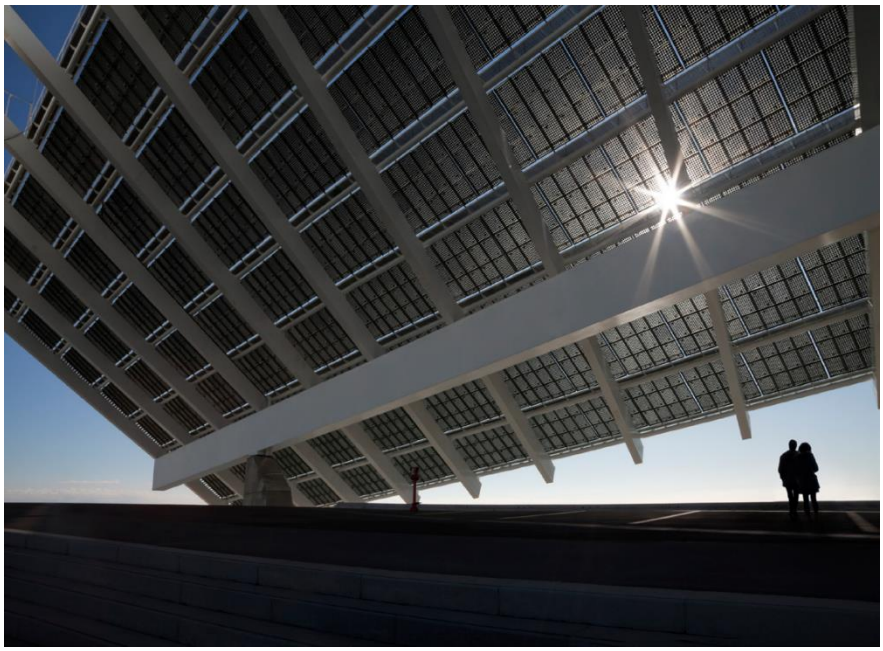
Vermont Solar Market Pathways



Three-Year Update & Status Report

February 2020

VEIC

Vermont Solar Market Pathways

Becoming an Advanced Solar Economy by 2025

Three-Year Update and Status Report

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This report updates the ***Vermont Solar Market Pathways*** report issued in December 2016.

The original study was made possible by an award from the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy (Award No. DE-EE-0006911), to VEIC

Support for this Update

The Vermont Department of Public Service, the Vermont Public Utility Commission, ISO-New England, and Renewable Energy Vermont provided data and assistance for this Three-Year Update and Status Report. Norwich Technologies funded the Update.

VEIC looks forward to continuing to work with these and other stakeholders to add to the information on Vermont's progress toward becoming an advanced solar economy by 2025. Any errors or omissions in the report are the responsibility of the primary authors.

Preface

Solar is growing as a significant and strategic contributor to the energy system. In 2014, with support from the U.S. Department of Energy SunShot Initiative, VEIC began a three-year stakeholder engagement process and scenario modeling study to investigate opportunities and challenges for Vermont becoming an advanced solar economy.

We defined *advanced* to mean at least 20 percent of the state's electricity comes from in-state solar by 2025. We conducted and refined scenario modeling, with contributions from public and private stakeholders, resulting in ***Vermont Solar Pathways,***[1] a compendium of (1) a summary report, (2) briefs relating to focus topics, (3) a brief on barriers to substantial amounts of solar installations and integration, and (4) methods and detailed tables of inputs and assumptions.

The four volumes of the study discussed the business, technical, and regulatory implications of this level of solar market development. It also examined the contributions solar can make to the state's broader energy and emissions targets and policies and concluded that Vermont is capable of meeting 20 percent of its electricity needs with solar, by 2025. Further, the report concluded that meeting that goal saves money, compared to a scenario of "business as usual."

This ***Three-Year Update and Status Report*** assesses Vermont's progress toward the advanced solar target and projections for complementary technologies. The results are mixed.

For example, if the *percentage growth rate* from the last five years continues, Vermont can meet the solar development pathways target. But Vermont has not yet installed solar capacity at the *annual installation rate* necessary from 2020 to 2025 to meet the target.

That is, growth has been uneven over the past five years in response to various market and incentive conditions, and the last three years have not matched the amount of capacity installed in 2016. Current challenges to continuing the pace of solar installation necessary to meet the targets are the possible phase-out of federal tax credits, recently added tariffs on imported equipment, and the addition of fees for new projects in certain areas.

As the state progresses toward achieving 1 GW of cumulative capacity, there will be increasing technical issues related to siting and integration of new installations. There will also be increased pressure to make sure the benefits and costs of solar development are equitably shared.

The 2025 solar target is just a portion of what Vermont needs to meet its "90 percent renewable energy by 2050" target.[2] Efficiency, strategic electrification, and non-solar renewables all need to grow, at growth rates matching solar's, to put Vermont on track to meet these objectives.

The original report and this update are meant to provide timely information and analysis to assist decision makers and other stakeholders in supporting the achievement of the State's targets.

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[1] The Solar Market Pathways Report is available at www.vermontsolarpathways.org.
[2] The "90 percent renewable by 2050" target first appeared in the 2011 Vermont *Comprehensive Energy Plan.* See https://publicservice.vermont.gov/publications-resources/publications/energy_plan/2015_plan.

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Executive Summary

The Vermont Solar Market Pathways Report, issued in December 2016, was a comprehensive overview of how in-state solar could provide 20 percent of Vermont's electricity by 2025.

When the study began in 2014, there were many doubts about whether the target was attainable. During the study period, the rate of installations increased dramatically, and the target began to look more likely. Three years after the study was published, this update finds that, although growth has been uneven, the *year-over-year percentage growth rate* that solar experienced between 2014 and 2019 is sufficient to meet the Solar Development Pathway (SDP) target.

At the end of 2014, the installed solar capacity in Vermont was 82 MW_{AC}. Four-and-a-half years later, by the end of Q2 2019, it had quadrupled to 335 MW_{AC}. Over that same time period, the national cumulative installed capacity more than tripled from 18.3 GW_{DC} to 69.1 GW_{DC}. Sustaining that *pace of growth* between now and 2025 in Vermont will result in greater than 1 GW of installed capacity, meeting the Solar Development Pathways target of meeting 20 percent of total electricity needs from in-state solar. **Figure 1** shows the progress in the growth of solar capacity across the past decade.

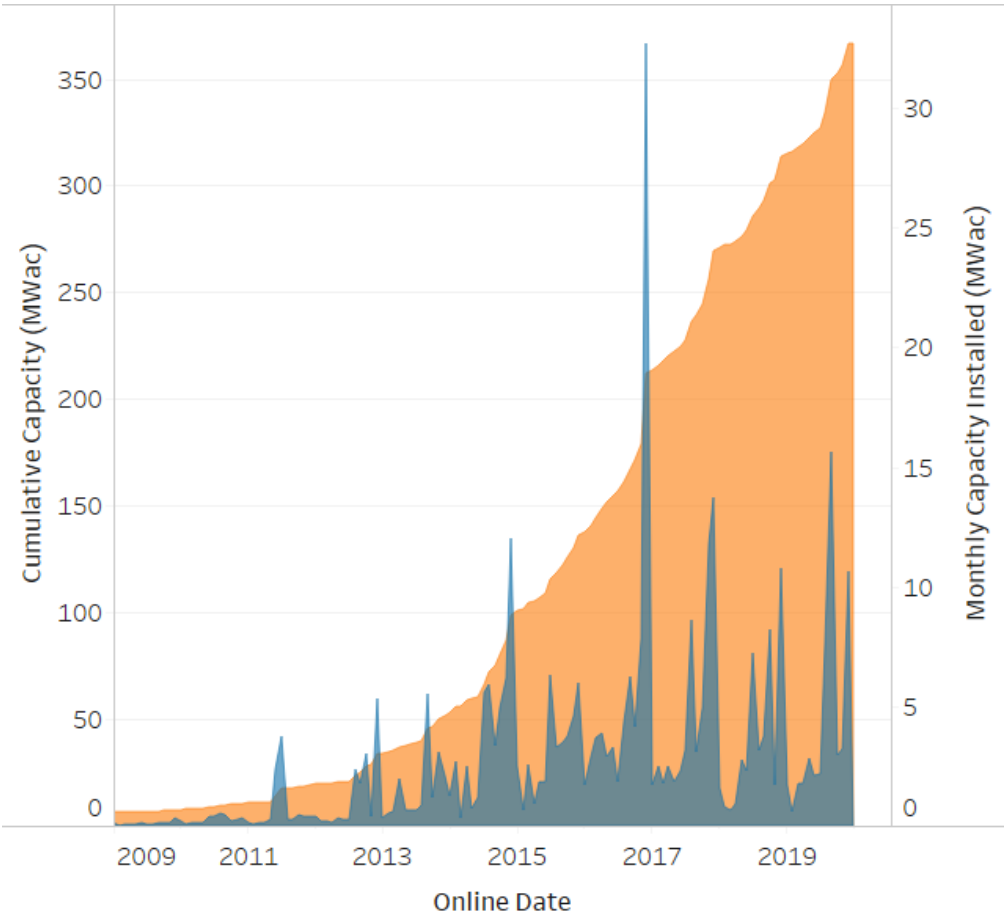

Figure 1. Monthly and cumulative "online" solar capacity in the past 10 years in Vermont. The graphic is derived from data on Certificates of Public Good issued by the Vermont Public Utility Commission, as of the end of 2019. The three tallest monthly spikes occurred, respectively, in December 2016, September 2019, and December 2017.

As the caption for **Figure 1** indicates, the capacity "online date" values are from the essential data provided by regulators from issued Certificates of Public Good (CPG). The data are an improvement on what was used in the original study, when we reported values from the CPG data based on permit application date. The Public Utilities Commission and the Public Service Department have improved their data tracking, and the solar capacity in this data is now within 1% of the cumulative total for Vermont in the ISO-New England 2019 PV Survey.[3] In the past the CPG data was higher.

