## Appendix C

# REPORT ON VERMONT NET-METERING PROGRAM

A Report to the Public Utility Commission and the Vermont General Assembly Pursuant to 30 V.S.A. § 8010.

**Prepared by the Department of Public Service**

**January 15, 2023**

# Overview

Vermont's net-metering program has changed considerably since it was first authorized in 1998. Early iterations of the program were designed to incentivize small-scale (15 kW) projects that were used to offset the onsite electric consumption of the net-metering customer (i.e., "spin the meter backward"). Under the current program, projects can be up to 500 kW, and there is no requirement that a net-metered project's production physically offset a customer's load – although projects directly tied to a customer's usage usually receive slightly higher compensation. In 2021, just over 75% of the generation produced by net-metered generators was exported directly to the grid and not used onsite, with participating customers receiving monetized bill credits for that exported generation. In effect, net-metering has become a financial construct that allows customers to offset their electric bills by supporting the development of a net-metered system.

This program model has resulted in a significant expansion of the amount of distributed renewable generation in Vermont and helped increase the number of clear energy jobs in the state. However, as with any state-mandated program, it is essential to periodically evaluate whether the benefits associated with the program are commensurate with costs and determine whether those benefits and costs are allocated fairly. As the amount of net-metering has grown to over 32% of Vermont's peak load, it has become clear that the current structure of net-metering will need to be modified to reduce the financial impacts on non-net-metered customers and to help advance Vermont's transition to a low-carbon economy.

Under the current net-metering structure, new participating customers are compensated at their retail rate for own-use generation (generation offsetting load in real time or within a billing period) and the applicable blended residential rate for excess generation (generation in excess of consumption within a month for on-site systems, and all generation for "virtual" or off-site systems). The statewide blended residential rate is currently $0.17/kWh. This rate is effectively modified by adjustors for REC disposition and siting (see Table 1 below). A residential project or one up to 150 kW on a preferred site, transferring RECs to the interconnecting utility, will be effectively compensated at around $0.15/kWh. Larger net-metered projects, and those not on preferred sites, will be compensated at$0.11/kWh to $0.12/kWh. Outside of the net-metering program (e.g., the Standard Offer program and bilateral contracts with utilities), new solar resources are being built for a cost well under $0.10/kWh, including RECs.

While the differential between net-metered and other renewable resources has shrunk in the last several years (for new projects), it still exists, and it is important to keep in mind that all electric customers are paying this premium. However, since net-metering customers have reduced their electric bills, they do not experience the brunt of this cost-shift to the same degree as customers who do not have net-metering systems or credits. Customers have the right to manage their electric usage, including through on-site generation, to reduce purchases from their electric utility. However, there is no corresponding right to have other electric customers subsidize this practice; and with increasing adoption of heat pumps and electric vehicles, net-metering is starting to result in Vermonters paying for the heating and transportation costs of net-metered customers in addition to the electric costs.

New renewable generation can be procured in multiple ways, and almost all other options come at lower cost than the current net-metering program. A net-metering program that would promote Vermont's clean energy goals in an equitable manner would be structured to allow participating customers to offset on-site consumption in real time and receive compensation for the generation exported to the grid *at the value of that generation to other electric customers*, since at that point, it is a supply resource like any other. *T*his structure would return the net-metering program to its roots of incentivizing customers to offset their onsite energy usage and would better align the net-metering program with promotion of distributed, flexible, beneficial loads.

## History of Net-Metering in Vermont

In 1998, Vermont enacted net-metering, requiring electric utilities to permit customers to generate their own power from small-scale renewable energy systems of 15 kW or less. Farms could have larger, anaerobic digesters systems up to 100 kW. The utilities were required to allow net-metering up to 1% of their 1996 peak demand, and any excess power (not consumed on site) generated by these systems could be fed back to the grid, running the electric meter backwards. Excess generation rolled over month to month as kWh but was zeroed-out on December 31.

The net-metering statute was changed in 1999 and almost annually after that, with major modifications in 2001, 2007, 2012, and 2014. These changes included:

- Raising the percent cap of net-metering to 2%, then 4%, then to 15% in 2014.
- Increasing the allowed net-metering system capacity to 150 kW, then 250 kW, then 500 kW in 2011.
- Allowing for credits to roll forward on a 12-month basis. In 2012, the kWh credits were changed to monetary credits and applied to non-energy charges on the electric bills, including monthly service charges, reducing some customers' bills to $0.
- Group net-metering was initially restricted to farmers and their meters. In 2007, group net-metering was expanded to all customers as long as the group members were contiguous. Group net-metering was eventually made available to all customers within a service territory.
- Established a simplified registration and permitting process for systems under 5 kW. This was expanded to 10 kW, then 15 kW, and in 2017 to 150 kW for roof-mounted systems.
- Created a solar adder of up to $0.06/kWh for all solar net-metered systems (based on the solar adder GMP had been paying to solar net-metered systems in its territory). The legislation required the solar adder be paid for ten years from the commissioning of the

system and initiated a Commission process to determine the compensation framework for net-metering going forward.

Act 99 of 2014 moved net-metering out of the statutes and created a regulated net-metering program administered by the Commission. The Commission was charged with putting a new "Net-Metering 2.0" program in place in 2017.

In 2017, the Commission established new rules for net-metering as required by Act 99. Notably the new net-metering program eliminated the cap of net-metering and the solar adder and created siting adjustors for projects on so-called preferred sites and REC adjustors for projects that transfer the RECs to the utility (before 2017, RECs were owned by the customer by default).

