Vermont Solar Pathways

From a Developed to An Advanced Solar Economy

Ferrisburgh Solar Farm, segroup.com

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Vermont Solar Pathways

Can we get 20% of electricity from solar by 2025?

- Do we have enough room for that much solar?
- Can the grid handle it?
- Is it too costly?
- Can it address equity and affordability?
- What are the barriers & opportunities?

Today

- Introduction
- Overview of study
- Discussion
- Identify your questions
- Dissemination

"Vermont has already seen significant growth in solar. Our installed capacity has increased nearly tenfold over the past five years and we now rank third in the nation in terms of solar jobs per capita. However we must do more and now that we have a roadmap we must redouble our efforts to make it happen"…

Bernie Sanders, U.S. Senator from Foreword to the Vermont Solar Pathways Report.

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About VEIC

- Private, nonprofit corporation founded in 1986
- Provides energy efficiency and renewable energy consulting and implementation services
- 300+ employees
- Locations: VT, DC, NJ, OH

Major Initiatives

Efficiency Vermont

DC Sustainable Energy Utility

Efficiency Smart

BERC Biomass Energy Resource Center

Renewable Energy Resource Center

Drive Electric Vermont

Commons Energy
Saving Energy, Strengthening Communities

Way to go!

Sun Shares

VEIC Consulting and Implementation

Areas of Expertise

- Policy development & regulatory support
- Program delivery structure
- Market research & analysis
- Program design & implementation
- Project feasibility & technology suppor
- Transportation research & policy

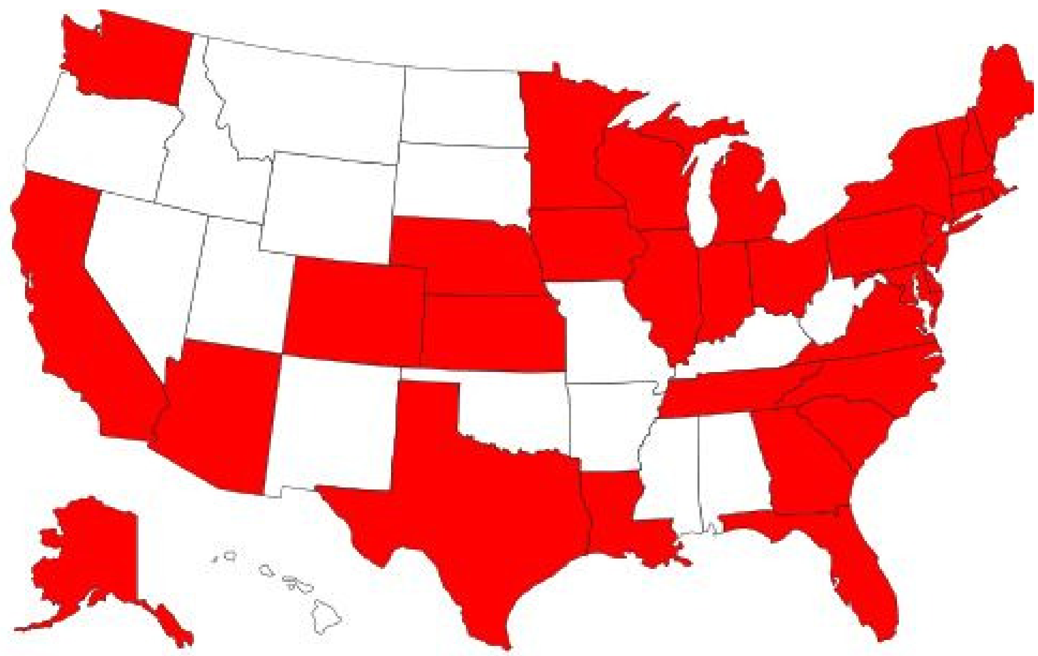
Range of Clients

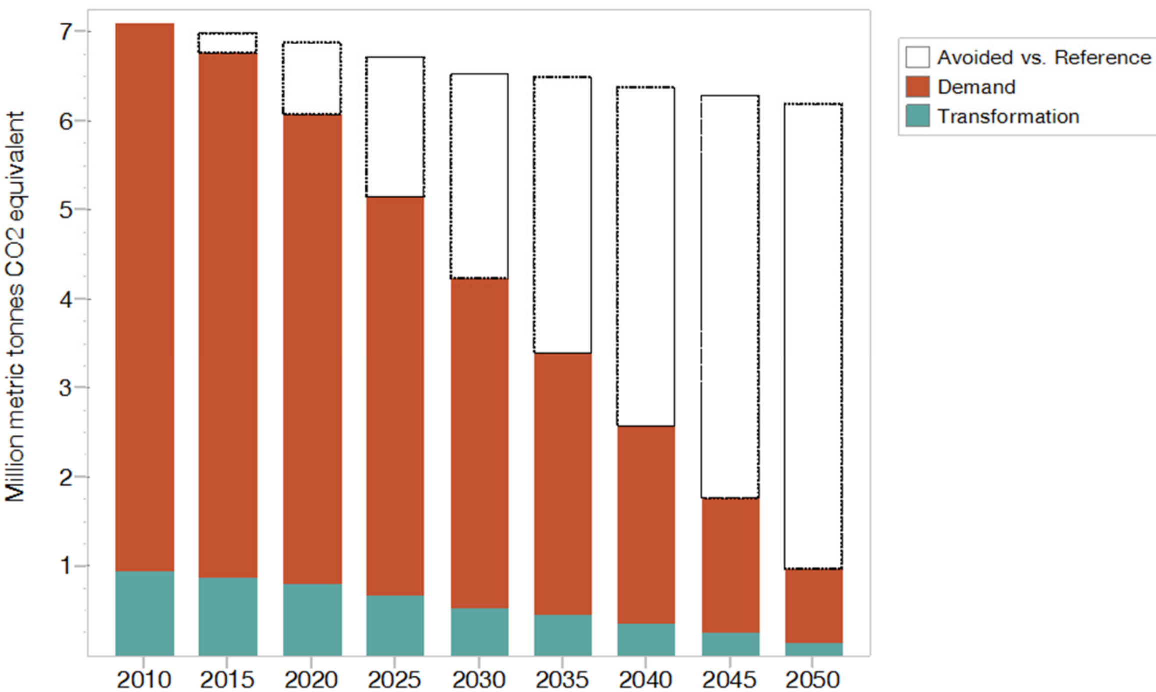
- Regulators
- Government agencies
- Advocates
- Utilities – IOUs, munis, co-ops
- Foundations

Range of Jurisdictions

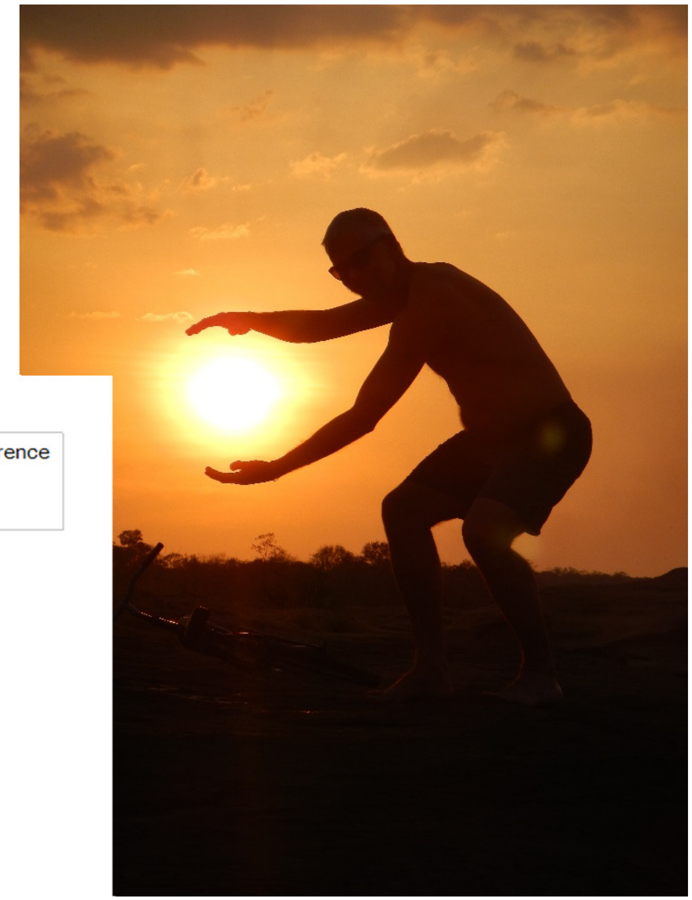
- 28 states, 6 Canadian provinces
- China, Vietnam, Mexico, Ireland, United Kingdom, others

VEIC work in the United States





Million metric tonnes CO2 equivalent
1
2
3
4
5
6
7
2010
2015
2020
2025
2030
2035
2040
2045
2050
Avoided vs. Reference
Demand
Transformation



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Cooperative Agreement with U.S. Department of Energy

$750k over 3 years (2015-2017) including 20% cost share

Public Service Department (PSD)

Subrecipient, advised on energy scenario modeling related to Comprehensive Energy Plan and other policy initiatives

Regulatory Assistance Project (RAP)