The original study and this update do not consider Renewable Energy Certificate (REC) trading. With the creation of the Renewable Energy Standard in 2015 and a change in net metering compensation in 2016, most new solar systems do count toward Vermont's energy and emissions goals. Renewable energy projects that sell their RECs out of state do not count toward those goals. We have not reconciled the statewide data shown in this report against the utility reports of REC settlements, but that type of accounting is needed to track against goals and understand where the economic benefits of projects is accruing.

Solar installation rates were highest in 2016 and 2017. Capacity installed in 2018 and projected for 2019 is lower, as shown in **Figure 2**, which also uses CPG database information.

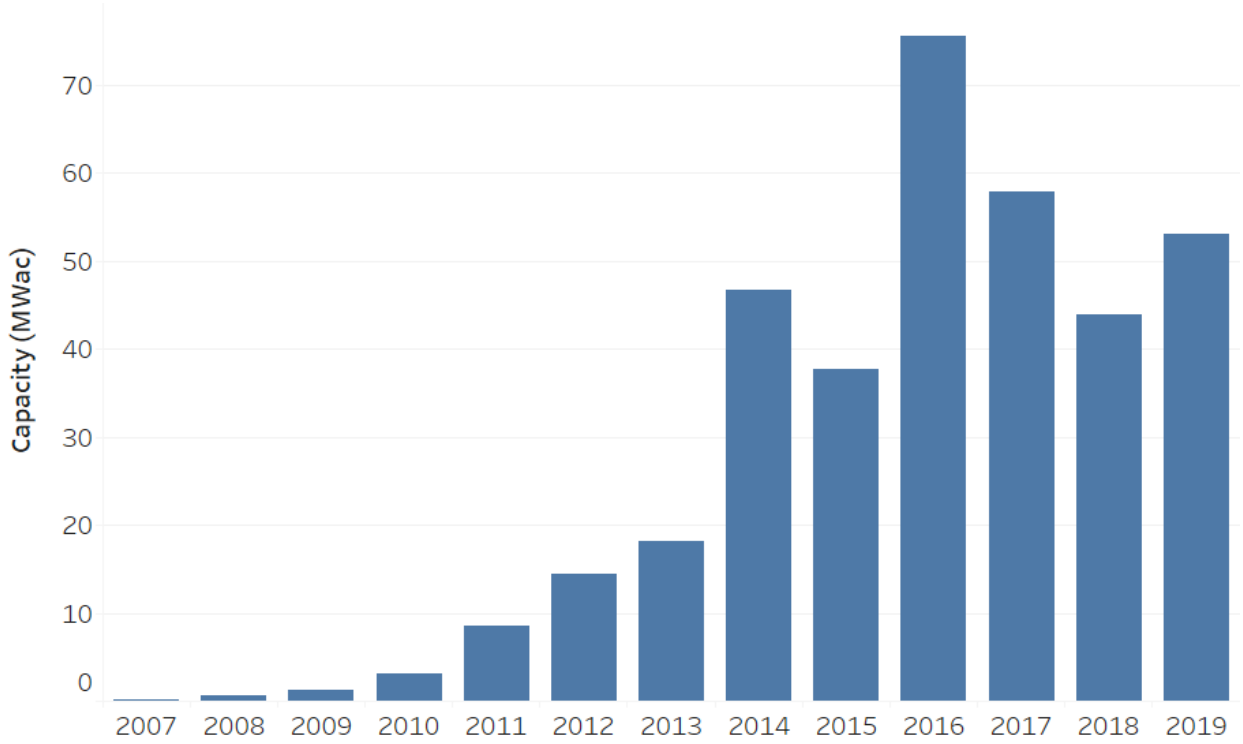

Figure 2. Vermont solar incremental new capacity "online," by year, from the database of Certificates of Public Good, as of the end of 2019.

[3] "December 2019 Distributed Generation Survey Results," (Independent System Operator – New England, 2019), https://www.iso-ne.com/static-assets/documents/2020/02/pv_survey_results_021420.pdf

The high amount of capacity installed in 2016 was driven by the anticipated end of the federal Investment Tax Credit (ITC), and by a change to Vermont's net metering compensation. The ITC was extended, and solar compensation in Vermont continues to be adjusted.

Reaching 1 GW by 2025 will require annual installations to average just over 100 MW. Note that this is higher than the level achieved, to date, in each year. For example, 2016's achievement of 75 MW of capacity is not high enough. If new installations between now and 2025 were to remain steady at the level of the past two years, total installed capacity by 2025 would fall roughly 50 percent below 1 GW. In this context, the goal appears to be daunting, if not unattainable.

However, reaching 1 GW is possible if the cumulative capacity grows 19 percent each year. In the past seven years, it has grown slower than that only twice, has averaged 49 percent, and topped out at 128 percent from 2013 to 2014. With stable and predictable policy, Vermont's stakeholders—in particular, solar developers, the supply chain, and customers—have shown they can achieve the rate of growth needed to meet the target.

Two insights from these findings are:

- **The growth rates required to meet the Solar Pathways target are attainable, and Vermont and national markets have demonstrated such rapid growth**

- **Sustained growth at these levels is not easy, and changes to market and policy conditions in recent years have resulted in slowing. If that trend is not reversed, Vermont will miss the Solar Development Pathway target and its benefits.**

Section 2 contains details and analysis on solar market growth and the pace required to meet the Solar Development Pathway target. The following text box presents the original findings from the Solar Market Pathways study. They provide context and emphasize that the research for this Update does not lead us to modify any of those findings.

The most important conclusion of the original study is validated by the three-year update:

- **Solar can provide 20 percent of Vermont's electricity by 2025 and can do so with costs that are less than 1 percent of total annual energy expenditures.** Over the longer term, through 2050, the study analyses suggest net economic benefits from investing in Vermont's advanced solar economy are in the billions of dollars.

The Study Team and stakeholders have considered the most commonly cited limitations of solar—cost, space requirements, and intermittency of energy generation. They concluded it is possible and profitable to overcome those limitations and move toward a future in which more of Vermont's energy comes from its own renewable sources, owned by Vermonters. In addition to cleaner air and billions of dollars a year kept within the state, there are co-benefits from enhanced affordability, occupant health, and building durability, and resilience.

Vermont Solar Market Pathways: ORIGINAL Findings

SOLAR IS WIDELY AVAILABLE TO HELP MEET VERMONT'S ENERGY NEEDS.
Vermont has sufficient solar resources well-dispersed across the state to meet 20 percent of electricity needs with solar by 2025. Careful planning and siting are important for lower cost and impact. To host enough solar to meet the 2025 target requires about 0.1 percent of Vermont's land area.

MEETING THE VERMONT SOLAR MARKET PATHWAYS TARGET CREATES SIGNIFICANT ECONOMIC BENEFITS.
Through 2025, the total investments and energy expenditures for the Reference (business as usual) scenario and the Solar Development Pathways scenario (SDP; the solar needed to achieve the advanced solar economy target) vary by less than 1 percent. The SDP scenario has higher investments in energy efficiency, solar, and new electric end uses. It also has much lower imports of electricity and fossil fuels. By 2050, the SDP scenario is estimated to create $8 billion in net benefits to Vermont compared to outcomes of the Reference scenario.

THE ELECTRIC GRID CAN HANDLE THE INTEGRATION OF HIGHER AMOUNTS OF SOLAR GENERATION.
To meet the target, Vermont must integrate 1 GW of solar capacity into Vermont's electric grid (which currently peaks at 1 GW). This will require more planning, investment, and upgrades to hardware and operations systems. Technologies and strategies available today can safely and reliably meet these challenges. Many initiatives, collaborations, and new business approaches in Vermont and elsewhere will help the state meet these challenges.

SOLAR CAN HELP LOW- AND MODERATE-INCOME HOUSEHOLDS AFFORD ENERGY.
Great opportunity exists for projects that combine solar and efficiency in increasing energy affordability for low- and moderate-income households. Applying social and energy justice in every project is critical for VEIC. Vermont already has business models, financial strategies, and philanthropic initiatives to support this segment of market growth.

SOLAR INTERACTS WELL WITH OTHER ENERGY TECHNOLOGIES AND EMERGING MARKETS.
Solar and energy efficiency are the most common examples of distributed energy resources (DERs). DERs can also be energy storage, electric load shaping, and demand response. DERs are reshaping energy markets and delivery infrastructure in Vermont and elsewhere. Technical and market advances in Vermont are making electrification of vehicles and space conditioning more attractive. As they accelerate, they will help drive the growth of solar energy, and be driven by it.

THE VERMONT SOLAR PATHWAYS TARGET WILL HELP THE STATE MEET ENERGY, ENVIRONMENTAL, AND OTHER POLICY GOALS.
Vermont has policy targets for meeting 90 percent of the state's total energy needs with renewable resources by 2050 ("90% x 2050"). Vermont Solar Pathways indicates solar is an important contributor for meeting this target in economically and socially equitable ways. Moreover, installing solar energy in Vermont keeps energy expenditures in the state, and reduces dependence on imported fuels. These economic benefits are consistent with Vermont's policy objectives and public opinion. Meeting these targets offers opportunities for Vermont's utilities and businesses to continuously improve and to innovate—and positions them to influence energy markets outside the state.

1. Introduction

1.1 Vermont Solar Market Pathways

The Vermont Solar Market Pathways study, conducted from 2014 to 2017, examined the potential and implications for Vermont to obtain 20 percent of its electricity from in-state solar by 2025.[4] Across three years, with participation from dozens of stakeholders, the Study Team used scenario analysis and modeling to explore the policy, regulatory, planning, technical, business model, and consumer implications for reaching this level of solar market development. The study placed solar in the context of the total energy economy, recognizing that solar and other energy demand and supply options are best considered holistically, rather than in isolation.