# Rates, Deployment, and Technology Types

## Rates

Since net-metering 2.0 ("NM 2.0" or "NM 2.X") was first implemented in 2017, the compensation rates have been periodically evaluated and adjusted to ensure that the requirements set forth in the statute are met. Specifically, the net-metering statute, under 30 V.S.A § 8010(c)(1), requires the Commission to promulgate rules that establish and maintain a net-metering program that:

- (A) advances the goals and total renewables targets of [30 V.S.A. Chapter 89] and the goals of 10 V.S.A. § 578 (greenhouse gas reduction) and is consistent with the criteria of subsection 248(b) of [Title 30];
- (B) achieves a level of deployment that is consistent with the recommendations of the Electrical Energy and Comprehensive Energy Plans under sections 202 and 202b of [Title 30] . . . ;
- (C) to the extent feasible, ensures that net-metering does not shift costs included in each retail electricity provider's revenue requirement between net-metering customers and other customers;
- (D) accounts for all costs and benefits of net-metering, including the potential for net-metering to contribute toward relieving supply constraints in the transmission and distribution systems and to reduce consumption of fossil fuels for heating and transportation;
- (E) ensures that all customers who want to participate in net-metering have the opportunity to do so;
- (F) balances, over time, the pace of deployment and cost of the program with the program's impact on rates; and
- (G) accounts for changes over time in the cost of technology; and
- (H) allows a customer to retain ownership of the environmental attributes of energy generated by the customer's net metering system and of any associated tradeable

renewable energy credits or to transfer those attributes and credits to the interconnecting retail provider, and:

- (i) if the customer retains the attributes, reduces the value of the credit provided under this section for electricity generated by the customer's net metering system by an appropriate amount; and
- (ii) if the customer transfers the attributes to the interconnecting provider, requires the provider to retain them for application toward compliance with sections 8004 and 8005 of this title.

Table 1 below summarizes net-metering compensation rates over time.

| | | | RECs | | CATEGORY | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Program** | CPG Application Date | Statewide Blended Rate | Transfer to Utility | Retain Ownership | I | II | III | IV | Hydro |
| **NM 1.0** | before 1/1/2017 | $0.149 | n/a | | n/a | | | | |
| **NM 2.0** | 1/1/2017 - 6/30/2018 | $0.149 | $0.03 | -$0.03 | $0.01 | $0.01 | -$0.01 | -$0.03 | $0.00 |
| **NM 2.1** | 7/1/2018 - 6/30/2019 | $0.154 | $0.02 | -$0.03 | $0.01 | $0.01 | -$0.02 | -$0.03 | $0.00 |
| **NM 2.2** | 7/1/2019 – 2/1/2021 | $0.154 | $0.01 | -$0.03 | $0.01 | $0.01 | -$0.02 | -$0.03 | $0.00 |
| **NM 2.3** | 2/2/2021 – 8/31/2021 | $0.164 | $0.00 | -$0.04 | $0.00 | $0.00 | -$0.03 | -$0.04 | $0.00 |
| **NM 2.4** | 9/1/2021 – 8/31/2022 | $0.164 | $0.00 | -$-0.04 | -$0.01 | -$0.01 | -$0.04 | -$0.05 | $0.00 |
| **NM 2.5** | 9/1/2022 – 6/30/2024 | $0.171 | $0.00 | -$0.04 | -$0.02 | -$0.02 | -$0.05 | -$0.06 | $0.00 |

Table 1: Net-metering programs and rates

The net-metering rates – historical, current, and future – aim to strike a balance among the goals of the program. As conditions related to renewable technology, costs, the economy, and environmental goals shift, it is appropriate to reevaluate net-metering rates and make appropriate adjustments to achieve these goals at the lowest feasible cost, consistent with Vermont's least-cost planning framework.

## Net-Metering Installed Capacity

While the net-metering program is open to a variety of technologies and fuel sources, as illustrated in the chart below, actual installations have been dominated by solar. Of the 324 MW of currently installed net-metering, almost 314 MW, or 98%, is solar, 1.5% is hydro (primarily pre-existing resources), and the remaining 0.5% is split between wind and biomass.

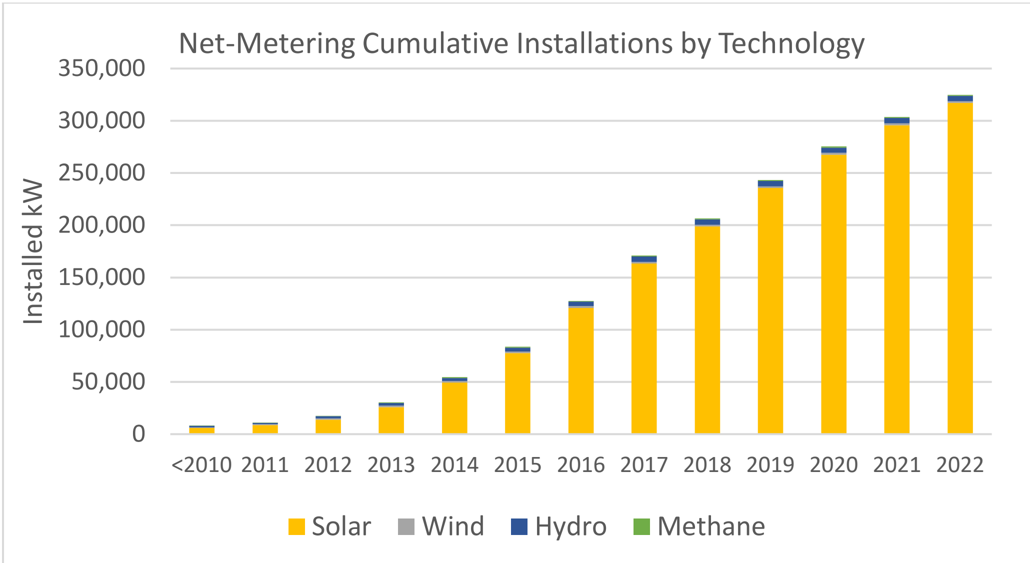


Figure 50: Cumulative net-metering installations by year[97]