Subrecipient, lead analysis of net metering and alternatives

Project approach

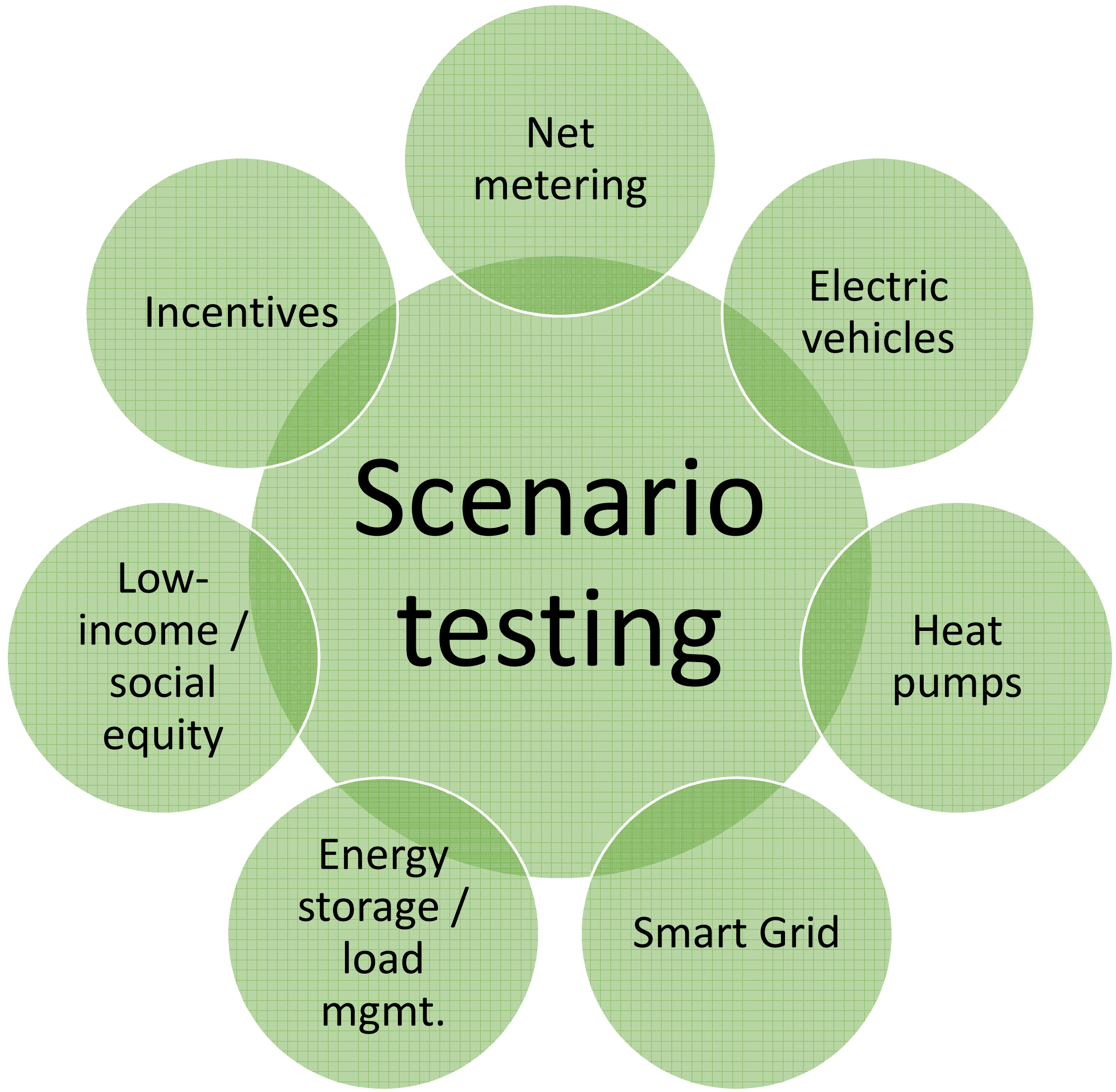
Stakeholder engagement

- Create a shared vision and buy-in
- Review and vetting, ideas for alternative scenarios
- 10 stakeholder meetings over 2+ years
- Utilities, regulators, solar companies, researchers, activists, citizens

Scenario Modeling

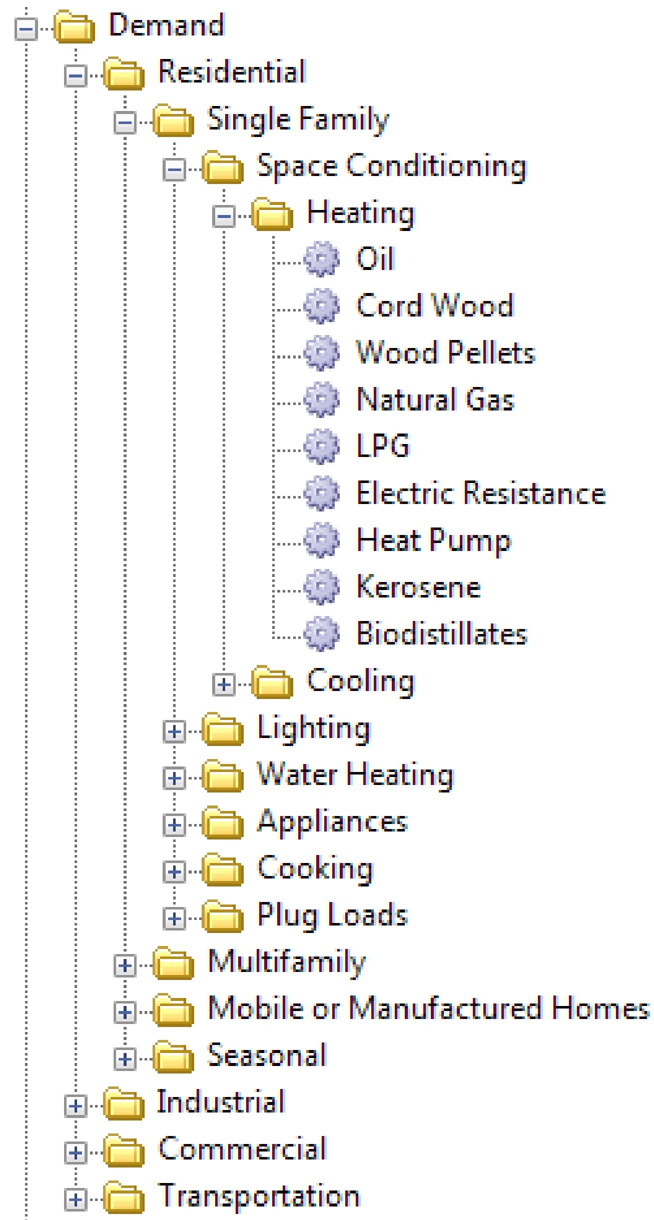
- Define desired future state
- Compare to business as usual and other paths
- Examine issues
- Estimate costs and impacts

Focus areas


Net metering
Electric vehicles
Heat pumps
Smart Grid
Energy storage / load mgmt.
Low-income / social equity
Incentives
Scenario testing

Model of total energy system

- Don't look at solar in isolation
- Includes all sectors
- Demand and activity driven
- Ability to test various assumptions and sensitivities



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Three main scenarios

Reference

Business as usual, expanding natural gas and cars becoming more efficient because of CAFE standards

90% x 2050_{VEIC}

Meets the state's 90% renewable energy goal, based on economic modeling in their Total Energy Study[1]

SDP – Advanced Solar

Meets 90% x 2050 and 20% solar generation by 2025

Lower net metering

Based on SDP but more utility solar instead of net metered

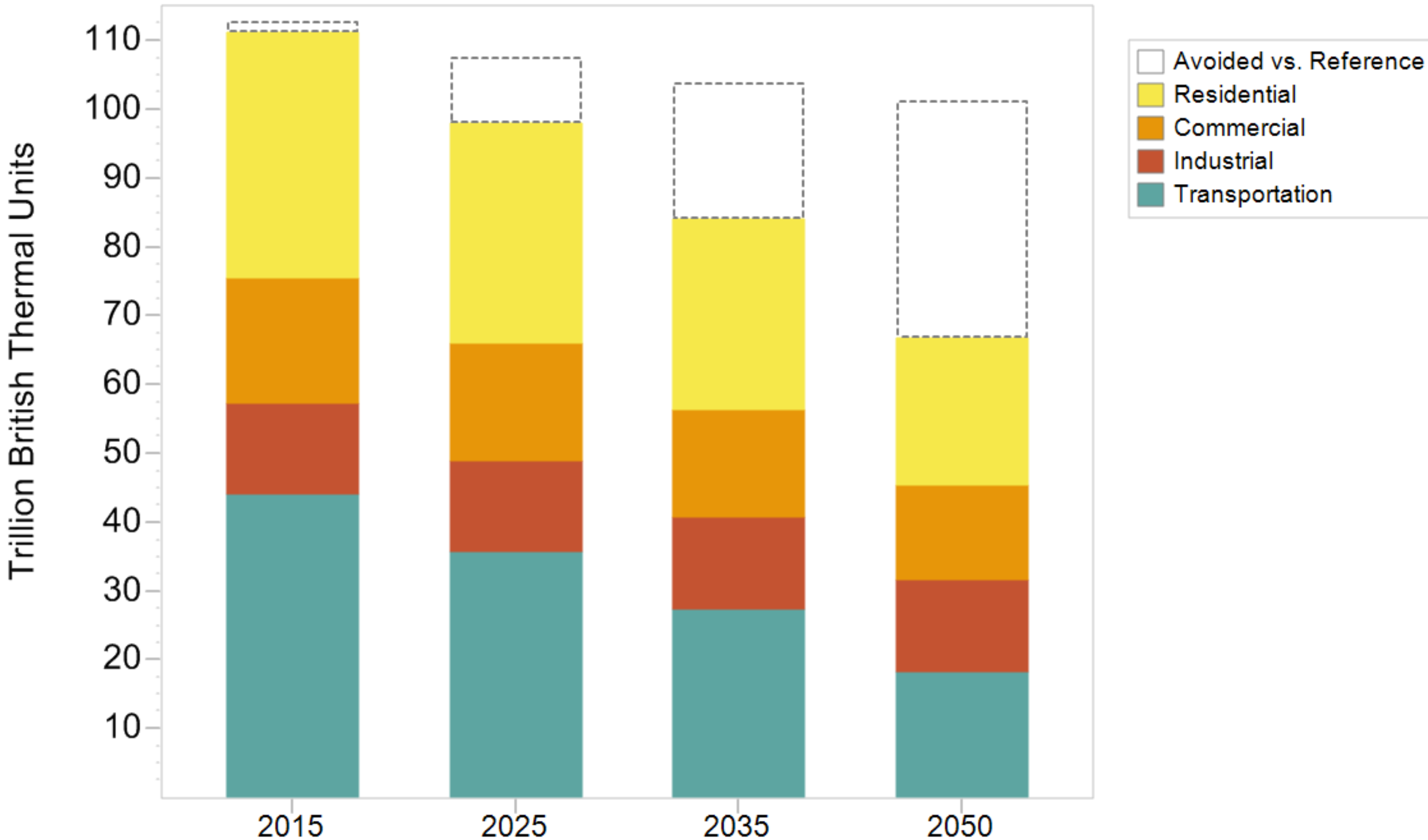
Delayed solar deployment

Solar installed later: costs less, misses out on federal tax credit

1. Vermont Department of Public Service, Total Energy Study, 2014
http://publicservice.vermont.gov/publications-resources/publications/total_energy_study