The Study Team considered ways in which solar can contribute to Vermont's broader energy policy objectives of affordability, reliability, and providing 90 percent of total energy from renewables by 2050. The challenge of the climate imperative[5] continues to grow, and solar is an essential asset as we seek balanced and sustainable solutions.

> *Vermont's Solar Market Pathways shows that going solar will not only have enormous environmental benefits, but also will provide affordable energy for Vermonters, create new energy sector jobs, and ensure that more energy dollars stay in our state.*
>
> **Senator Bernie Sanders** Foreword to original report

1.2 Three-Year Update

Three years after the release of the original report, we have further experience and data to be able to comment on progress and continuing challenges to reaching solar and other energy targets. Several Regional Planning Commissions in Vermont have used the original study and its supporting models to inform regional and town energy plans, and to aid in siting considerations for solar, wind, and other renewable resources. Local and state rules, regulations, and processes affecting solar markets have continued to be updated and revised. Ideally, these activities together can lead to sustained and orderly market development.

[4] The Vermont Solar Market Pathways Report is available at www.vermontsolarpathways.org.
[5] The *climate imperative* has been expressed in several sources, and solidified when the United Nations' top executives in 2019 declared a "moral, ethical, and economic imperative" to take more action to mitigate the existential threat posed by climate change. Office of the United Nations Secretary-General, 2019. "Note to Correspondents: Joint Appeal from the UN System to the Secretary-General's Climate Action Summit." May 9. https://www.un.org/sg/en/content/sg/note-correspondents/2019-05-09/note-correspondents-joint-appeal-the-un-system-the-secretary-general%E2%80%99s-climate-action-summit. Summarized in a news release: https://news.un.org/en/story/2019/05/1038231.

Our primary objective for this update is the same as that for the initial study: to inform current and future discussion and decisions. The original report benefited greatly from stakeholder review and feedback during the scenario modeling and report writing. For the update we are using the latest available data but have not sought new stakeholder review or feedback.

Figure 3 shows progress toward the goal of the Vermont Solar Pathways project. The first two points were the only ones known when the original study began. Since then we have seen strong growth, with some year to year variation, and a trend that is currently too low to reach the goal. However, an s-shaped adoption curve could exceed the goal.

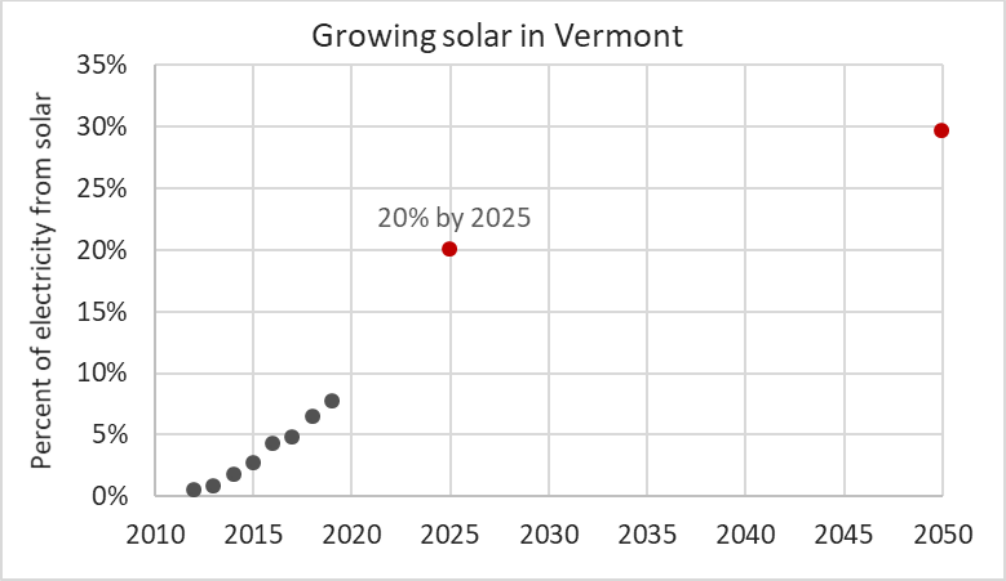

Figure 3. Estimated solar generation as a share of electricity consumption

1.3 Solar Is Part of the Total Energy Economy

The original study and this update consider solar growth in the full energy economy context. Our research considers all energy supply and demand resources, across all market sectors. The original study also placed progress toward the solar target within the context of Vermont's objective to obtain 90 percent of the state's total energy from renewable resources by 2050.[6] **Table 1** compares projections in the original study to recent results.

Table 1. Total energy and electricity consumption and solar generation

Total energy		Electricity		Solar		
Total energy demand (TBtu)		Electricity demand (GWh)	Electricity share of total energy demand	Solar generation (GWh)	Share of electricity from solar	Installed capacity (MW)
2015	114	5,700	17%	155	2.7%	125
2016	106	5,416	17%	248	4.6%	198
2019*	*106*	*5,416*	*17%*	445	8.2%	364
2025	106	6,200	20%	1,300	20%	1,000
2050	69	8,800	44%	2,500	28%	2,000

* 2019 values are estimates based on 2019 solar capacity and 2016 energy and electricity consumption data.

The projections in **Table 1,** in the light-yellow rows, are one pathway for solar, electricity, and efficiency that meet the "90 x 2050" objective and the 20 percent solar electricity by 2025 objective. Note that total energy demand decreases, and electricity demand increases, from efficiency and electrification of thermal and transportation end uses; solar grows to provide an increasing share of electricity.

Our research and analysis confirm the findings of the State's *Total Energy Study*[7] and Vermont's *Comprehensive Energy Plans*.[8,9] The research and analysis also affirm the following are requirements for meeting the 90 x 2050 target:

- ***Energy efficiency*** increases across all sectors and end uses
- ***Fuel switching*** from fossil fuels (particularly for space heating and transportation) to electricity and biomass
- ***Decarbonization*** of the electric grid through increased solar and other renewables

[6] The goal is articulated in "2016 Comprehensive Energy Plan - Executive Summary" (Montpelier, VT: Vermont Department of Public Service, 2016), http://legislature.vermont.gov/assets/Legislative-Reports/Executive-summary-for-web.pdf.
[7] "Total Energy Study: Final Report on a Total Energy Approach to Meeting the State's Greenhouse Gas and Renewable Energy Goals" (Montpelier, VT: Vermont Department of Public Service, December 8, 2014),http://publicservice.vermont.gov/publications-resources/publications/total_energy_study.
[8] "2011 Comprehensive Energy Plan" (Montpelier, VT: Vermont Department of Public Service, December 2011),http://publicservice.vermont.gov/publications-resources/publications/energy_plan/2011_plan.
[9] "2016 Comprehensive Energy Plan" (Montpelier, VT: Vermont Department of Public Service, December 2015),http://publicservice.vermont.gov/publications-resources/publications/energy_plan/2015_plan.

Reflecting these key elements, the SDP scenario estimates total energy demand decreasing by 5.3 percent from 2015 to 2020, as shown in **Figure 4**. These savings come from a combination of equipment stock turnover, efficiency standards, efficiency initiatives for buildings and transportation, and fuel switching. The Study Team added the 2016 actual total energy consumption, according to the *2019 Annual Energy Report* to the Vermont General Assembly, as a black line, to show progress to date. Projections tend to be smooth, whereas actual performance varies, according to weather and the economy. The lower 2016 result is promising, but the Study Team would need data for more years to show a true downward trend that is required to meet the targets.

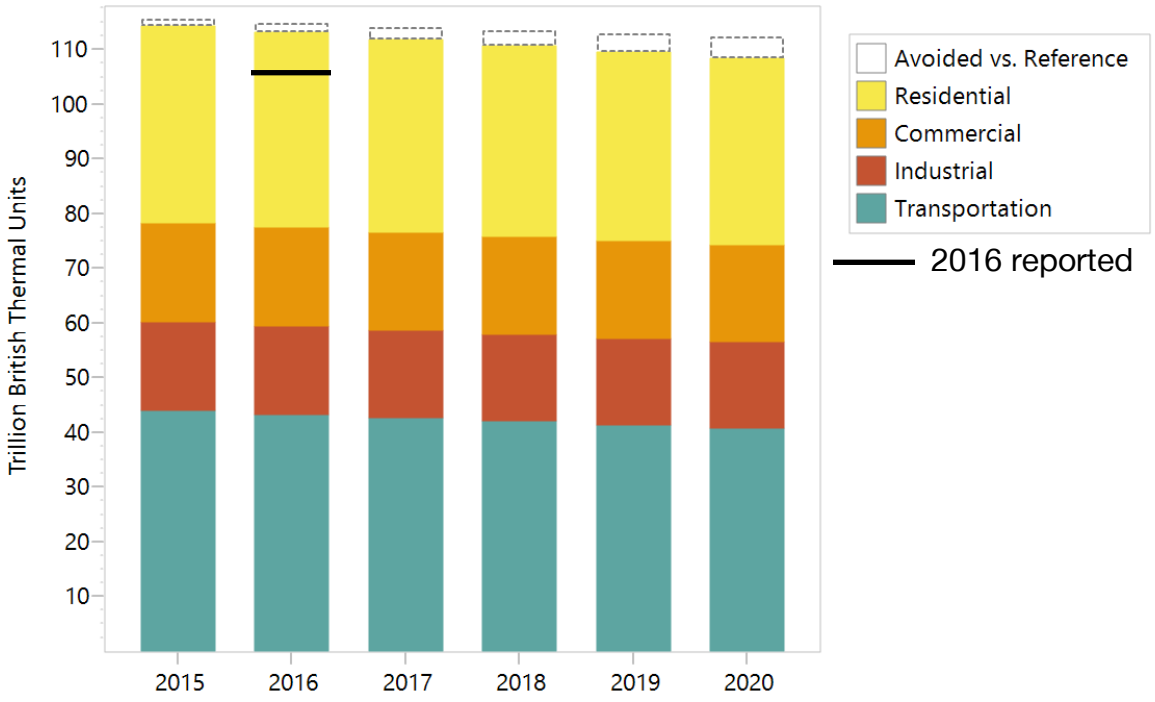

Figure 4. Vermont site energy demand in the SDP for 2015-2020, by market sector, with 2016 total reported.[10]

Figure 5 shows progress in the transition from fossil fuels toward electricity, for the 90 x 2050 goal. In the SDP scenario, in 2015, electricity accounts for 17 percent of the total energy requirements, by 2020 it is 18.5 percent. The latest data from the *2019 Annual Energy Report* indicate electricity accounted for approximately 17.5 percent of final demand in 2016, a slight increase from 2015, but less than projected.