All Vermont utilities host net-metering projects. Green Mountain Power has the greatest share of projects, with 84% of Vermont's total capacity, exceeding its 76% share of the state's load. Burlington Electric Department, Vermont's mostly densely populated service territory, hosts just 1.7% of the state's net-metering capacity while serving 6% of the load. Table 2 below shows the distribution of net-metering installations among utilities.

| Utility | Total Installed NM (kW) | 2019 Non-Coincident Peak | NM as % of Peak Load | Percent of NM Capacity | Percent of Retail Sales |
|---|---|---|---|---|---|
| Green Mountain Power | 221,266 | 684,450 | 32% | 84.2% | 76.4% |
| Vermont Electric Cooperative | 20,720 | 80,082 | 26% | 7.7% | 8.4% |
| Vermont Public Power Supply Authority | 10,251 | 71,019 | 14% | 4.0% | 6.4% |
| Burlington Electric Department | 4,718 | 63,076 | 7% | 1.8% | 6.0% |

[97] 2022 data only through October

| | | | | | |
|---|---|---|---|---|---|
| Washington Electric Cooperative | 3,722 | 16,067 | 23% | 1.4% | 1.3% |
| Stowe Electric Department | 1,645 | 17,655 | 9% | 0.6% | 1.4% |
| Hyde Park Electric | 528 | 3,370 | 16% | 0.2% | 0.2% |
| **TOTAL** | **262,850** | **909,433** | **29%** | | |

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Table 2: Net-metering deployment by utility

## Net-Metering RECs

The current net-metering compensation structure provides an effective incentive for customers to transfer the RECs to the utilities. Net-Metering 1.0 did not differentiate compensation based on REC disposition. As a result, more than 98% of Net-Metering 1.0 projects retained the ownership of RECs and those projects cannot be claimed as renewable by Vermont utilities to be used for RES compliance. Compensation rates for Net-Metering 2.0 and beyond have had up to a $0.06/kWh differential between a system owner retaining (and potentially selling RECs in the regional REC market) versus transferring them to the utility. The current differential is $0.04/kWh, which still appears to decisively encourage REC transfers with more than 97% of

RECs being transferred to utilities in 2020 and 2021, consistent with prior years of NM 2.0. In the 2022 Biennial Review, the Commission maintained the $0.04/kWh differential.

In 2018, net-metering RECs accounted for about 17% of utility Tier II compliance.[98] By 2021, with more systems online, net-metering RECs accounted for 66% of Tier II compliance.[99] As additional projects are built and transfer RECs to the utility, RECs from net-metering projects will continue make up a large share of Tier II compliance.

The Department expects 28 to 30 MW of new distributed generation will be needed annually to meet increasing Tier II RES requirements between 2022-2031 under a business-as-usual forecast, if the majority of Tier II compliance continues to be met by solar resources. Higher electrification scenarios would lead to more load, and proportionally higher Tier II RES requirements, reaching as high as 57 MW by 2031. Compliance can come from a variety of project types, from net-metering to Standard Offer to utility-owned and -contracted projects, in order to meet the RES requirements in the most cost-effective manner. Consistent with 30 V.S.A. §§ 202(b), 218c, 8001, 8010(c)(1)(F) and Vermont's least cost planning rubric, the highest priority should be ensuring that the state's renewable energy policies continue to deliver renewable energy at least cost. Currently, net-metering is the most expensive means for utilities to meet the Tier II requirements, and the current structure is a barrier to realizing greenhouse gas reductions – and to achieving the goals of the Vermont Electrical Energy and Comprehensive Energy Plans – because higher power supply costs lead to higher electric rates and electricity must be affordable to encourage fuel-switching for heating and transportation end uses.

The Department notes that installation costs continue to decrease, though at more modest rates than previously experienced. From 2009-2014, installed prices saw significant annual declines, but these have since tapered off. The decreasing REC and siting adjustor compensation rates have thus been partially offset by the decreasing installation costs and higher retail rates, making net-metering profitable for both participating customers and developers over the years. Looking forward, solar installation costs are expected to continue to see declines like those experienced in recent years.[100]

## Other Net-Metering Technologies

Net-metering is available to renewable facilities in Vermont that have a capacity of 500 kW or less. The current net-metering rule allows for existing resources that meet net-metering eligibility requirements to convert that system into a net-metering system. This applies to existing facilities that do not need the additional compensation that net-metering provides and do not provide Tier II RECs for RES compliance. For example, several hydroelectric projects that

[98] In 2018 13,765 net-metering RECs were retired for compliance and an additional 5,629 RECs were banked and used for 2019 compliance. If all 2018 generated RECs were used for 2018 compliance, net-metering would have accounted for 24% of Tier II compliance.

[99] In 2019, the 5,629 vintage 2018 RECs were used for 2019 compliance along with 52,395 vintage 2019 RECs. In addition, 3,437 vintage 2019 RECs were banked for used in future years.

[100] https://emp.lbl.gov/sites/default/files/2_tracking_the_sun_2022_report.pdf

had contracts under Rule 4.100 that have expired are eligible for net-metering, although they are not providing new renewable power and the long-term contracts previously received should have paid most or all the initial capital costs of the project.

