of Ocean Energy Management (BOEM) Director Amanda Lefton.

"However, it is essential that BOEM do additional outreach and research to inform the agency's planning process prior to conducting lease sales and to improve the ability to assess, predict, monitor, and manage potential environmental impacts of offshore wind in the Gulf of Maine." (https://www.tigerdroppings.com/rant/politics/senators-go-nimby-on-new-england-off-shore-wind-farm/101093232/).

The goal of the Biden administration is 30 GW of offshore wind by 2030 for the entire United States (https://www.whitehouse.gov/briefing-room/statements-releases/2021/03/29/fact-sheet-biden-administration-jumpstarts-offshore-wind-energy-projects-to-create-jobs/).

It is clear from these various reports and the actual history, that offshore wind will face a lengthy implementation period at best. Let's presume that we reach 12 GW of offshore wind capacity in the next decade, which is highly unlikely to actually happen. At a 50% capacity factor (i.e. 24*365 * 50% = 4,380 hours), which is an overly optimistic number, 12 GW of offshore wind would produce 52.6 TWh (terawatt-hours: 12 * 4,380) of electricity annually. This *ALMOST* replaces the

54.6 TWh of New England's electricity currently produced by fossil fuels, but does *NOTHING* to provide electricity for the coming electrification through EVs and heat pumps.

Reason #7: There are many future options: today, let's focus on options that are technically proven and financially viable

There are many climate solutions that have been suggested, such as carbon capture and storage, direct carbon capture, fourth generation nuclear technologies such as Terrapower, advanced SMRs (Small Modular Reactors), geoengineering, nuclear fusion, biofuels, and hydrogen. Most of these options are not proven and/or commercially viable today. Research into many of these options is warranted, and some may eventually make significant contributions to the climate crisis. However, none are immediate solutions that can be implemented by Vermont.

Reason #8: We need to reduce carbon TODAY!

The IPCC has released its bleakest warning yet, saying that "Any further delay in concerted global action will miss a brief and rapidly closing window to secure a liveable future." (https://www.theguardian.com/environment/2022/feb/28/ipcc-issues-bleakest-warning-yet-impacts-climate-breakdown). We cannot wait for a possible future panacea (e.g. offshore wind) that has already been claimed as our salvation for over 15 years without results.

Reason #9: There is HOPE.

If we slash emissions to zero TODAY, global temperatures will stop rising almost immediately (https://michaelmann.net/content/best-climate-science-you%E2%80%99ve-never-heard?utm_source=ActiveCampaign&utm_medium=email&utm_content=Weekend+Reader%3A&utm_campaign=Weekend+Reader+Email). There is a great deal of momentum in the climate system. In any such system, any immediate change has far more impact on the outcome than a change 5 or 10 years into the future. We should do everything we can to cut carbon emissions today. The fastest method we have for doing that is to build onshore wind and solar TODAY.

Reason #10: Vermonters are clamoring to do their part by installing solar, buying EVs and electrifying thermal needs. Vermont state policy is the largest barrier to them.

Why do we have a 34% tax (negative one cent site adder, negative four cent REC adder, one cent energy efficiency tax, or 6 cents out of roughly 18 cent retail rate) on self-consumed solar in Vermont? We should be taxing carbon, not solar; the current policy is unconscionable. The production meter on solar is not required in other states and should be eliminated.

Conclusion

To solve the climate crisis, we need to agree on some basic facts. The assertions in this paper are backed up by a great deal of data and academic theory. If the data are incorrect, then let's examine the data and make corrections. Otherwise, let's use these facts as the basis for sound climate policy.