[10] Vermont Department of Public Service, 2019. *2019 Annual Energy Report:* 4, 22, and 33. https://legislature.vermont.gov/assets/Legislative-Reports/Annual-202be-report-final.pdf.

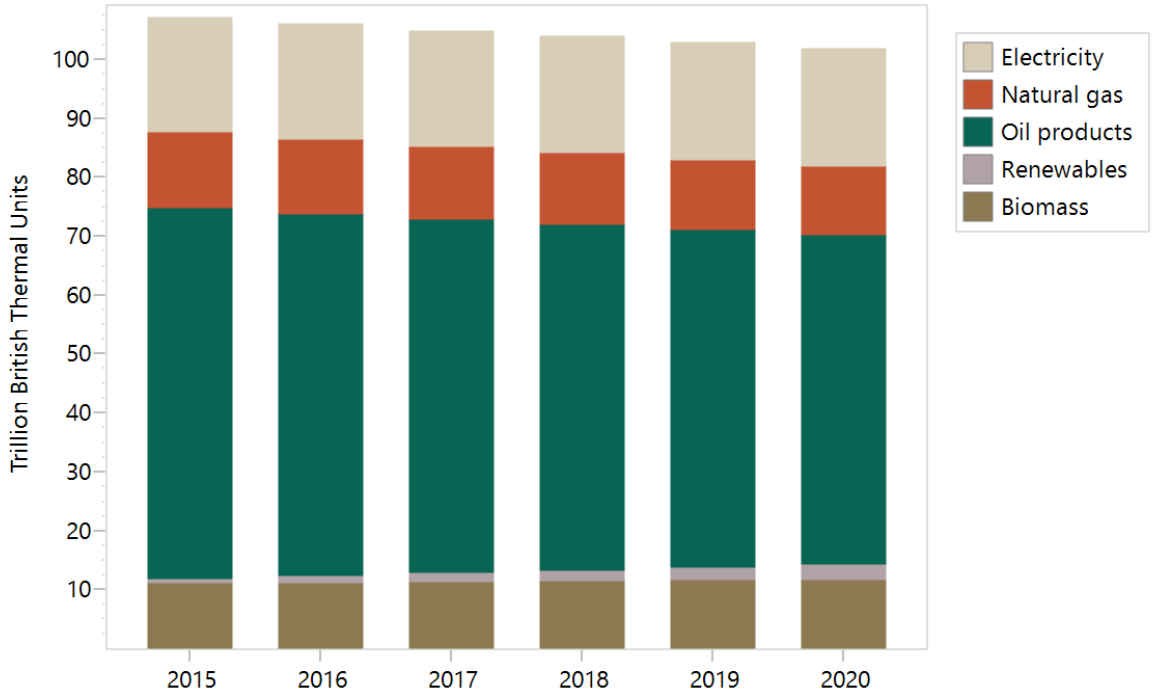

Figure 5. Beginning the transition from fossil fuels to renewable electricity and other renewable fuels to meet the 90 x 2050 renewable energy target, by fuel. This view, zoomed into 2015-2020, shows small change that sets the stage for an expected dramatic change in the next decade.

The Study Team has expected the transition to strategic electrification to pick up significantly after 2020, with the years before then being the relatively flat start to an s-shaped adoption curve.

Figure 6 shows progress toward a decarbonized grid, with the SDP projection for an increasing mix of renewable resources between 2016 and 2019. For this Update, we have not changed the projections, but compared the original projection for 2016 to 2016 actuals in the *2019 Annual Energy Report.* Although newer electricity generation data are available, they are based on the generator location. **Figure 6** and the overall study primarily addressed the electricity that serves Vermont demand, regardless of where it is generated. How generator output is allocated to buyers would require additional data. We estimated 2019 solar generation from the capacity information in the CPG database.

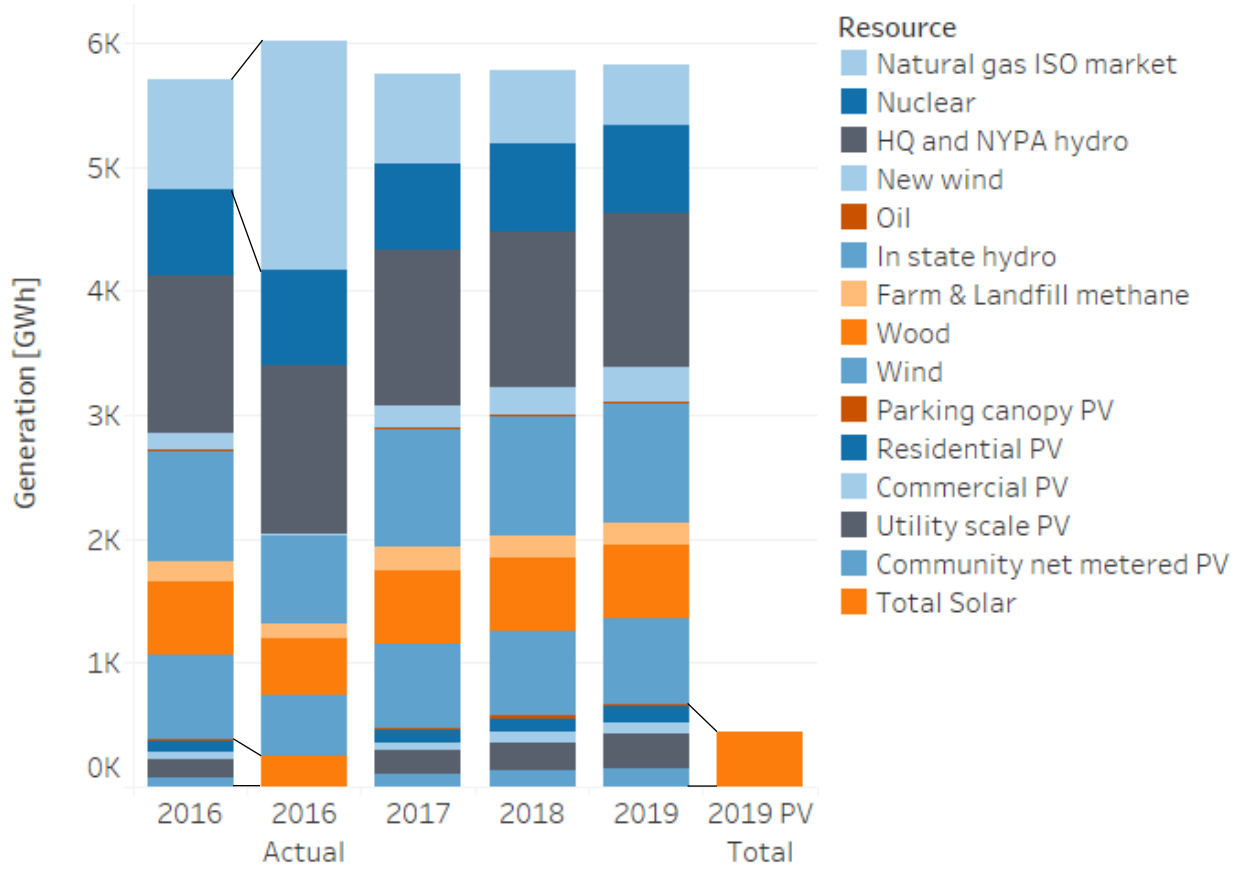

Figure 6. Projected Vermont electricity supply in the SDP scenario, by year and energy source, compared to 2016 actual electricity generation and to an estimate of 2019 total solar generation.

The biggest differences between projections and actual data are highlighted by lines between the original bars and the bars showing actuals for 2016 and 2019: ISO-New England natural gas provided approximately twice the 2016 projected Vermont supply, and actual solar generation was lower in 2016 and 2019 than projected. No new wind capacity is currently planned. Wind is a strong resource in Vermont and complements solar in its daily and seasonal cycles. The SDP projection did assume a lull in wind development, but it projected 300 MW of new wind capacity to be built by 2030, and more after that to help meet the 90 x 2050 target.

2. Vermont's Progress on Becoming an Advanced Solar Economy

2.1 Updated Solar Growth Trends

At the end of 2014, the installed solar capacity in Vermont was 82 MW_{AC}. Four and a half years later, by the end of Q2 2019, it was 335 MW_{AC}. For comparison, over that same time period, the national cumulative installed capacity grew from 18.3 GW_{DC} to 69.1 GW_{DC}. This means that capacity grew in Vermont by more than four times, and in the national market by 3.8 times. Sustaining that *pace of growth* between now and 2025 in Vermont will result in more than 1 GW of installed capacity, meeting the Solar Pathways target of 20 percent of total electricity from in-state solar. **Figure 7** presents monthly and cumulative capacity installed in Vermont.