# Economic Impacts of Net-Metering

## Cost of Net-Metering

The net-metering compensation rates over time are summarized above in Table 1: Net-metering programs and rates. Each biennial review by the Commission has resulted in gradual decreases to the compensation rate, but net-metering remains one of the highest-cost renewable resources. Based on data collected from each utility, the cost of net-metering in 2021 was more than $49 million higher than the market value of the products provided, resulting in an inequitable cost-shift from participating net-metering customers to non-participating customers.[101] As previously noted, the large majority of net-metered projects are solar, so the Department's analysis of the costs and benefits of net-metering focus on that technology. Below, Table 3 shows the total net-metered generation and above-market costs in 2021 as reported by each utility.

| Utility | Reduced Retail Sales (kWh) | Excess Generation (kWh) | Gross Generation (kWh) | Net Metering Above Market Cost | Rate Impact |
|---|---|---|---|---|---|
| BED | 1,347,383 | 4,064,135 | 5,397,580 | $655,326 | 1.4% |
| GMP | 66,296,018 | 243,993,774 | 310,289,792 | $43,393,505 | 6.5% |
| Hyde Park | 178,737 | 146,114 | 324,851 | $42,497 | 1.8% |
| Stowe | 1,725,790 | 14,371 | 1,740,161 | $215,740 | 1.8% |
| VPPSA | 1,869,263 | 11,584,665 | 13,453,928 | $1,569,202 | 3.0% |
| VEC | 11,641,896 | 11,869,254 | 23,511,150 | $2,642,267 | 3.5% |
| WEC | 4,567,842 | 799,144 | 5,366,986 | $717,768 | 4.2% |
| **TOTAL** | **87,626,929** | **272,471,457** | **360,084,448** | **$49,236,305** | 5.6% |

Table 3: 2021 net-metering generation and above market costs

As shown in the table above, utilities must absorb a significant amount of "excess generation" from net-metered projects. When the profile of the generation does not match a customer's load shape (or is not directly serving their load), the customer must rely on the grid to serve or balance their physical energy needs. At times when the generation is insufficient to meet

[101] This figure represents the costs and values of solar projects in 2021, treating generation from all net-metering projects equally. In recent years, the high adoption of solar in Vermont, and throughout New England, have effectively flattened loads and shifted peak hours. Therefore, projects that came online 10 years ago provided a greater value than projects that came online one year ago. This analysis does not assign a greater value to first-generation projects.

demand, electricity is delivered from the grid. At times when generation is greater than on-site demand, the excess is pushed onto the grid – this is called excess generation.[102] Due to the predominance of solar as a net-metering resource and its seasonal nature, some of the highest generation occurs at times with the least demand. For example, in May, when days are long, and temperatures are moderate, solar is producing the most and demand for electricity is already very low. Additionally, group net-metering allows several customers to share the output of a single larger project, for which all the energy is exported to the grid. The result is significant amounts of excess generation. Customer generation that serves on-site load reduces the utility's need to purchase energy as well as reducing the burden on the distribution system. Excess generation, on the other hand, is essentially a power supply resource that utilities must purchase, but it does not provide the same distribution benefits as generation that is consumed onsite – unless it happens to be located very close to load centers.

In 2021, more than 75% of total net-metered generation was excess and exported to the grid. This does not count "real-time" excess from onsite systems, which is treated as reduced retail sales as long as it nets consumption within the month it is generated. Credits for excess generation totaled more than $57 million in 2021 with the generation valued at $23 million. If net-metering systems are appropriately sized such that most of the generation is consumed onsite, or if excess generation were compensated based on the value provided as proposed by the Department in Docket 19-0855-RULE, then the cost-shift caused by net-metering would be greatly reduced.

## Impact on Retail Revenue

The extent to which net-metering costs have impacted Vermont utilities' revenues and retail rates varies. As described above, net-metering systems cost more than the value they provide. Additionally, net-metering reduces the utility's retail sales without reducing fixed costs; therefore, there are fewer MWhs to spread the costs over, resulting in higher retail rates for all customers. On average, in 2021, net-metering is estimated to have caused 5.6% of electric rate pressure (see Table 3 above).

Going forward, the impact of net-metering should taper off as the older and most expensive systems reach the end of their 10-year adder or positive adjustor incentives and revert to the current net-metering tariffs, and new projects have lower compensation rates.

[102] Excess generation figures are based on the current net-metering convention of monthly netting of a customer's excess production (anything not used in real-time) with their consumption from the grid. Therefore, under this convention, excess after monthly netting from customer-sited systems, and all generation from "virtual" systems that are located elsewhere from associated customers, is counted as excess.

## Economic Benefits of Net-Metering

Early in the net-metering program, new solar projects effectively shifted the peak hour, and reduced load at the time of peaks, resulting in reduced capacity and transmission costs. However, the benefits provided by new and future net-metering projects have diminished as the peak shifts into the evening, where solar can no longer contribute. Regional capacity and transmission ("RNS") costs are allocated based on a utility's load at the time of the system peak load. As more solar comes online, and peak hours shift later in the day to hours when solar is not generating, the value of new solar has been eroded. Most monthly statewide peaks (the basis for RNS charges) have moved to after dark. Capacity peaks have moved to the 5 p.m. Or 6 p.m. Hour, when solar output is diminished. Energy prices are highest in winter months. Compared to other available renewable resources in Vermont, the cost of net-metering is significantly higher, as shown in Figure 2.[103]