Efficiency is critical

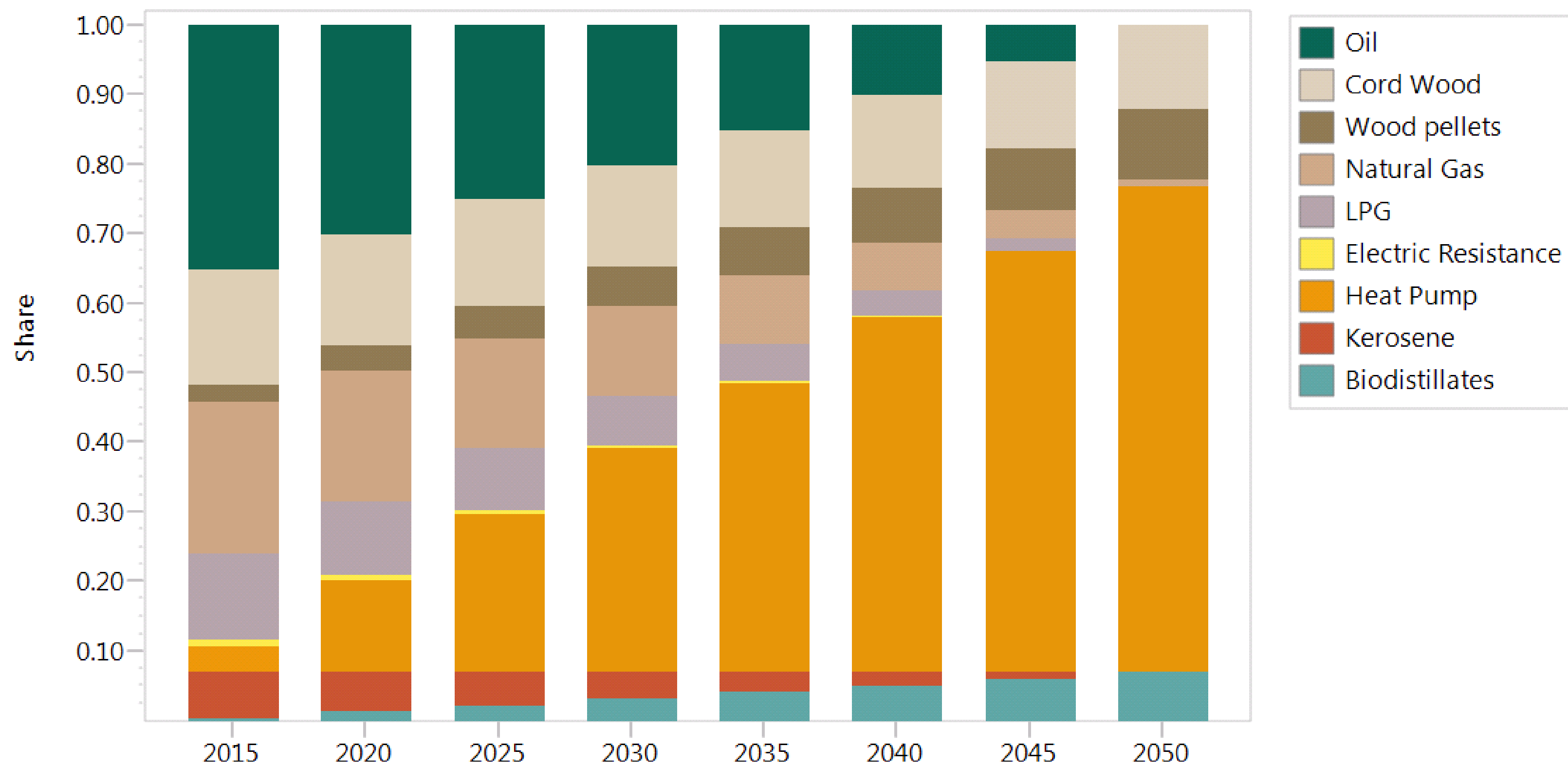
Total energy declines even in reference scenario



Electrification provides much of the decreased demand

Heat pumps and electric vehicles are 3-4 times more efficient than their combustion based competition

Share of single family residential heating energy



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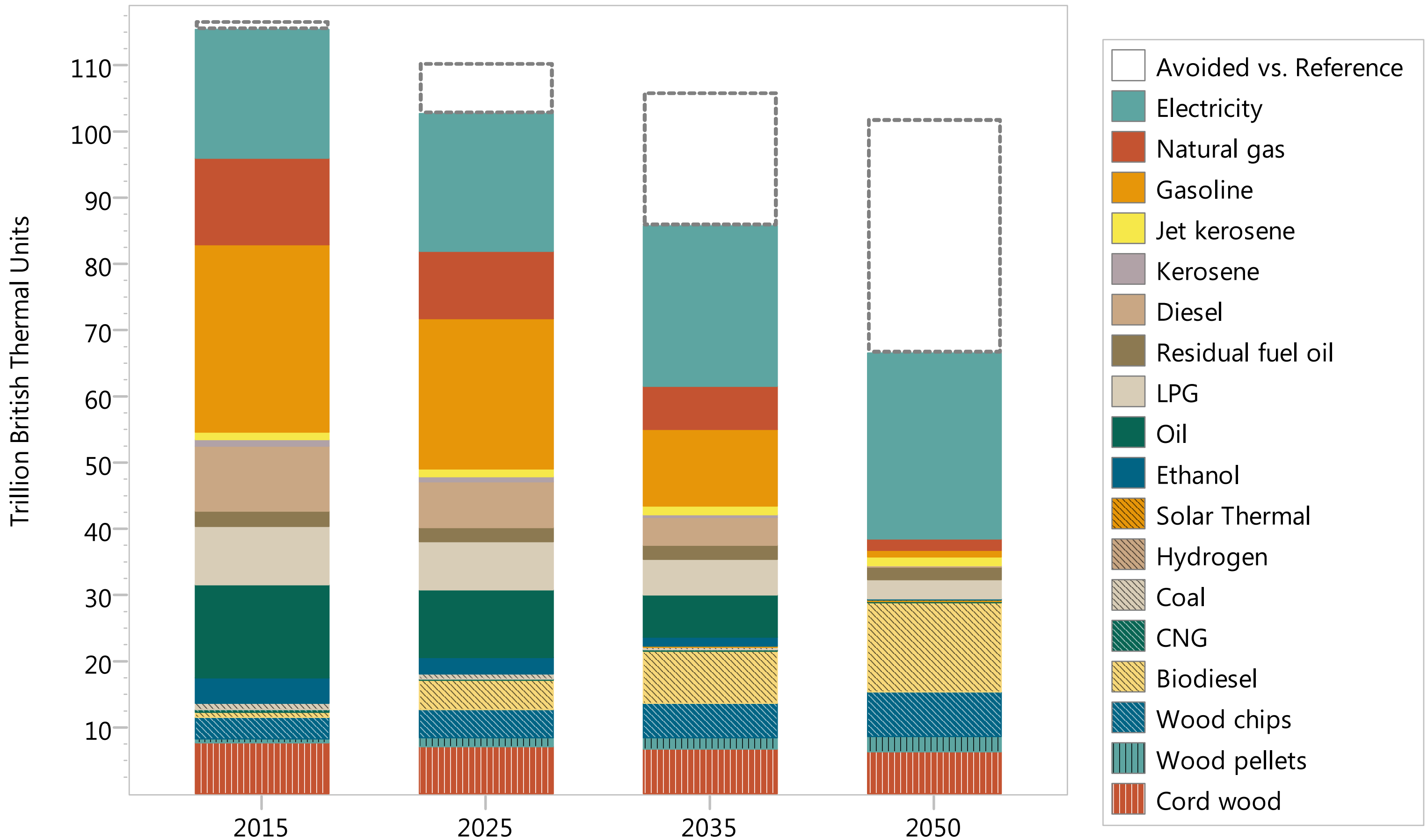
Efficiency, electrification, and renewables

Total energy by fuel shows growing electricity and wood displacing fossil fuels



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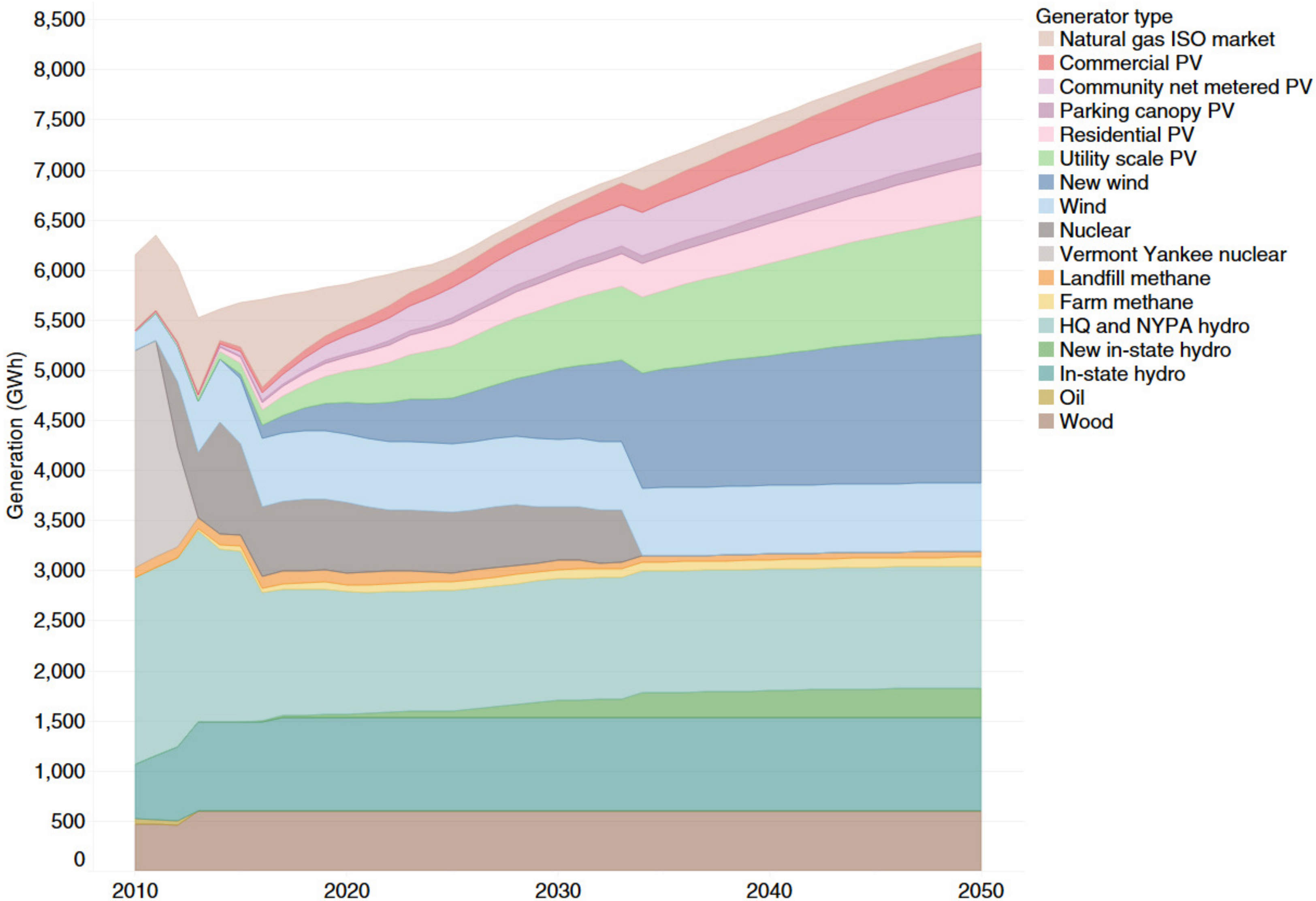
Electricity generation by year