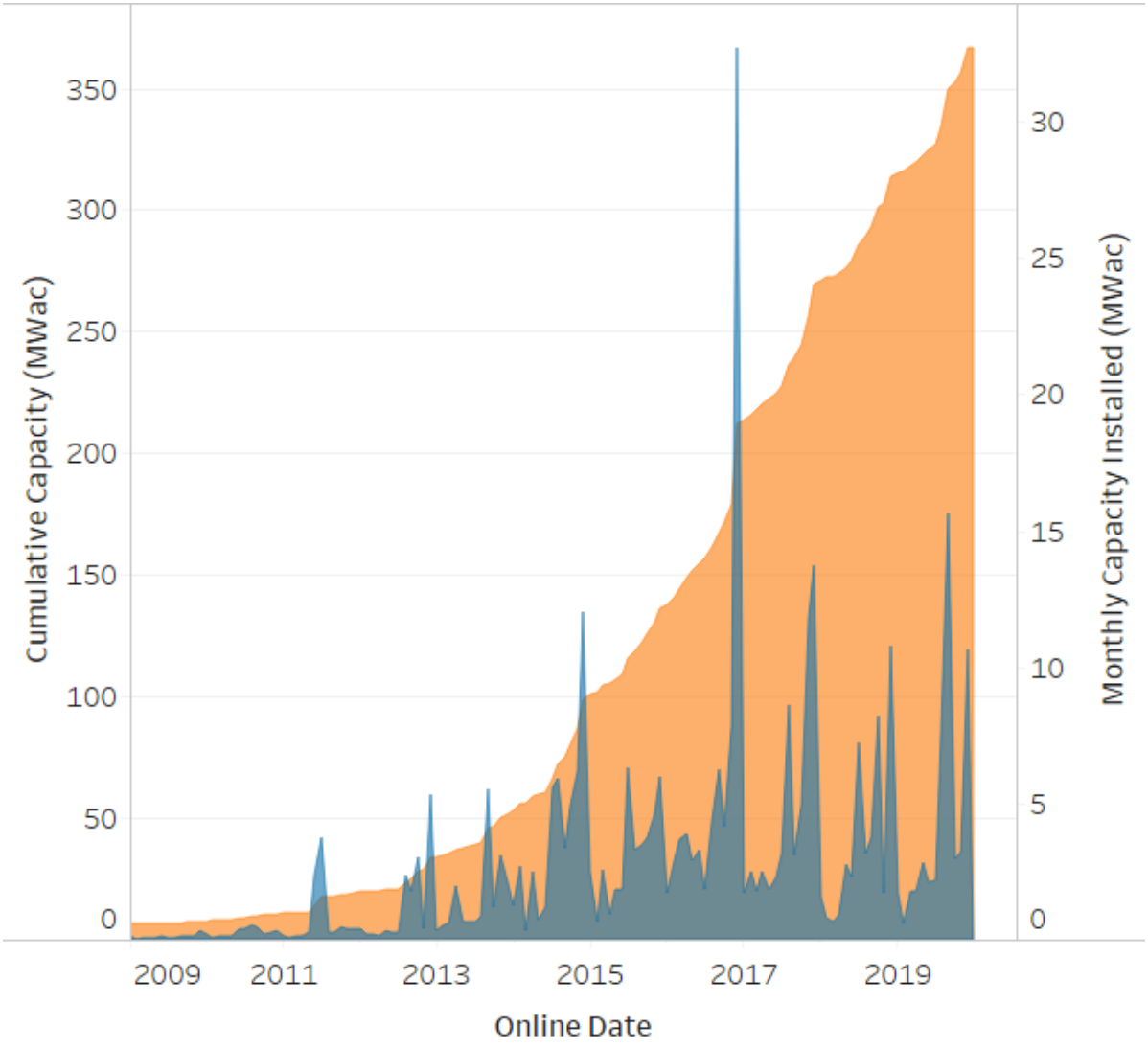

Figure 7. Monthly and cumulative "online" solar capacity over time in Vermont from the database of Certificates of Public Good, as of the end of 2019. The tallest three monthly spikes occur respectively in December 2016, September 2019, and December 2017.

However, there are important qualifiers to this trend. Solar installation rates were highest in 2016 and 2017. Capacity installed in 2018 and projected for 2019 is lower, as shown in **Figure 8**.

Figure 8 reflects the same data as **Figure 7** and **Figure 2**, but the Study Team has presented it by year, showing detail by program. In this figure, net metering has been the largest component of solar capacity and most consistent over time. Results from Vermont's standard offer program (Sustainably Priced Energy Enterprise Development [SPEED],[11] and later power purchase agreements provide the next-largest element. Liberal policy development toward group net metering has propelled this market expansion, as have simple permitting and strong financial performance from a regulated, solar adder on utility bills for net-metered generation. The feed-in tariff also has contributed to the expanded market.

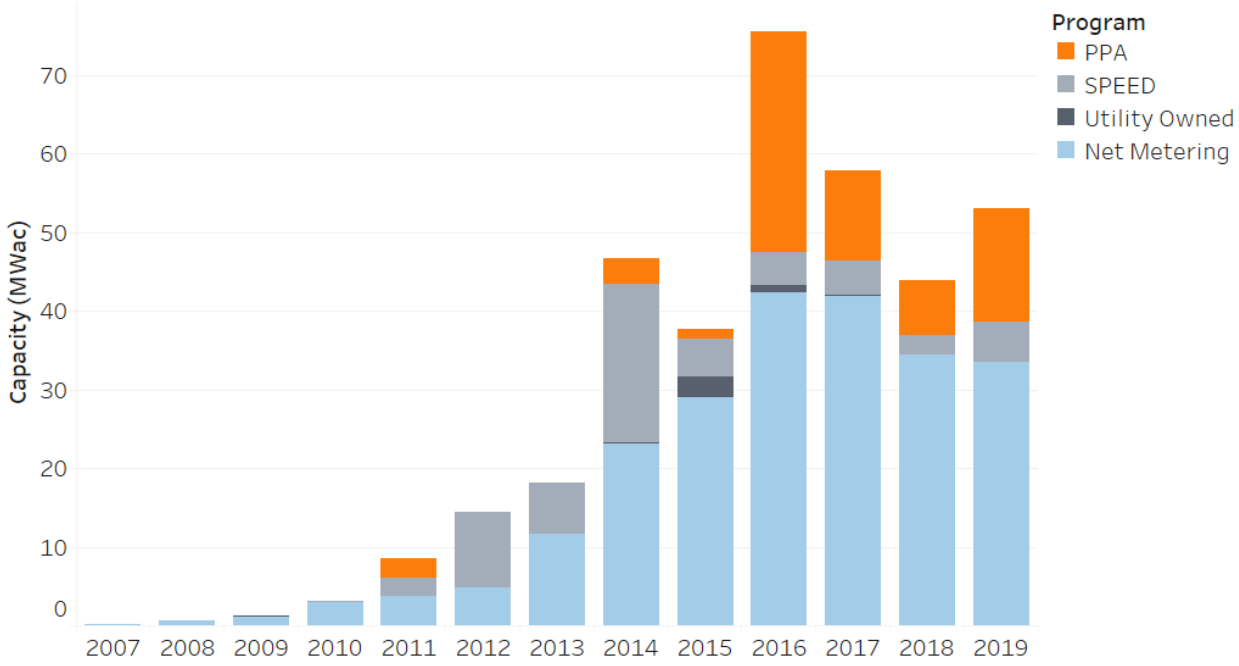

Figure 8. Annual additions to "online" solar capacity in Vermont over the last decade (database of Certificates of Public Good, as of the end of 2019).

The anticipated end of the federal Investment Tax Credit drove the high amount of capacity installed in 2016, as did a change to Vermont's net metering compensation. In actuality, the ITC was extended, and solar compensation in Vermont continues to be adjusted.

Reaching 1 GW by 2025 will require annual installations to average just over 100 MW, a higher amount than that in any year in the past. The achievement of 2016's 75 MW is not high enough. If new installations between now and 2025 were to remain steady at the level of the last two years, total installed capacity by 2025 would fall roughly 50 percent below 1 GW.

[11] VEPP, Inc., n.d. "Standard Offer Program." http://vermontstandardoffer.com/standard-offer/.

However, reaching 1 GW is possible if the cumulative capacity grows by 19 percent in each year of the next six years. In the past seven years, it has grown slower than that only on two occasions, has averaged 49 percent each year, and topped out at 128 percent growth from 2013 to 2014. The rate of growth needed to meet the target is achievable, assuming stable and predictable policy.

The two essential findings are:

- **The growth rates required to meet the Solar Pathways target are attainable, and Vermont and national markets have already demonstrated sufficient rapid growth to meet the target.**
- **Sustained growth at these levels is not easy, and changes to market and policy conditions in recent years have resulted in slowing; if those changes are not reversed, Vermont will definitely miss the Solar Development Pathway target and its benefits.**

2.2 Policy and Regulatory Landscape

There have been many changes in solar market, regulations, and rules since the 2014 beginning of the Solar Market Pathways project:

- The General Assembly raised the cap for net-metered renewable capacity from 4 percent to 15 percent of the connected utility's peak load, as the project began.
- Later in 2014, Burlington Electric Department, the state's third-largest utility that operates its own efficiency services, acquired an existing 7.4 MW hydropower station to complete its efforts to supply 100 percent of its energy from renewable sources.
- In June 2015, the General Assembly passed a renewable portfolio standard (Act 56) that allows credit for reducing fossil fuel use in building and transportation sectors. It is among the most aggressive policies in the United States,[12] requiring 75 percent of electricity to come from renewable sources by 2032. As the 2020 session begins, the General Assembly is considering increasing it and moving the deadline earlier.
- In November 2015, Green Mountain Power (GMP), an investor-owned utility serving 71 percent of the state's utility accounts, reached the net metering cap, 15 percent of peak. It decided to continue to allow small systems to interconnect, as well as 7.5 MW of strategic larger systems. The utility created a map to guide new solar to areas of the grid that have ample capacity to accept it.[13]
- By the close of 2015, Vermont Electric Cooperative (the second-largest utility), Washington Electric Cooperative (the fourth-largest utility), and three smaller municipal utilities reached, or were approaching the 15 percent net metering cap.