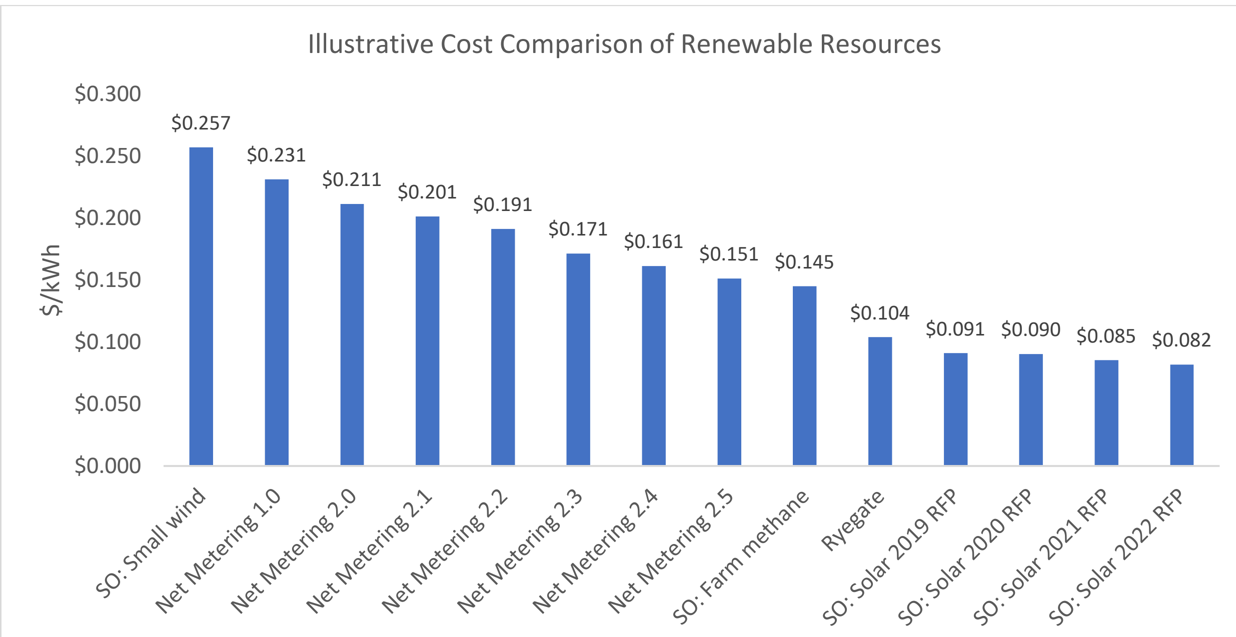


Figure 51: Cost comparison of renewable resources

It is important to note that while the costs of these resources vary greatly, so does the value of the products delivered. For example, the shape of generation from a solar net-metering project is very seasonal and much different than the shape of the generation from a farm methane generator that has a high capacity factor (a measure of actual output relative to capability) across all hours of the day throughout the year. It follows that the value of the generation is also different, as a farm methane project is more likely to be generating at the time of monthly peaks that occur after the sun sets. The solar Standard Offer prices have the most comparable

[103] Utilities have also recently entered into purchase power agreements with developers for the output from solar projects, ranging from $0.085-$0.095/kWh.

value to net-metering but come at a much lower cost, making it clear that even with reduced compensation rates that went into effect September 1, 2022, as a result of the Biennial Review, net-metering still does not satisfy the least-cost planning requirements of 30 V.S.A. § 218c.

## Economic Development

While net-metering is one of the most expensive resources available to meet Vermont's renewable energy goals, it does employ many Vermonters. According to the 2022 Vermont Clean Energy Industry Report prepared by the Clean Energy Development Fund,[104] the number of Vermont jobs associated with renewable energy overall at the end of 2021 was expected to be 5,656, with 1,750 of these jobs in the solar industry. This was nearly a 3% increase in solar jobs over 2021 but remained significantly lower than solar jobs in 2017 timeframe. That said, renewable energy workers that spend 100% of their time on renewable energy have increased substantially – from 58% in 2016 to 67% in 2022.

As the solar industry matures, it was reasonable to expect some consolidation of employment in the industry. When incentives were extremely attractive, many new entrepreneurs tried their hand in the solar industry. As subsidies tightened, the most competent solar firms continued to thrive, while less organized and efficient firms may have pursued other ventures. At the same time, the pace of net metering continued to be strong. Vermont has remained first in clean energy jobs per capita, at 6% of the workforce. These are meaningful jobs that contribute to the Vermont economy.

Net metering – with smaller facility sizes than Standard Offer and utility contracted solar projects – creates some marginal construction induced economic development impact. However, it should be acknowledged that under the existing framework of net-metering incentives, these jobs come at a net cost, especially compared to those alternative resources available to meet Tier II of the RES. **Vermont ratepayers are effectively paying a premium to retain jobs associated with net-metering.** While subsidies are ubiquitous in many job sectors, it is useful to recognize the extent of the subsidy in order to make an informed policy decision. The existing framework for net-metering provides jobs but does so in a way that results in economic distortion. To the extent that electric rates are higher than they could otherwise be, there is less disposable income and therefore less economic activity across the Vermont economy.

Meanwhile, keeping electric rates low is essential to encourage electrification – and therefore decarbonization. In Vermont's carbon-intensive heating and transportation sectors, current net-metering compensation creating unnecessary rate pressure inhibits progress toward Vermont's greenhouse gas goals. To meet these goals, Vermont will need more people working in weatherization, electric vehicles, heat pumps, and advanced wood heating systems. Decreasing

[104] 2022 VERMONT CLEAN ENERGY INDUSTRY REPORT, *available at*: https://publicservice.vermont.gov/sites/dps/files/documents/Renewable_Energy/CEDF/Reports/2022_VCEIR_Final_Report.pdf

compensation for net-metering need not lead to job losses in the renewable energy sector if a concerted effort to redirect efforts and incentives toward these sectors is undertaken.

The Department did not undertake an econometric analysis to specifically analyze net-metering economic impacts versus the economic impact of less expensive alternative solar resources. The discussion throughout this report emphasizes the relative costs to ratepayers of procuring net-metering to meet Tier II RES requirements vs. Lower-cost resources such as Standard Offer and utility bilateral contracts. Net-metering is the most expensive pathway to procuring RECs to meet the RES (and energy and capacity to meet other ratepayer needs). It is not necessary to know precisely *how many more* jobs net-metering supports vs. Standard Offer, bilateral contracts, or a new procurement program(s) Vermont could implement. In the bigger picture, the more important questions are related to whether Vermont policy directs limited public dollars efficiently, to the resources and technologies that best reduce costs for Vermonters and ratepayers while mitigating the most greenhouse gas emissions.