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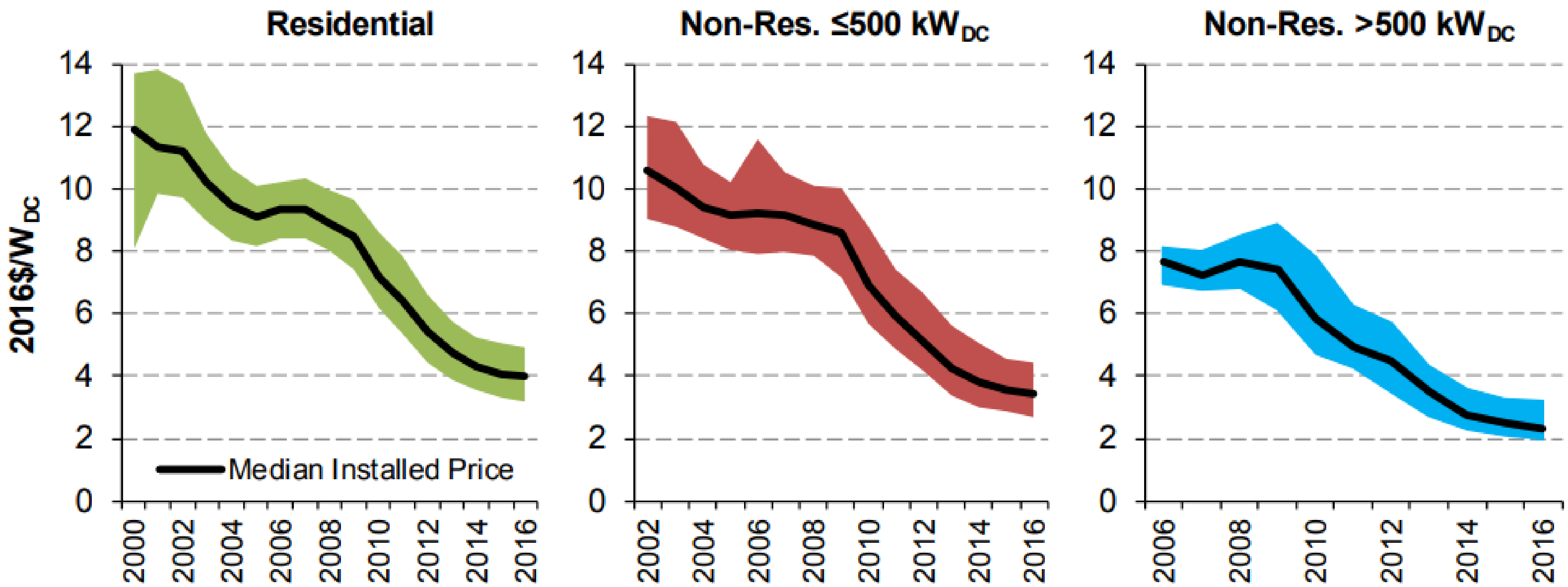
Falling price of solar



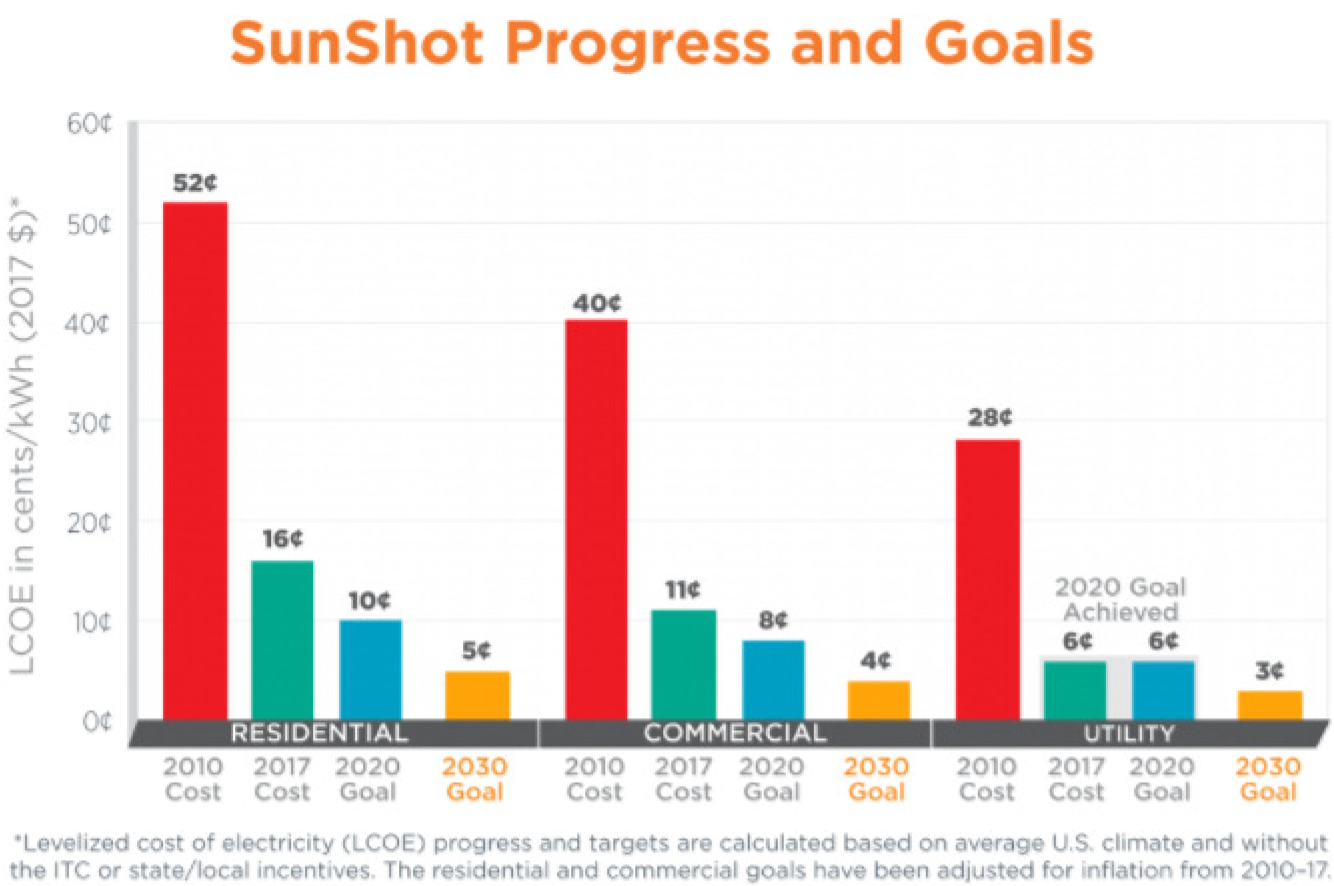
Notes: Solid lines represent median prices, while shaded areas show 20th-to-80th percentile range. See Table 1 for annual sample sizes. Summary statistics shown only if at least 20 observations are available for a given year and customer segment.

Figure 5. Installed Price Trends over Time

In the first half of 2017, prices have fallen another 6% for residential, 12% for small non-residential, and 5% for large non-residential.

Barbose, Galen and Naïm Darghouth. 2017. Tracking the Sun 10: The Installed Price of Residential and Non-Residential Photovoltaic Systems in the United States. https://emp.lbl.gov/publications/tracking-sun-10-installed-price

Falling price of solar



Utility scale solar met the 2020 goal in 2017. New 2030 goals were added in response to lower wholesale electricity costs.

Economic Results

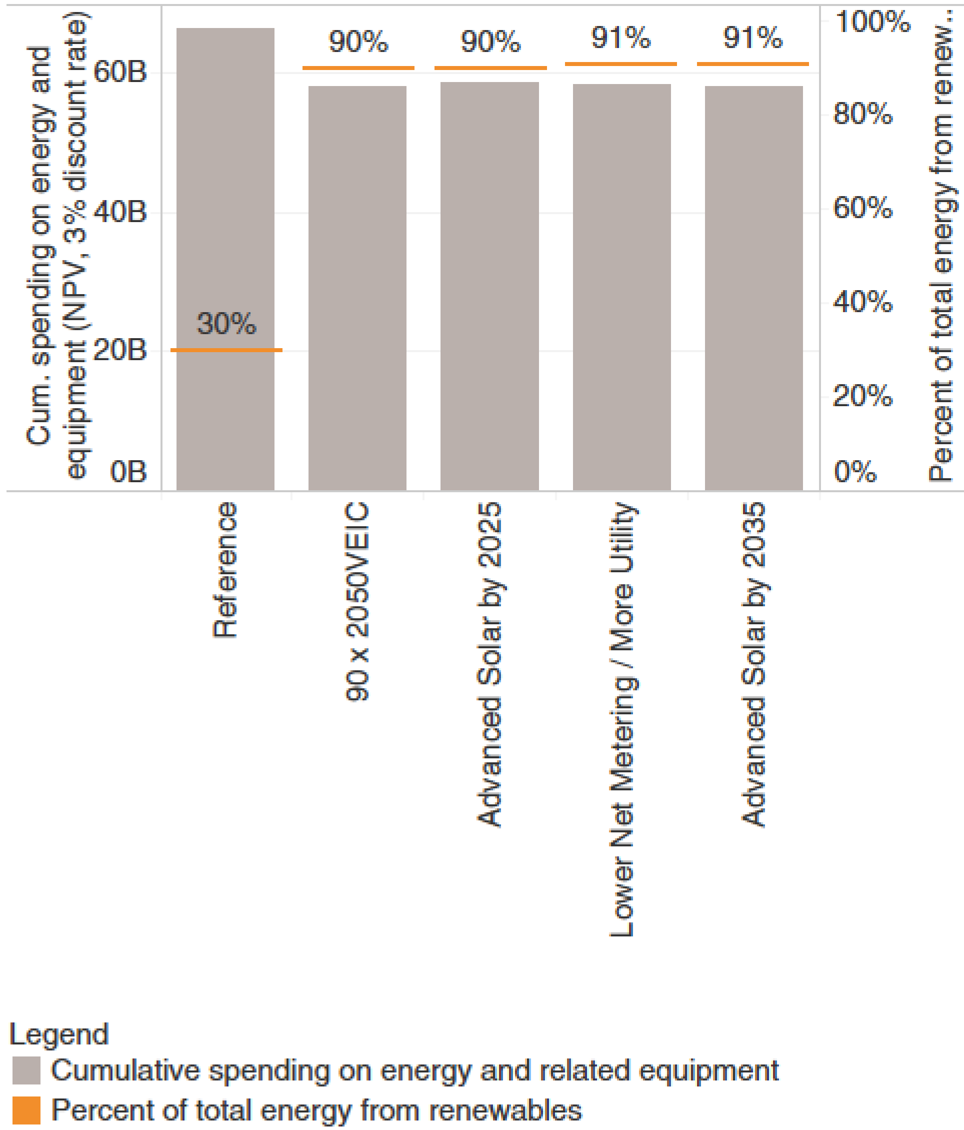
- Significant investments:
  - efficiency across all sectors
  - solar, wind, distribution upgrades
- Net investments of less than 1% of annual expenditures
- Benefits from reductions of fossil and electric imports
- By early 2030's net positive benefits – by 2050 about $8 billion net economic benefit to state's economy.