[12] Marcy, Cara, 2015. "Hawaii and Vermont Set High Renewable Portfolio Standard Targets," *U.S. Energy Information Administration*, June 29. http://www.eia.gov/todayinenergy/detail.cfm?id=21852.
[13] "Solar Map," *Green Mountain Power*, http://gmp.maps.arcgis.com/apps/webappviewer/index.html?id=4eaec2b58c4c4820b24c408a95ee8956

- Beginning in 2015, the Vermont Solar Energy Capacity Tax came into effect, at $4 per kW per year for systems 50 kW and larger.
- In August 2016, the Vermont Public Service Board (now the Public Utility Commission) issued new net metering rules that removed the program cap, added incentives for preferred siting and renewable energy credits (REC) treatment, and slightly lowered the total incentive for most systems.[14]
- A new federal tariff on imported solar panels was added in 2018. The first 2.5 GW each year are exempt from the tariff; but beyond that amount of capacity, it imposed a 30 percent adder to the cost of imported solar photovoltaic (PV) cells and modules. The tariff declines by 5 percent a year until 2021.[15]
- In 2018, the Public Utility Commission provided the first biennial update to the 2016 net metering rules, reducing the compensation rates by 0.5 – 1.5 cents per kWh, to be taken in annual steps. The rate for systems above 150 kW decreased by 2.5 cents per kWh.[16]
- Many regions and towns created energy plans in response to Act 174 (2016).[17] By demonstrating how they could contribute to State goals, and how renewables could be sited in their territories, these jurisdictions can earn additional consideration at Certificate of Public Good hearings with the Public Utility Commission.
- Act 81 of 2019 increased the amount of net metering capacity that may be attributed to a school or school district.
- In 2019, the Commission approved GMP's request to charge new solar projects $38 / kW to connect, if they are located where the grid has required, or could require, a transmission ground fault overvoltage (TGFOV) upgrade.[18]

2.3 Solar Costs

The sources and assumptions used for cost projections in the original study and this Update are:

- The Study Team estimated costs from Vermont-specific data if available; if not, they used the best regional or national estimates.

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[14] Vermont Public Utility Commission, 2016. "Revised net-metering rule pursuant to Act 99 of 2014," June 30. https://epuc.vermont.gov/?q=node/104/27065.

[15] Office of the U.S. Trade Representative, n.d. "Section 201 Cases: Imported Large Residential Washington Machines and Imported Solar Cells and Modules." Washington, DC: Executive Office of the President of the United States. https://ustr.gov/sites/default/files/files/Press/fs/201%20Cases%20Fact%20Sheet.pdf.

[16] Vermont Public Utility Commission, 2018. "Biennial Net Meter Order," May 1, https://greenmountainpower.com/wp-content/uploads/2018/06/Biennial-Net-Meter-Order-5.1.18.pdf.

[17] Vermont Public Utility Commission, n.d. "Introduction to the Act 174 Regional and Municipal Energy Planning Standards." Montpelier, Vt. https://publicservice.vermont.gov/sites/dps/files/documents/Pubs_Plans_Reports/Act_174/Standards%20Overview.pdf.

[18] Green Mountain Power, 2017. *Tariff filing of Green Mountain Power Corporation for net-metering transmission ground-fault overvoltage ("TGFOV") fee and new generation resource rider on bills rendered on or after July 1,2019*, https://greenmountainpower.com/wp-content/uploads/2017/01/Tarriff-Approval-Order-19-0441-TF.pdf

- Initial solar costs are from the 2016 *Vermont Solar Cost Study* by the Clean Energy States Alliance.[19]
- Future solar costs use that baseline and decrease according to a VEIC profile using national trends. These are shown in **Figure 9**.
- To update the figure, the Study Team used same 2016 baseline with actual annual percentage decreases experienced nationally.
- Solar developers provided the prices they are seeing in 2019 for residential and commercial / 500 kW community scales. VEIC applied the effect of the federal Investment Tax Credit and added them to the graph as estimated data points, in Vermont only.

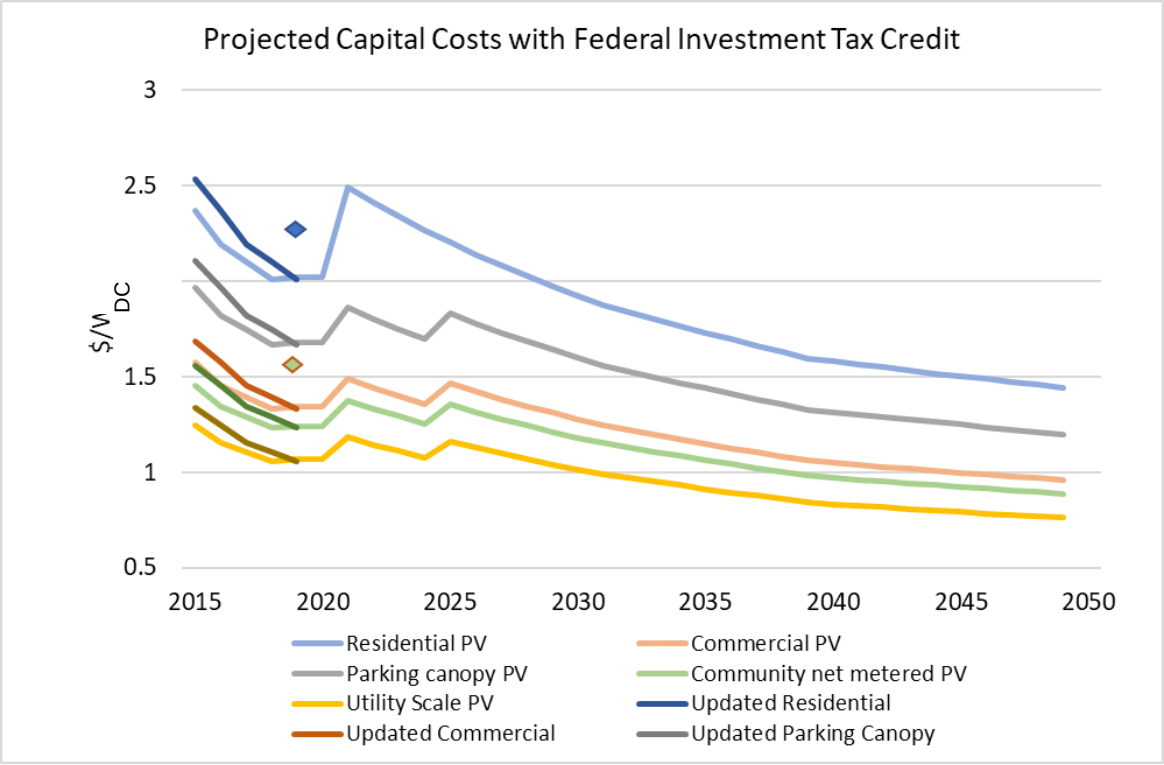

Figure 9. Projected future, after-tax installed cost of solar PV in Vermont, from the original study and updated in 2019. Industry reported costs, with ITC effects added, are shown as points for residential and commercial / community scales. The projections assume the ITC expires in 2025.

The projections from the original study are similar to updated projections. The update trends down slightly faster than originally expected. The new projection is higher in 2015 and lower in 2019. However, both sets of projections are based on 2016 Vermont data and the national changes since then. The Study Team could not obtain robust Vermont price data. Limited recent data from developers on average costs, shown as points in **Figure 9**, are 10 to 15 percent higher than the projected costs.

[19] Seddon, Leigh W., 2016. "Vermont Solar Cost Study: A Report on Photovoltaic System Cost and Performance Differences Based on Design and Siting Factors." Montpelier, Vt.: L.W. Seddon, LLC for the Clean Energy States Alliance and the Vermont Department of Public Service's Clean Energy Development Fund. February 29. http://www.cesa.org/resource-library/resource/vermont-solar-cost-study-a-report-on-photovoltaic-system-cost-and-performance-differences-based-on-design-and-siting-factors.

3. Other Contributions to 90 x 2050 and Greenhouse Gas Emissions Reduction Targets

Climate and renewable targets for Vermont depend on more than robust solar market development. In this section we update progress on other components of the pathways to 90 percent renewable energy.

3.1 Efficiency

Energy efficiency is a key resource for meeting high renewable energy goals. This efficiency comes from many places: aggressive home weatherization, automotive efficiency standards—and, most significantly, electrification of heating and transportation. As explained in Vermont's *2016 Comprehensive Energy Plan*, "Heat pump and electric vehicle technology is capable of supplying the same level of energy service as its combustion-based counterparts, with a third or less of the site energy requirements."[20] In the SDP scenario, the savings from thermal shell improvements, more efficient end use equipment, and more efficient vehicles combine to reduce total energy consumption by roughly 10 percent by 2025, and 40 percent by 2050, compared to 2010. **Figure 11** shows no discernible trend in the state's total energy consumption in recent years, after more significant variation before 2012.