## Environmental Impacts of Net-Metering

Net-metering, like other distributed renewable generation resources eligible under Tier II of Vermont's Renewable Energy Standard (RES), reduces greenhouse gas emissions and air pollution when it displaces fossil fuel alternatives. A range of variables can affect a specific project's net emission reductions, including the project's generation capacity and lifespan and – when looking at the project from a life-cycle perspective – the amount of embodied emissions associated with the manufacturing of project components, transportation, site preparation and construction activities, and for ground-mounted projects, the extent of soil disturbance and forest clearing. These environmental benefits and costs accrue to society in general.

The Agency of Natural Resources ("ANR") may assess lifecycle (or "embodied") emissions when it evaluates particular projects during Section 248 siting proceedings before the Public Utility Commission. Otherwise, for reporting purposes, ANR calculates year-end emissions based on the overall state power supply for its emissions reporting.[105] The Department's approach to analyzing emissions reductions is to calculate the "but-for" emissions reductions attributable to specific programs. When Vermont adopted the RES in 2015, it articulated statutory requirements for renewable energy supply from resources of various sizes, types, vintages, and locations. The "distributed generation" tier of the RES (also called "Tier II") can be met with a variety of project types, as long as they are less than 5 MW, built after June 1, 2015, and connected to the Vermont grid. Net-metering, Standard Offer, utility-owned, or utility-contracted project are all eligible. Compliance is demonstrated with Renewable Energy Credits ("RECs") and under this framework, a net-metering solar system, for example, will contribute to portfolio renewability and commensurate emission reductions like any other distributed solar resource in Vermont.

[105] https://dec.vermont.gov/air-quality/climate-change

Using 2016, the last year before RES was implemented, as the baseline, the Department calculated what Vermont's emissions would have been based on the electric mix in 2016, which included 35% renewables and 12.8% nuclear (47.8% carbon free). To evaluate 2021 impacts, the Department then calculated what the emissions would have been with 2016 emissions factors applied to the 2021 retail sales. As a result of RES, the electric mix is much different now, with 71% renewables and 16% nuclear. The Department attributes the 36.5% increase in renewables directly to the RES; in 2021 that corresponded to around 690,532 tons of carbon. Because utilities were required to meet a 2021 Tier II obligation of 3.4% of sales (a carveout of a broader "Tier I" obligation of 59% of sales), and net-metering comprised about 66% of Tier II in 2021, the approximate amount of emissions reductions that can generally be attributed to net-metering in 2021 is approximately 18,465 tons of carbon.[106] That said, in the context of the RES, net-metering in effect displaces other solar generation that could have achieved those same greenhouse gas emissions at lower cost. These greenhouse gas emissions reductions may be more rightfully attributed to the RES rather than net-metering.

Tier II-eligible resources such as net-metering are "behind the meter" to the regional system operator, ISO-NE: they look like a reduction in load, similar to energy efficiency, and reduce the energy products utilities need to procure from the regional markets. Any utility purchases that do not include environmental attributes, or RECs for renewable resources, are known as "system mix," and are assigned the emissions characteristics associated with that mix. Below, Figure 3[107] from ISO-NE shows the proportion of regional electric energy generation by resource type:

[106] Statewide, utilities overcomplied in 2021 with Tier I requirements, retiring RECs equal to 71.46% of sales. Net-metering RECs comprised 2.67% of total REC retirements and equivalent GHG emissions reductions