Cumulative costs and benefits of solar scenario relative to the Reference scenario, 2015-2025, discounted at 3 percent to 2015

	Costs $ million (2015)
Demand	**850**
Residential	415
Commercial	260
Industrial	60
Transportation	115
Transformation	**855**
Transmission and distribution	10
Electricity generation	845
Imports	**-1,160**
Environmental externalities	0
Non-energy costs	0
Net present value	**620**

Economic results in context

- Net positive benefits: $8 billion by 2050
- All scenarios with high efficiency and renewables outperform reference
- Vermont's annual energy expenditures ($2-3 billion) dwarf the sustainability investments



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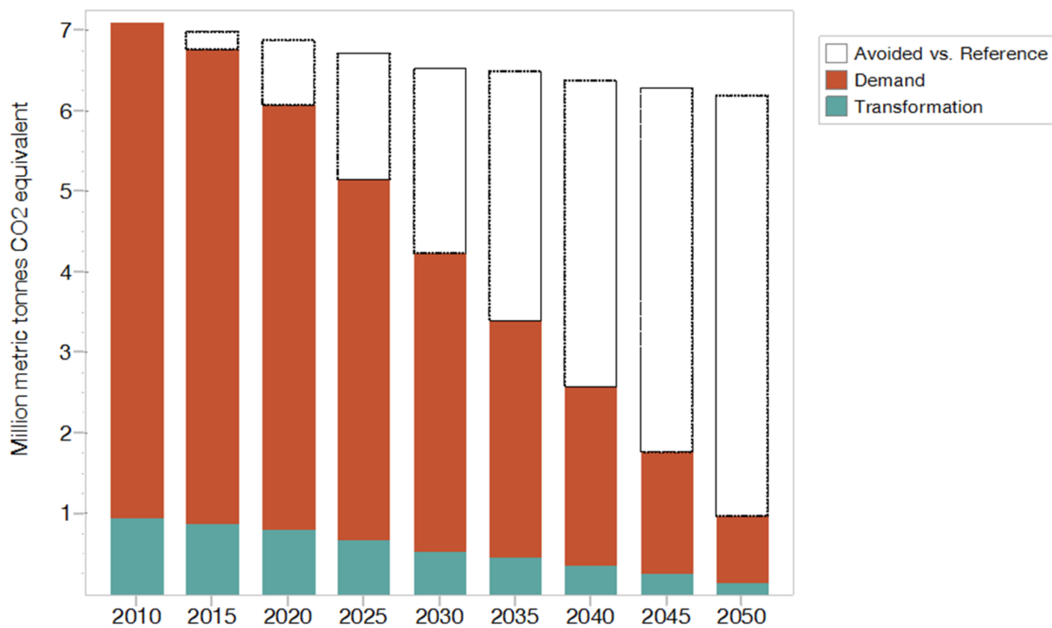
Environmental Results

- Meeting 90x50 goals
- Consistent with needs for a 2 degree C targets and the Paris Climate Accord
- With significant economic benefits
- Vermont leadership in new energy economy

Vermont GHG Emissions SDP versus Reference scenario, 2015-2050



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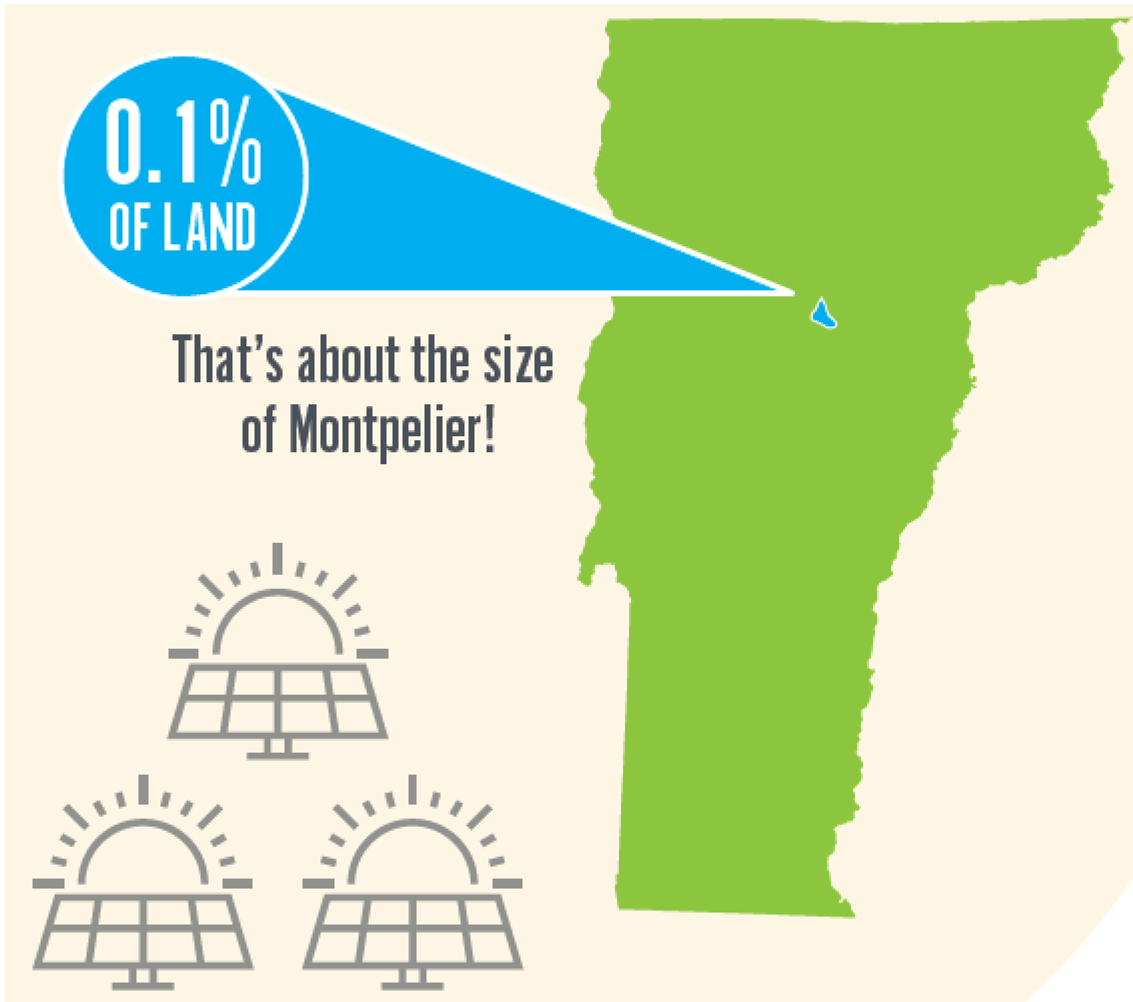
Space requirements



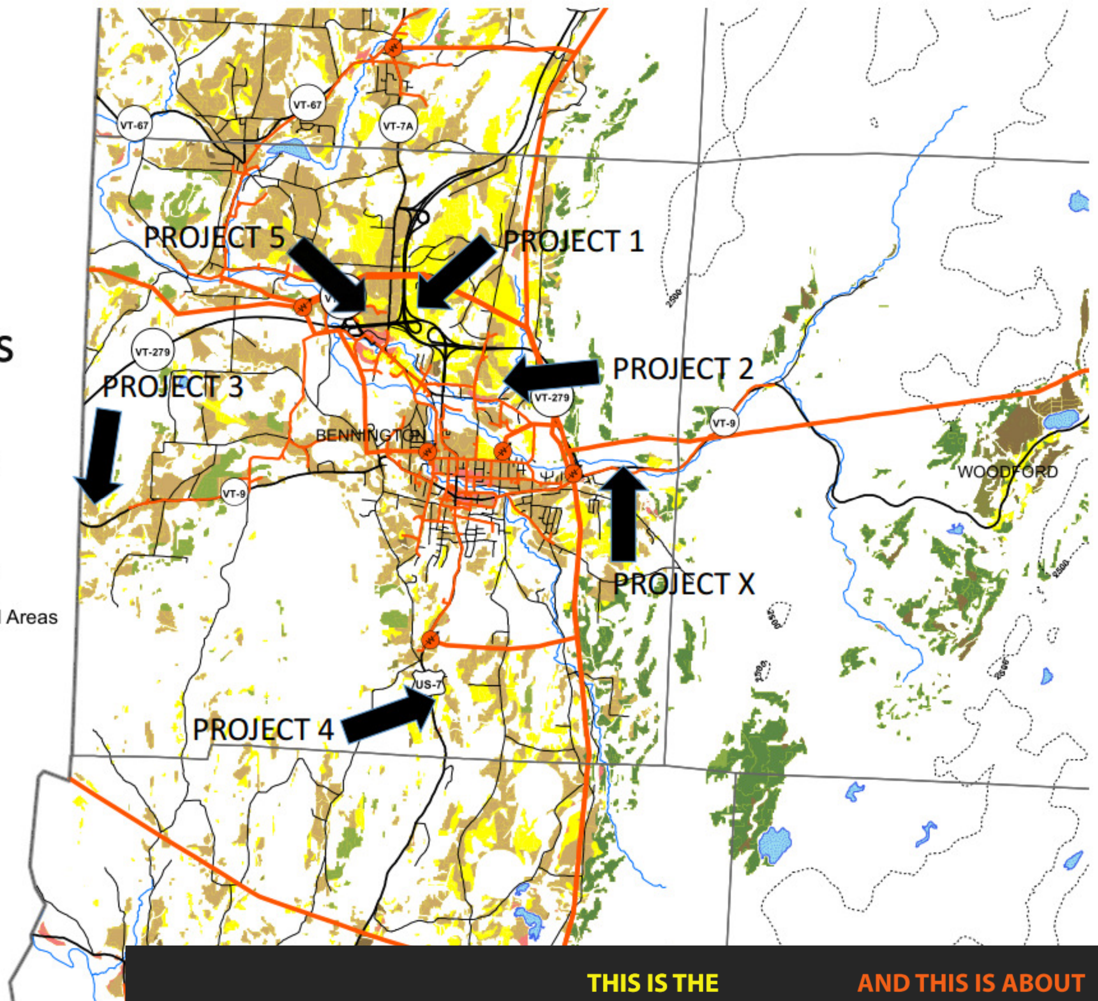
SOLAR MAP

- Prime Solar = Yellow
- Includes Level 2 Constraints

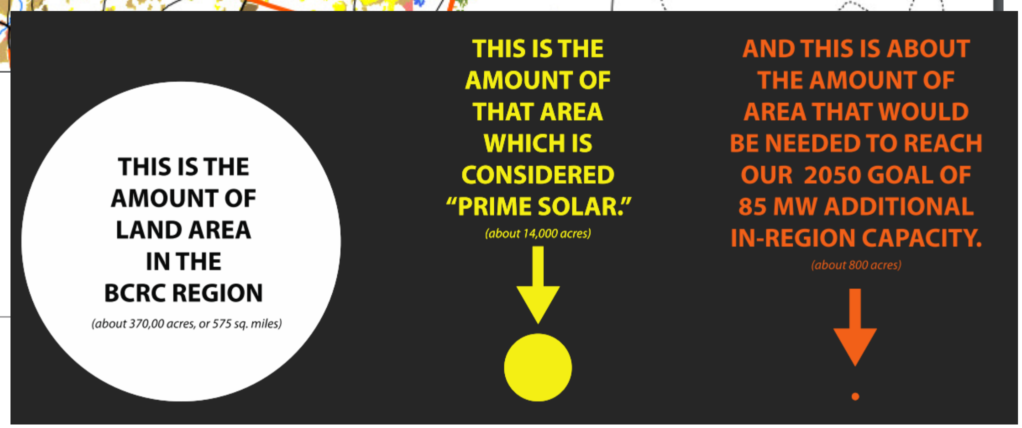
Substations	
3 Phase Power Lines	
Transmission Lines	
Major Roads	
Secondary Roads	
Rivers/Streams	
Lakes/Ponds	
2,500 Ft Elevation	
Prime Solar Potential - No Level 1 or Level 2 Constraints	

Level 2 Constraints

- Class 3 Wetlands
- Deer Wintering Areas
- Special Flood Hazard Areas
- Conserved Lands
- Hydric Soils
- Habitat Blocks *
- Agricultural Soils **



Images provided by Bennington Regional Planning Commission, 2016



Space requirements

Solar integrates well with other land uses and does not need to be the exclusive use of land

Of course solar works on pitched and flat roofs. This is on VEIC's office and provides solar credits to staff in BED territory. BED's wind turbine is in the background.