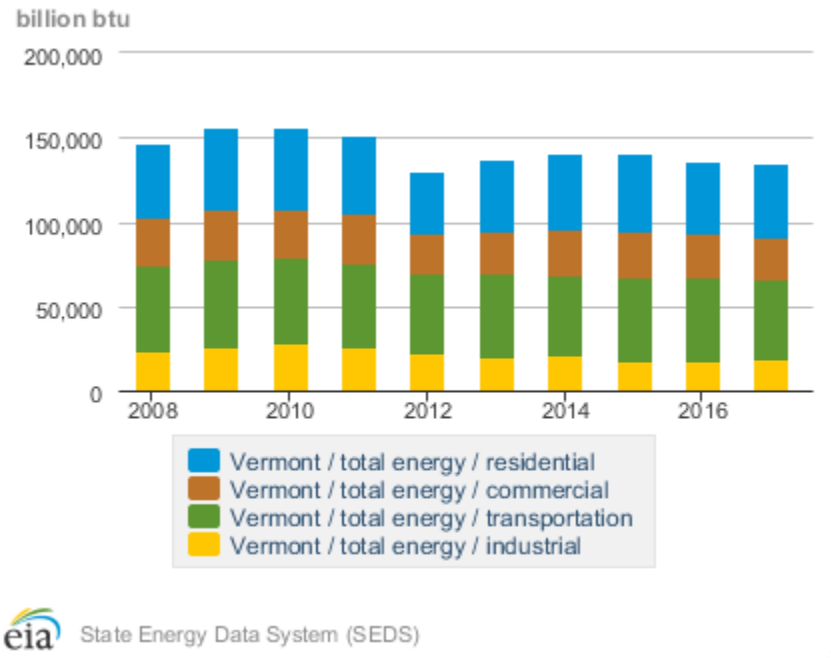

Figure 10. Vermont source total energy consumption by market sector. EIA, State Energy Data System.

[20] Vermont Department of Public Service, 2016. *Comprehensive Energy Plan 2016*: 7. https://outside.vermont.gov/sov/webservices/Shared%20Documents/2016CEP_Final.pdf.

3.2 Strategic Electrification – Heat Pumps

Heat pumps are an important electrification option that is readily available and cost competitive, compared to oil and propane. **Figure 11** shows the projection from the original study for heat pumps' share of single-family home heat.

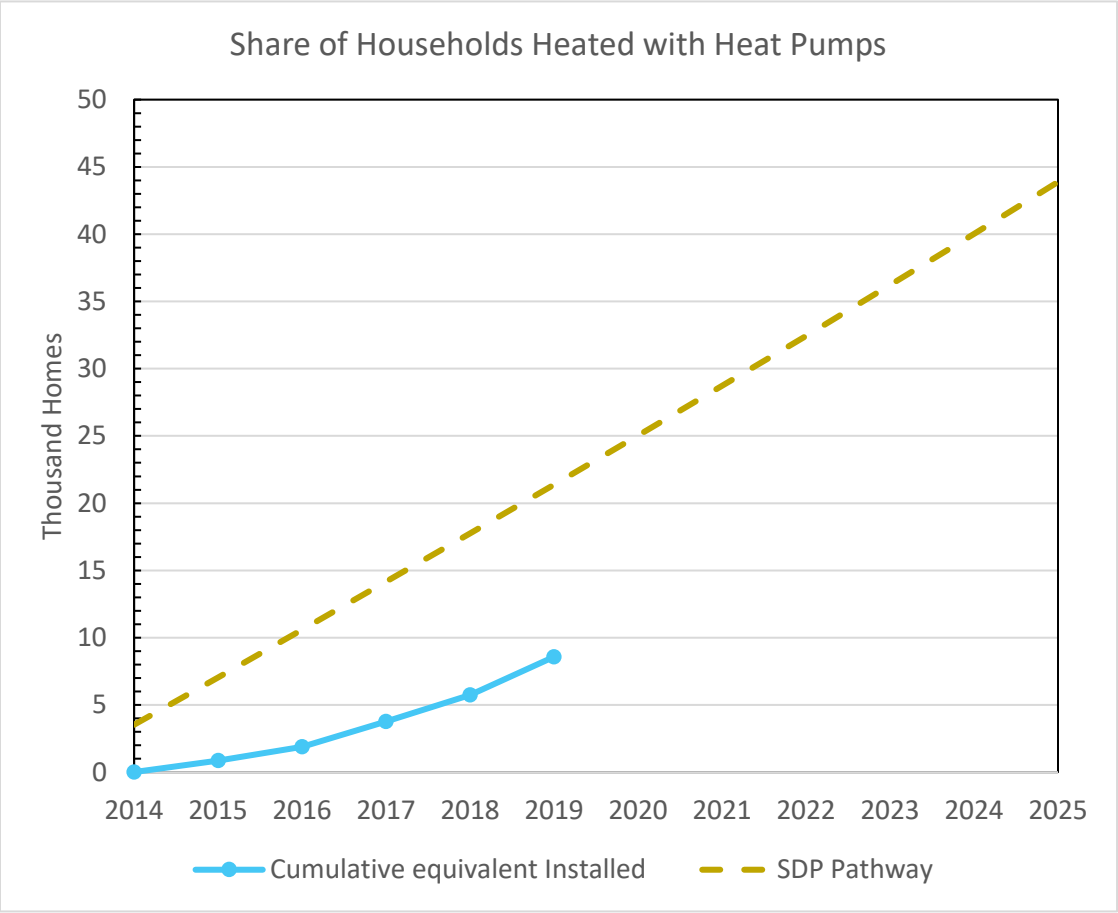

Figure 11. Projected cumulative growth in single-family homes heated with heat pumps compared to actuals through mid-year 2019, with a 2019 year-end estimate. *Source:* *Efficiency Vermont*

Figure 11 shows heat pumps lagging the projection in two ways: (1) a lower starting point, and (2) a lower installation rate (lower slope). The lower starting point is the greater difference. Both could be because Efficiency Vermont data do not reflect heat pump installations that occurred without ratepayer-funded incentives. The Study Team estimated installations in single-family houses by using the share of single-family units in the housing stock. The installation rate, indicated by the slope of the lines, is not inconsistent with the projected rate. Each year the rate of heat pump installations has accelerated, shown by the steepening slope. In fact, the most recent year's installations were almost quick enough to match the projection's rate. Of the technologies' installation data reviewed for this update, heat pumps are the only technology that is still seeing increased installation each year. Solar, electric vehicles, and advanced wood heating all continue to grow, but annual installations for those technologies have gone up and down in recent years.

3.3 Strategic Electrification – Electric Vehicles

The development of an advanced solar market in Vermont will provide significant opportunities for increasing the number of renewably powered vehicles in the state. The benefits of renewably powered transportation are reduced emissions of greenhouse gases and other harmful pollutants, reduced magnitude and volatility of transportation energy expenditures. Further, the batteries in electric vehicles (EVs) can support the electric grid through controlled charging and distributed energy storage. Both capabilities can respond to short-term fluctuations in power generation that might occur with high solar generation. Conversely, EVs can cause a need for grid upgrades for Level III (fast-charging) stations. If several charging stations are concentrated in a small area, grid upgrades might also be needed to avoid overloaded transformers, voltage drop, or other distribution grid problems.

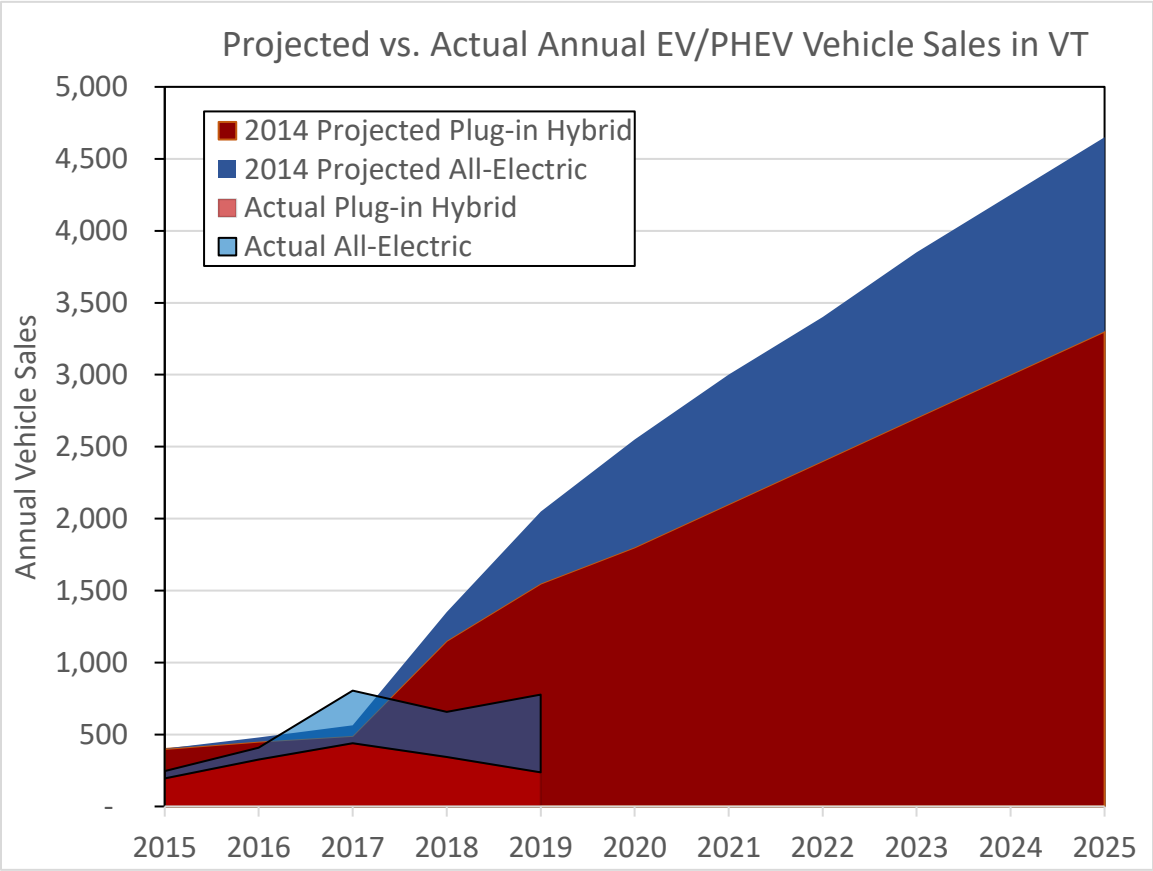

Figure 12. Projected annual sales of electric and plug-in hybrid vehicles, compared to actuals, through mid-year 2019 with a 2019 year-end estimate. *Source:* Drive Electric Vermont

Figure 12 shows that in 2017, EVs (hybrids, plug-in hybrids, and all-electric vehicles) were selling in Vermont faster than had been anticipated in the SDP scenario. However, instead of taking off from there, sales fell. Sales of all-electric vehicles have been above projection since 2015 and nearly equal the continuously growing projection in 2019. A new state incentive could help bolster this transition. This is important because transportation is the largest sector contributing to emissions and energy consumption in Vermont. EVs are an easily tracked metric, but they are not the only tool to reduce transportation energy, emissions, and cost.