[107] ISO-NE, communication of 12/15/22

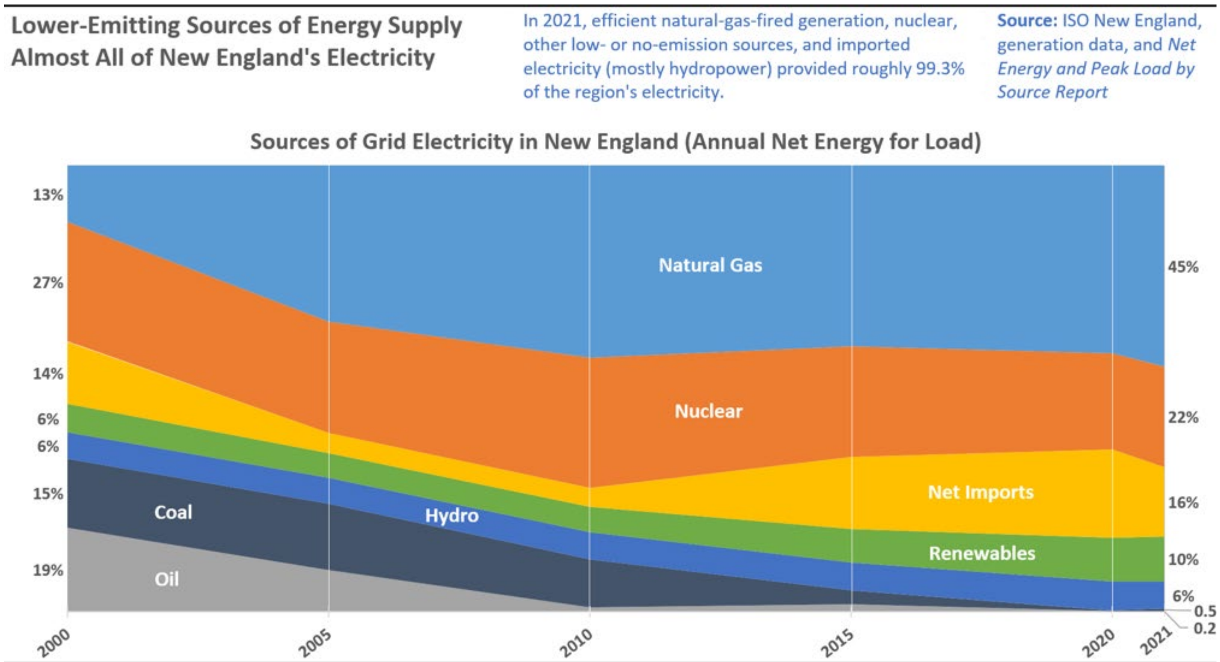


Figure 52: ISO-NE Electric Energy Generation

One takeaway from the chart is that accelerating clean and renewable energy requirements by New England states have led, at least in part, to nearly all the coal plants retiring and the oil plants that remain operate as capacity resources that generate limited energy; the proportion of market-facing renewables is growing, but load (real-time demand not being met with output from small renewables like net-metering, as well as efficiency) is still largely met with natural gas and nuclear generation at present. The system mix corresponds to the following changing emissions profile for the New England region, with decreases in air pollutants corresponding to fossil plant retirements as shown in Figure 4.[108]

[108] https://www.iso-ne.com/static-assets/documents/2022/05/2020_air_emissions_report.pdf

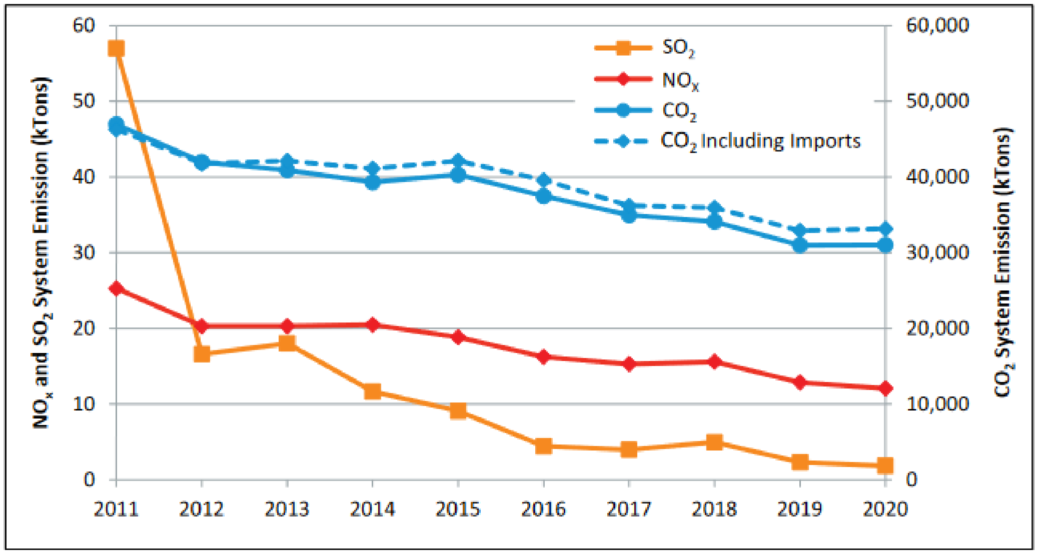


Figure 53: Historical ISO-NE Generators Air Emissions

As discussed above, in order to meet Vermont's RES requirements, utilities will need approximately 28 -57 MW per year of distributed, Tier II-eligible renewable resources to be deployed. A MW of solar, for instance, generated by any one of these resource types contributes equally to meeting the RES requirements (though at widely varying costs to ratepayers, net-metering resources being the most expensive). Similarly, a MWh of solar from any of these resource types contributes equally to offsetting other energy purchases with a particular emissions profile in a particular day or hour. And while the Department evaluates the emissions impacts of the RES on a net annual basis, it's important to recognize that actual emissions from regional generation can vary widely depending on the day or hour, with the regional system emitting the most in the coldest days of winter (when solar, regardless of resource type, is not much help). ISO-NE demonstrates this in the Figure 5[109] below:

[109] https://www.iso-ne.com/about/key-stats/resource-mix/

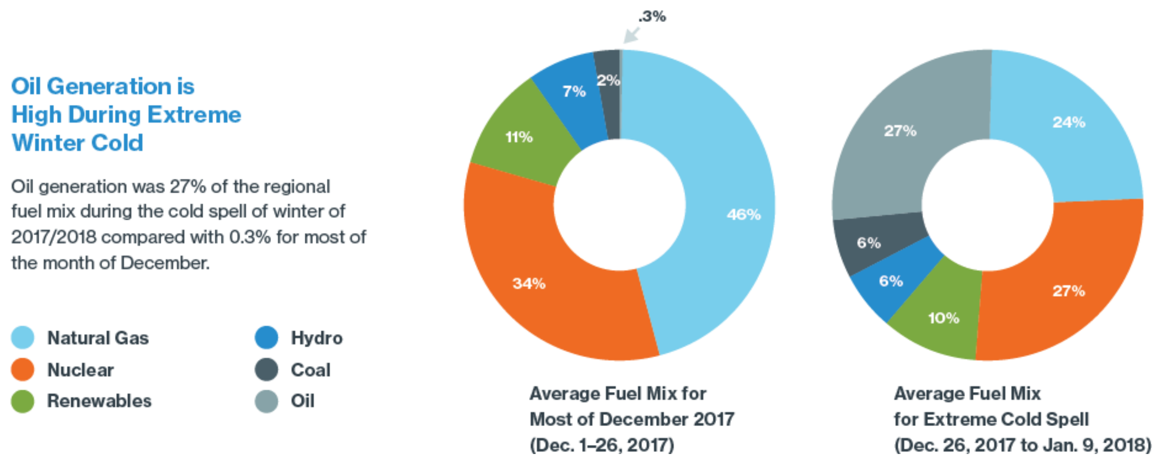


Figure 54: ISO-NE Fuel Mix During Normal and Extreme Winter Events

The Department has articulated concerns with the ability of net-metering customers to export most of their production in sunnier months, to monetize that excess, and to apply it to their bills in darker months elsewhere in this report and in Public Utility Commission Case No. 19-0855-INV, the net-metering rulemaking. This convention is beneficial to individual customers but adds stress to the grid and costs to other ratepayers, especially as distributed solar penetration increases. Like net-metering, the RES allows utilities to "net" their electricity sales with RECs that may be disconnected from real-time load. Some jurisdictions – notably Massachusetts – are taking the first steps toward attempting to incentivize renewable production when (if not necessarily where) it's needed with the adoption of a Clean Peak Standard. The Clean Peak Standard assigns higher value to generation correlated with peak load hours. This change to their Renewable Portfolio Standard is still quite new, and the Department looks forward to understanding its successes and challenges as it unfolds.[110]