Solar works well in parking lots, and offers the cars shade. This is behind the Burlington Unitarian Universalist church at the top of Church St.

Animals can graze below solar, or the land can be planted with wildflowers for pollinators and beauty.

Solar array vegetation managed by Prairie Restorations Inc.

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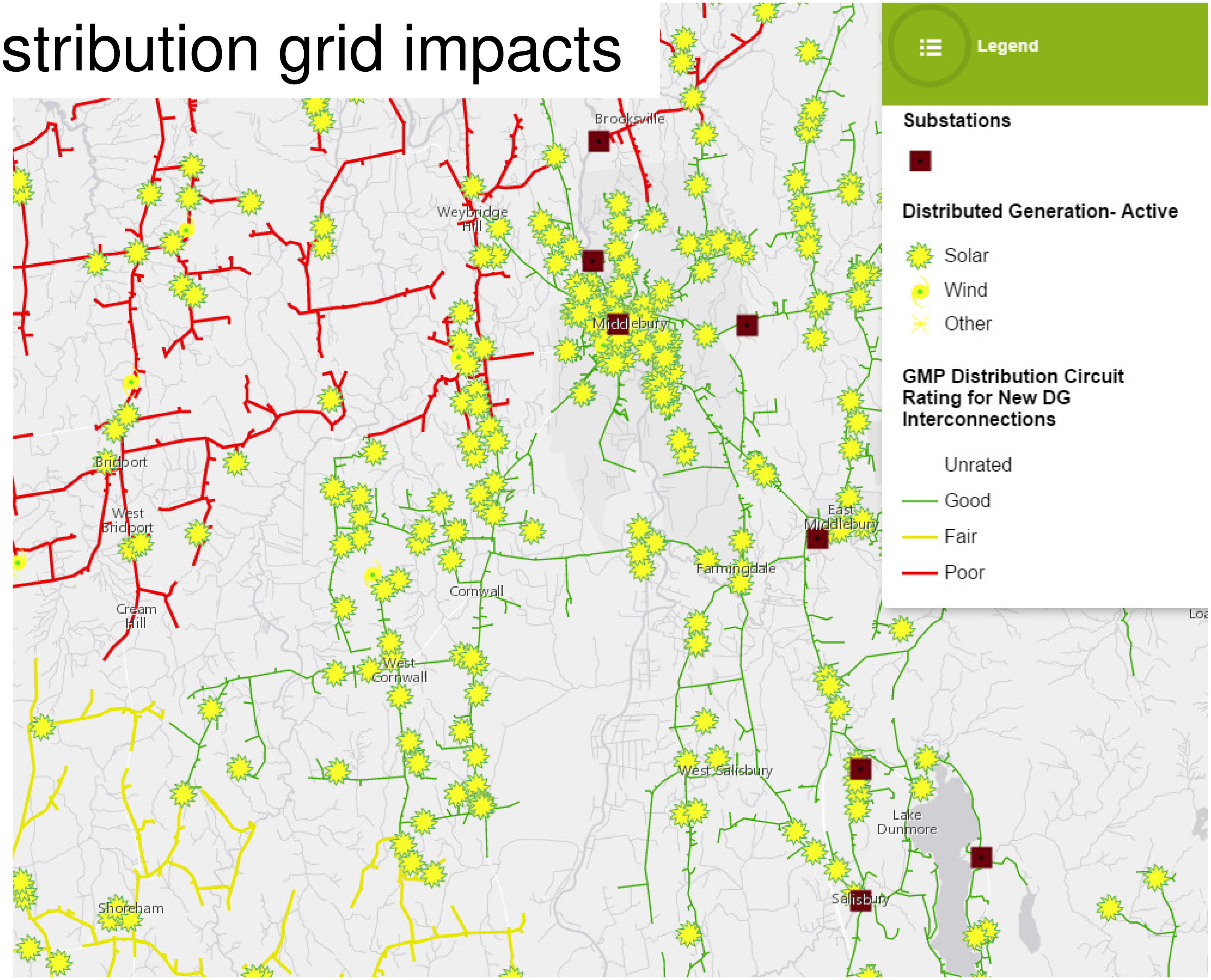
Strategies to locate PV where it supports the grid

- Avoid clusters that naturally form
- Site nearer to substations
- Site on higher voltage lines

Carrots, sticks, and information for better locations/lower grid impact

- Advanced Inverters reduce grid impact
- Solar map
- VEC is installing community solar located outside SHEI constrained area to members inside that area
- Locational Marginal Pricing
- Lessons from “Facilitating the Effective Expansion of Distributed Energy Resources” (FEEDER project)

Distribution grid impacts



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GMP Solar Map, updated weekly
http://www.greenmountainpower.com/innovative/solar/solar-map/

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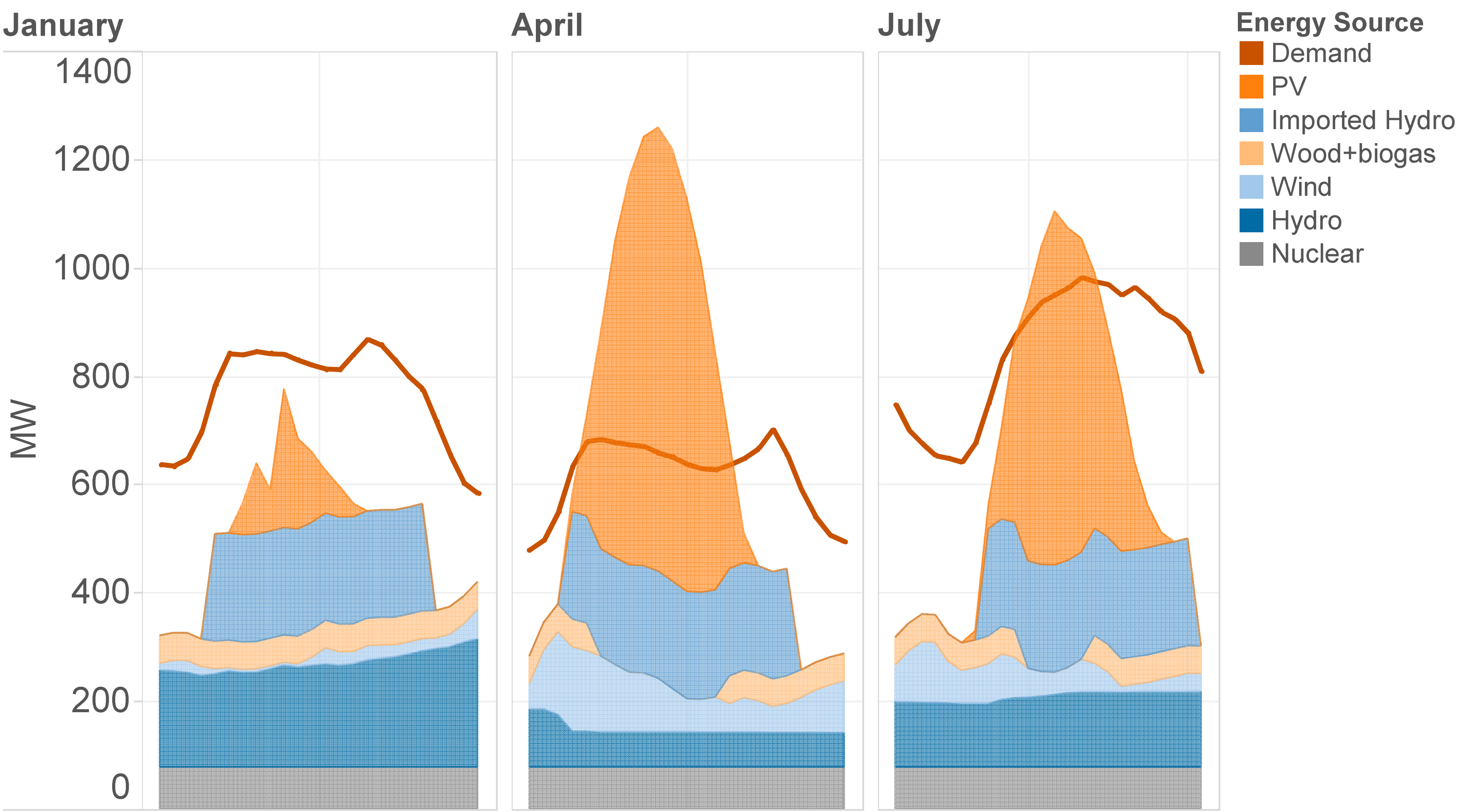
Statewide power system effects