3.4 Advanced Biomass Systems

The Study Team projected wood heating to be an important tool for reducing oil consumption and keeping more energy dollars in state. The trend in the actual data shown in **Figure 13** is clearly flat, and thus not growing enough to achieve State targets.

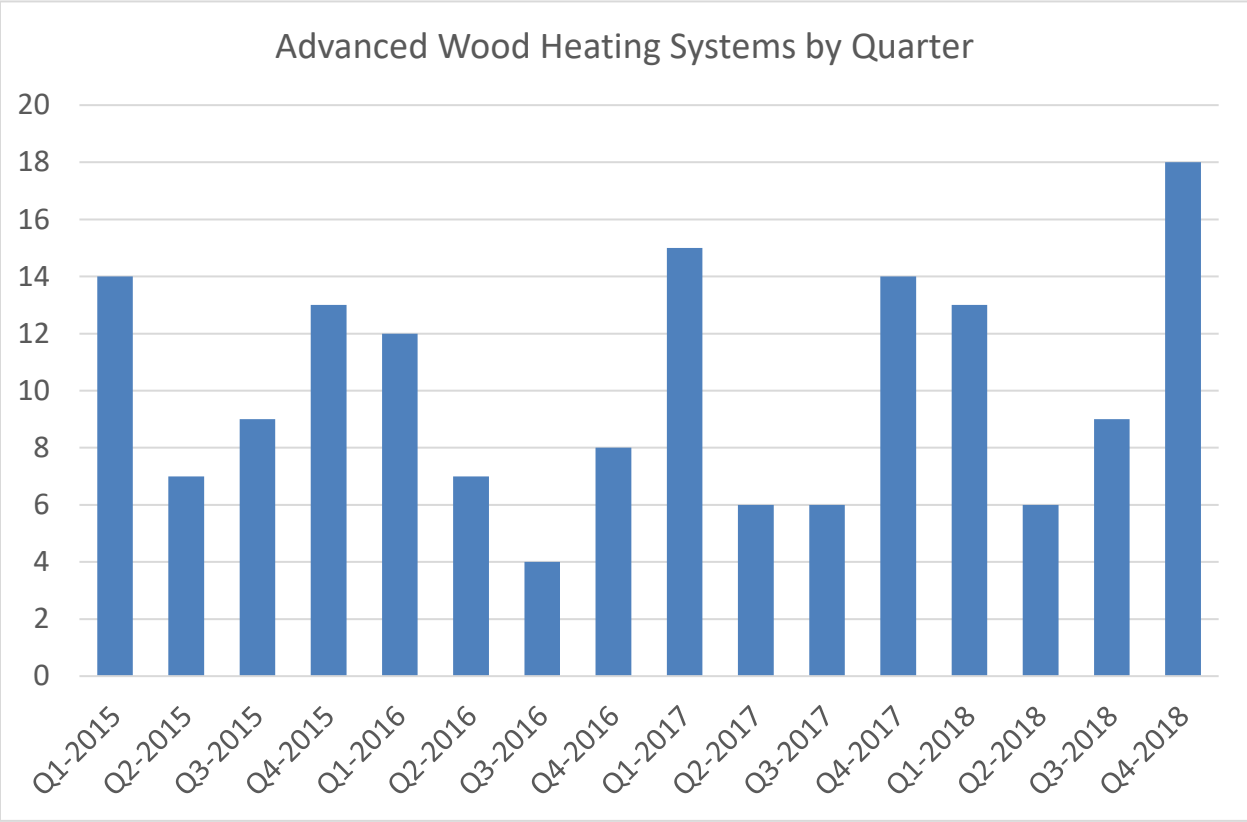

Figure 13. Advanced wood heating installations by quarter, 2015 to 2018. *Source: Small-Scale Renewal Energy Incentive Program*.

4. Conclusions

Achieving the Solar Development Pathways goal of 20 percent of electricity from solar by 2025 is possible, but it requires continued growth at a faster pace than has been experienced in recent years. Actual data for solar and other components of the 90 x 2050 pathway are lagging the original projections necessary for reaching the State's goals.

These results align with Vermont's and the world's too-slow progress on emissions reductions.[21] The longer we wait to seriously address climate change and these goals, the faster the required installation rates will be. This will necessitate either higher incentives for installation or stronger State intervention to spur customers, utilities, installers, and other stakeholders to increase installations.

There are four main considerations for viewing progress and the needed interventions: regulatory, technical, social equity, and market.

Regulatory

Actions by the General Assembly and the PUC are necessary for adjusting the process, rules, incentive amounts, and long-term and annual targets. These processes need to stay flexible, up to date—and even ahead of the curve, if possible. It is impossible to predict exactly what will happen. There will likely be mistakes. But these adjustments are necessary to get on and stay on track until the State's goals are met. The market contracted more than expected in 2017, following the burst of activity at the end of 2016 from an anticipated termination of the federal Investment Tax Credit and an expected change in the value of Vermont incentives.

Regulators are currently discussing the cost of net metering and lower-cost renewables available through the Standard Offer (SPEED program). Such strategies can be applied only to rationalize reducing net metering rates, if the amount of capacity sought through the Standard Offer rises sufficiently to compensate for those costs.

- *The Study Team believes such policies must be revised to target solar installations at or above 100 MW a year, every year.*

Technical

Solar technology is mature. For a long time, people were waiting for technical problems to be solved and for the price of solar equipment and installations to come down. Both of those have occurred. It is worth noting that technical problems were not a major issue in the original study, nor are they now.

[21] A comprehensive record of climate action worldwide can be found at Climate Action Tracker, which offers data and analyses of nations' progress toward meeting their specified climate goals agreed to at the United Nations Framework on Climate Change Conference of Parties in Paris 2015 (Paris Agreement or Paris COP21). See http://www.cop21paris.org/about/cop21, and https://climateactiontracker.org/.

Equity

The benefits of solar and the 90 x 2050 transition need to be shared across the population. Participation need to be affordable and accessible for all people living in Vermont. Community solar is the most suitable tool today to address social equity issues in solar. Vermont's community solar rules and incentives were among the most liberal in the nation until both were scaled back in 2017. The Study Team believes the overall contraction might have been too blunt a tool, bringing unintended consequences to the marketplace. Many states have requirements for low-income participation.

- *The Study Team believes Vermont could support community solar for its equity benefits and ensure that it is playing that role through participation criteria and/or requirements.*

Market

Vermont solar policies and incentives offer the market some clear targets and predictable timing for updates.

- *The Study Team believes that the targets and market signals must be developed with the State goals in mind, and a clear view of current progress toward those goals.*
- *The Study Team also believes that as of this update, Vermont must accelerate solar installations, as well as electrification and wood heating. Allof the technologies investigated for relevance and appropriateness* to meeting the State's goals are lagging, and thus not on track to meet them.

Final Comments

The most important conclusion of the original study and this update is:

- **Solar can provide 20 percent of Vermont's electricity by 2025, and can do so with costs that are less than 1 percent of annual energy expenditures.**

With this Update, we can borrow from and expand upon the conclusions from the original report:

- **Benefits bring enormous value to the state.** Through 2050, the study analyses suggest net economic benefits from investing in Vermont's advanced solar economy are in the billions of dollars.
- **Limitations are known, and can be overcome.** The Study Team and stakeholders considered the most commonly cited limitations of solar—cost, space requirements, and intermittency of energy supply and delivery.
    - We concluded it is possible and profitable to overcome those limitations and thus move toward a future in which more of Vermont's energy comes from its own renewable sources that Vermonters own.
- **Benefits are economic environmental, and societal.** In addition to cleaner air and billions of dollars a year kept within Vermont, there are co-benefits from enhanced affordability, occupant health, and building durability and resilience.

- **The State needs to act—quickly.** The Study Team notes that there are several ways to reach the State's goals. They cannot be met without further political, regulatory, and business planning work.
    - There are many possible paths to a future that relies on sustainable energy. Stopping or slowing the progress made to date will continue Vermont's reliance on imported fossil fuels. This reliance supports destructive climate change, social inequality, and a continuous drain on the Vermont economy.
    - Vermont has no defensible reason to discontinue its longstanding environmental leadership. It has every economic, environmental, and societal reason to demonstrate its sustainable-energy success with a high share of electricity coming from solar and with a steady and deliberate transition to renewable total energy. The state can do this, while strengthening its economy.

There is clear evidence that we are not proceeding at the pace required to meet State goals, nor are we on track to contribute meaningfully to slowing climate change—either in fact or as a model for others.

A timely course correction now will give us an easier path in the future, and bring us the economic and environmental benefits, enumerated in the 2016 report.