Challenging days in three seasons



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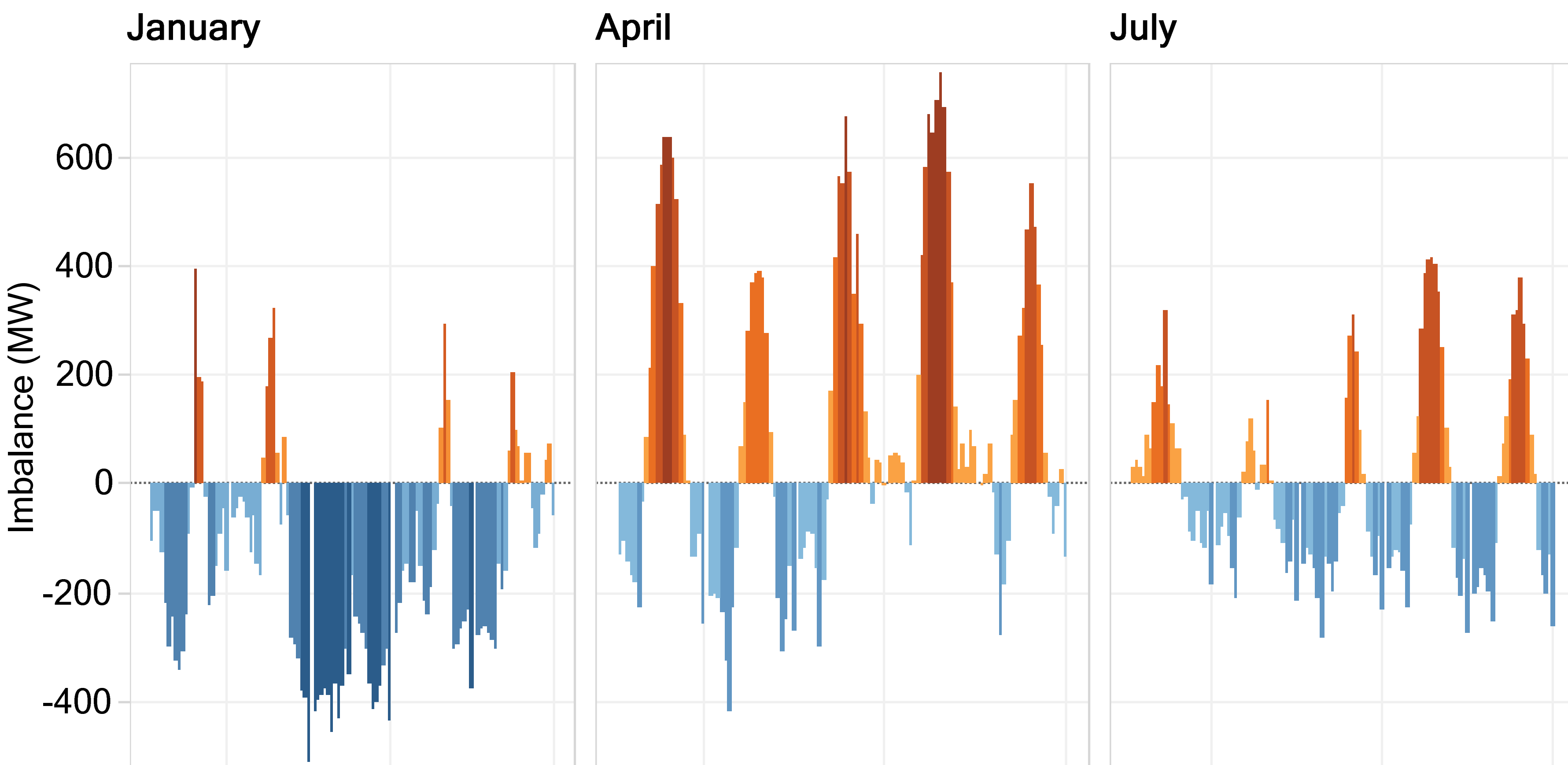
Statewide power system effects

The two days on either side of the last slide's challenges days show difficult conditions often persist for several days



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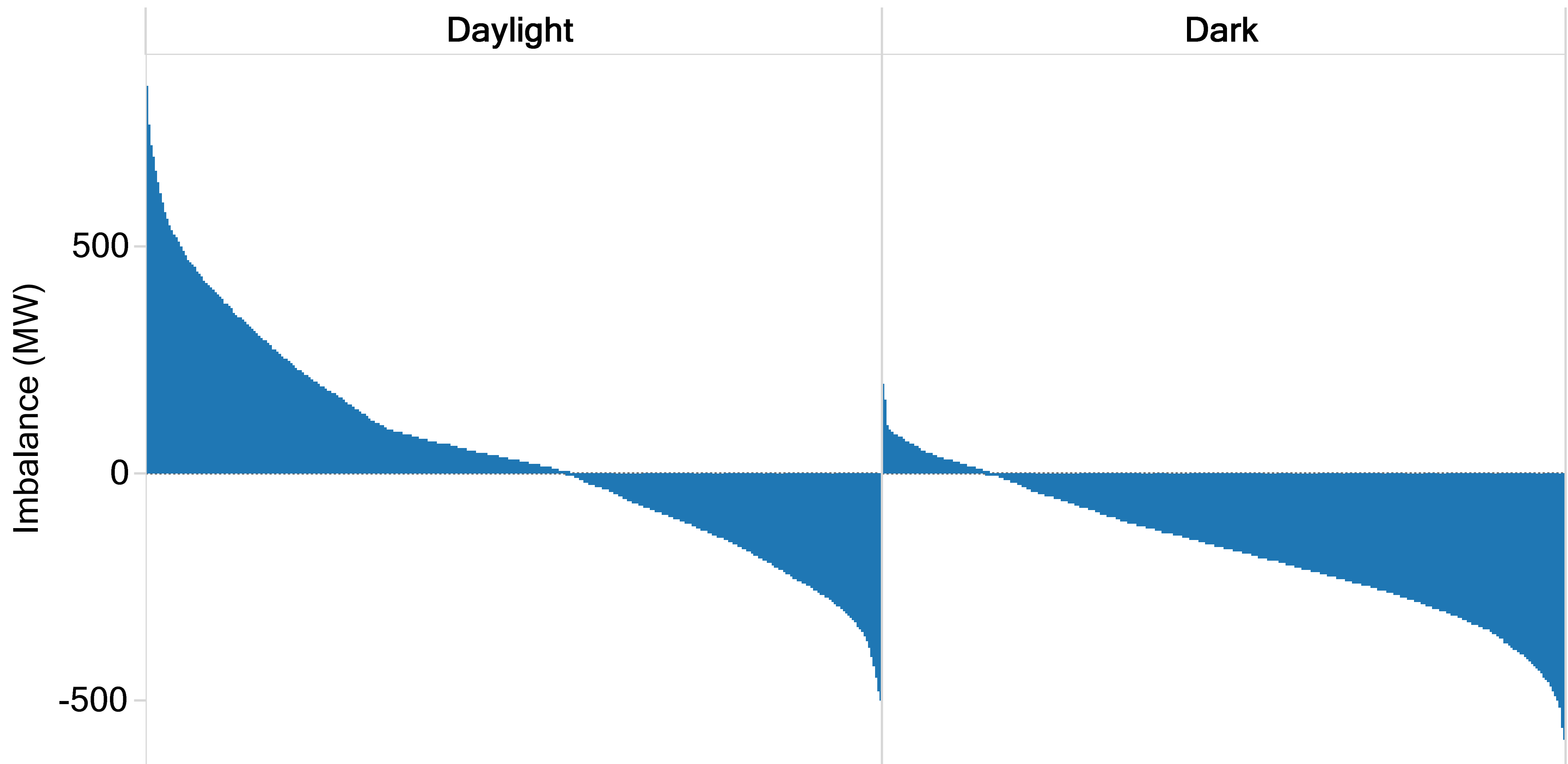
Statewide power system effects

Imbalance is partly predictable, forecastable



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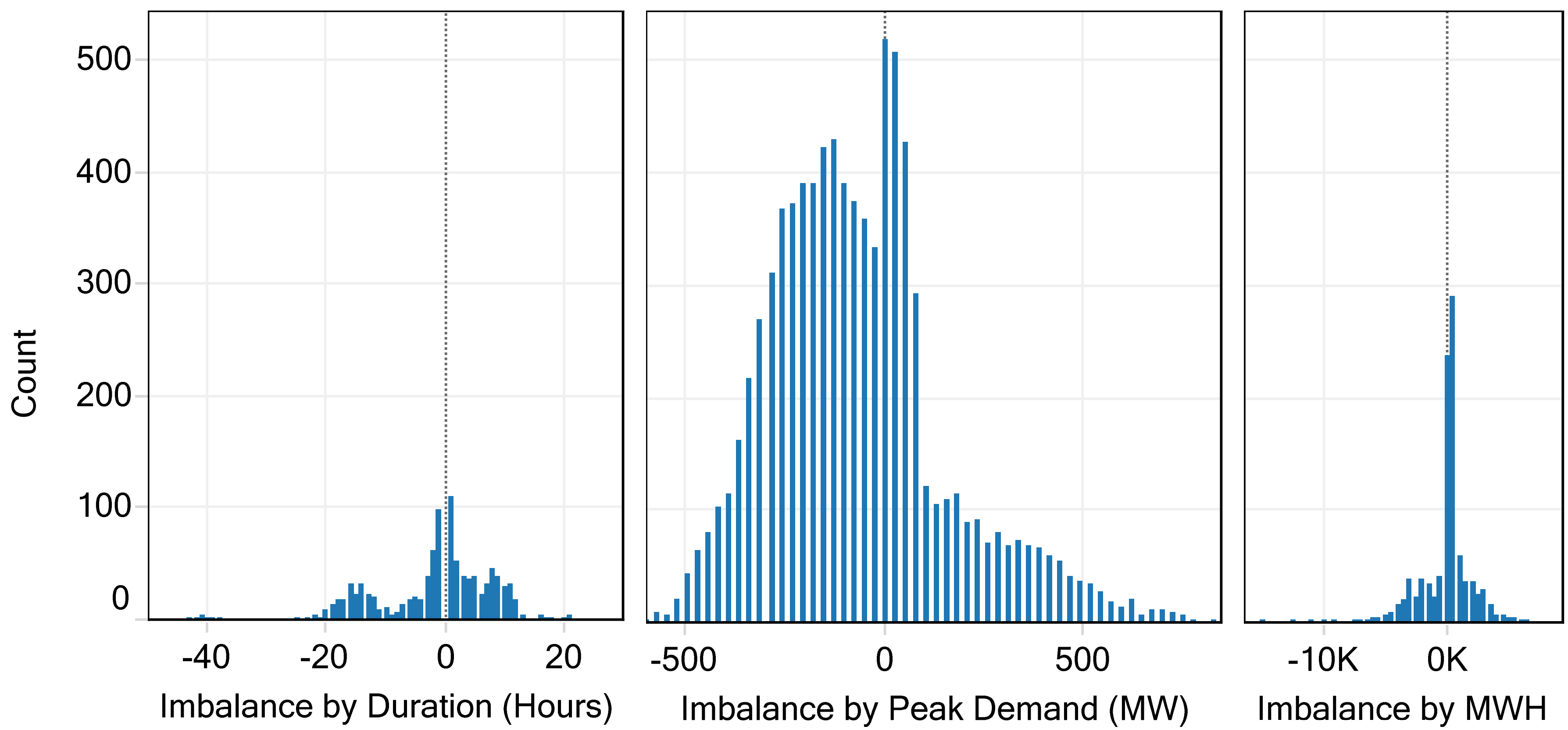
Statewide power system effects

Imbalances are usually less than a day, less than 10% of peak demand, and often a small amount of energy



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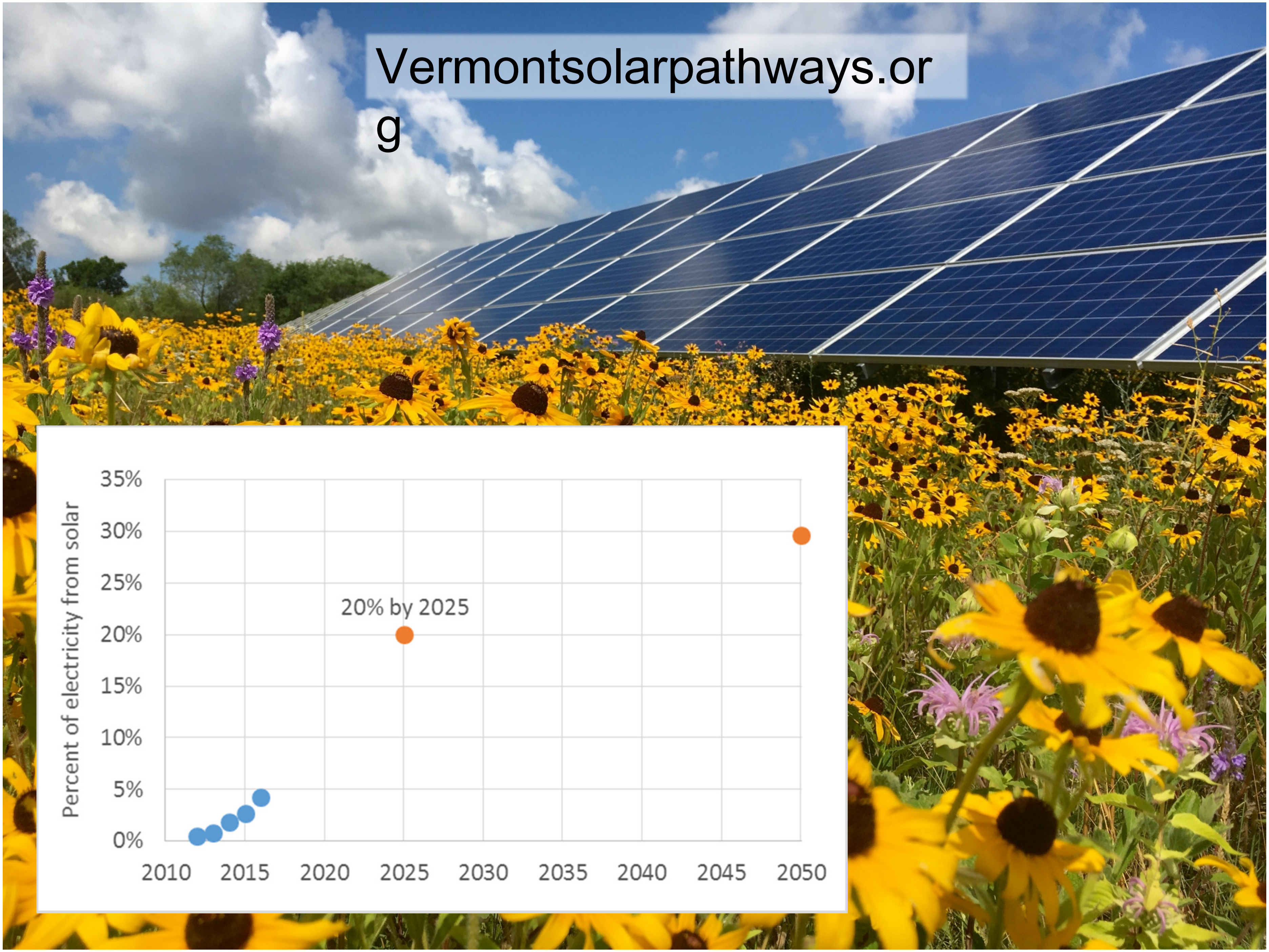
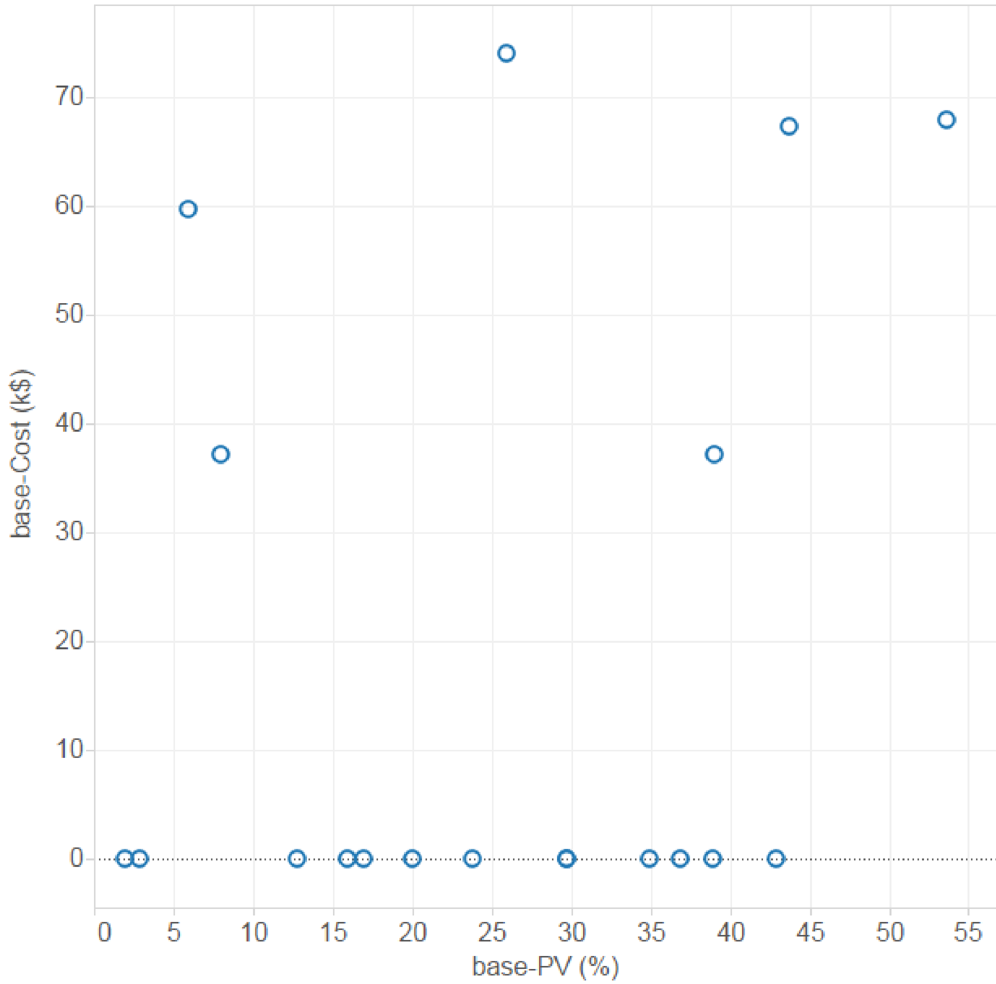
Can we get 20% of electricity from solar by 2025?

- Do we have enough room for that much solar?
  - Yes, 0.1% of our land could support it
  - Can be co-located with grazing animals or pollinator plantings
- Can the grid handle it?
  - Yes, careful siting can reduce the required upgrade costs
  - We will need controllable load and potentially storage
- Is it too costly?
  - No, relying on imported fossil fuels is much more costly
  - Business models and innovation can use solar to enhance affordability and equity


Vermontsolarpathways.org
Percent of electricity from solar
35%
30%
25%
20%
15%
10%
5%
0%
20% by 2025
2010
2015
2020
2025
2030
2035
2040
2045
2050

Results from PEPCO distribution study

“average” hosting capacity isn’t very helpful
Some feeders can accommodate a lot of PV at no or low cost, some cannot accommodate any more



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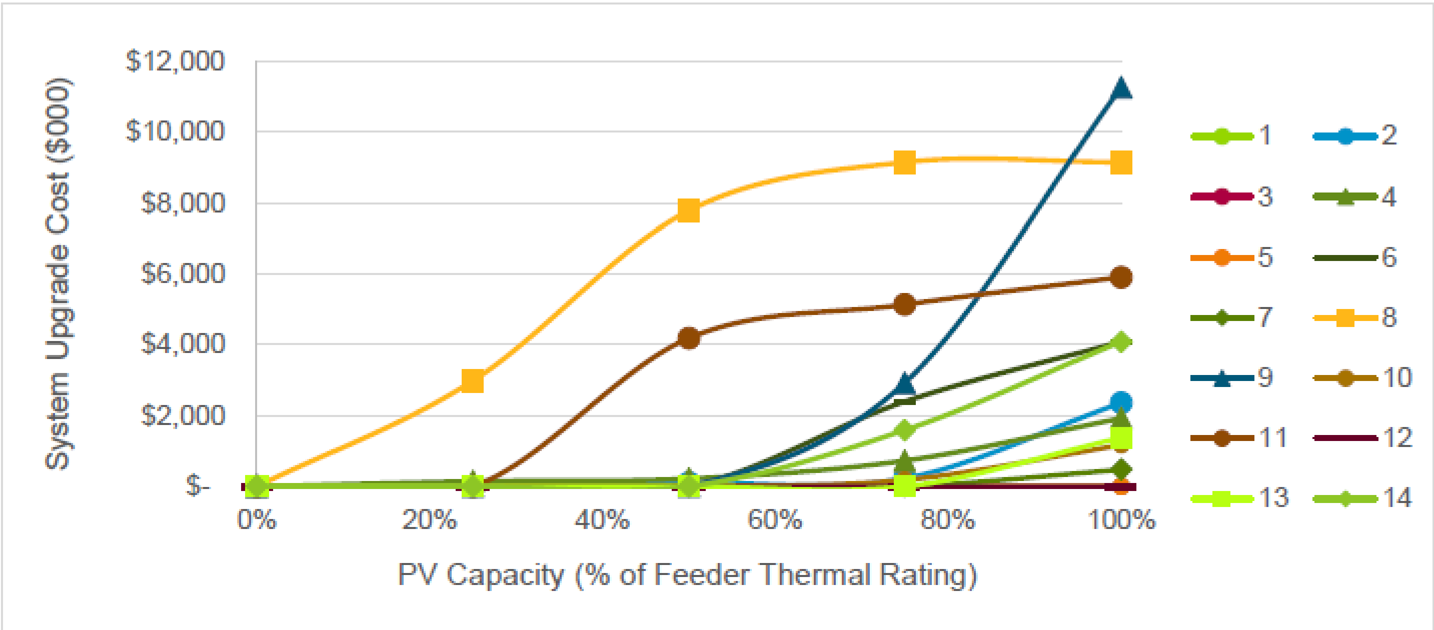
Similar distribution analysis for Dominion

Twelve of 14 feeders could accommodate PV capacity equal to 50% of their thermal rating before an upgrade was required

NAVIGANT | Virginia Solar Pathways Project

Figure 3-12. Steady-State System Capacity Upgrade Cost Curves for Representative Feeders



Source: Navigant