In addition to environmental benefits from emissions reductions, net-metering – again like other distributed renewable generation resources eligible under Tier II of Vermont's RES) – is not without environmental costs. Construction of net-metering systems, like any construction project that uses fuel-burning equipment or generates dust, creates temporary air emissions. Also, all forms of energy development in Vermont have a footprint on the landscape. In some cases that footprint is on rooftops, parking lots, landfills, or other already developed sites; in other instances that footprint is on an undeveloped landscape or "greenfield" site. Conversion of land from natural conditions, as can happen with net-metering systems on greenfields, can result in loss of or damage to natural landscapes and ecological function. These natural landscapes provide numerous environmental benefits to Vermonters, including clean air and water, crop pollination, carbon sequestration, flood protection, and fish and wildlife habitat.

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[110] https://www.mass.gov/info-details/clean-peak-energy-standard-guidelines. Critiques regarding the emissions benefits of the MA Clean Peak Standard structure are starting to emerge, indicating further refinement of the concept or pursuit of alternatives may be warranted. See, for example, https://www.sciencedirect.com/science/article/abs/pii/S0360544221003649?via%3Dihub.

The Public Utility Commission's Net-Metering Rule (Rule 5.100) incents, and in certain cases requires, the siting of net-metering systems on one of 9 types of "preferred sites." One goal of the preferred site framework is to promote siting of net-metering systems on the already developed landscape. It is not clear, based on the analysis conducted by ANR for this report, that that goal was achieved. From 1/8/21 through 12/2/22, ANR comprehensively reviewed 83[111] net metered applications that broke out in the following preferred site categories, based on ePUC summary information:

- Not a preferred site – 3
- Sanitary landfill – 2
- Parking lot canopy – 2
- Previously developed site – 3
- Gravel pit, quarry, etc. – 3
- Brownfield – 4
- Near customer load – 27
- Designated in municipal plan or letter – 39

Only 14 of the 83 applications were in preferred site categories that generally involve the already-developed landscape (sanitary landfill, parking lot canopy, previously developed site, gravel pit, brownfield). As with past reporting periods, the majority of applications were Designated in municipal plan or letter preferred sites. Though a similarly high number of projects were located near customer load.

Development of net-metering systems at gravel pits, quarries, landfills, and brownfields can hasten their reclamation, facilitate environmental investigation and remediation activities, and inject income to offset maintenance and site management costs, which are all beneficial outcomes. Though significant, development at these sites represents only 17 percent of all net-metering applications that were comprehensively reviewed by ANR during this biannual period. There have been no applications for net-metering systems for the Superfund preferred site type.

Of the 83 net-metering applications this biannual period that required comprehensive review by ANR, 37 involved some measurable level of forest clearing resulting in approximately 78 acres of forest conversion.[112] Of those, 21 applications involved an acre or more of forest clearing – the vast majority of which in the Designated in municipal plan or letter preferred site category. Incentivizing as preferred sites the conversion of forests for net-metering when non-forested alternative sites are available, unnecessarily displaces the carbon sequestration benefits provided by forests.

[111] All applications put on ANR's Section 248 Agenda for Agency-wide review between 1/8/21 and 12/2/22. This may not align exactly with when an application is filed with the PUC. ANR generally does not review net-metering registrations and reviews applications for net-metering systems under 50 kW on a case-by-case basis.

[112] Acres of forest cleared estimated by Fish and Wildlife Department from initial application filing or, if the Department did not estimate, taken from applicant testimony.

# Net-Metering and the Grid

## Infrastructure Impact of Net Metering

Under the best-case scenario, net-metered and other distributed energy resources ("DERs") can minimize infrastructure needed to support the grid or import energy from more distant locations, and reduce line losses associated with such imports.[113] Those are some of the reasons why the Vermont System Planning Committee ("VSPC") evaluates distributed generation – alongside energy efficiency and load management – as an alternative to poles-and-wires solutions when it assesses potential solutions to grid reliability concerns. In the past, many of these concerns were driven by load growth. And while energy efficiency, net metering, and the decoupling of economic growth from electric demand growth has effectively flattened overall load growth in Vermont in recent years and in the near-term future, the challenge of strategically deploying behind-the-meter resources in time and space to match specific areas or times of higher loads grows. Since nearly all the net-metering in Vermont is "uncontrolled" solar – in that it's not time-shifted with storage to match demand – its output coincides with the daily and seasonal arc of the sun. Customer demand for energy in the dark of night and of winter is therefore not being served with solar resources, which has reduced its infrastructure deferral benefits.

[113] In Case No. 19-0855-RULE, the Department included a line loss value of 8%, consistent with the Avoided Energy Supply Costs (AESC) study and further explored by the Commission in Case No. 19-0397-PET. The value was updated to 9% in the most recent AESC (see Case No. 21-2436-PET). The line losses calculated in that proceeding were specific to energy efficiency. The Department expects that transmission losses would be similar for net-metering resources as they are considered behind-the-meter resources from a regional perspective.
It is doubtful that the value for distribution losses assumed in 19-0397 and 21-2436 would be appropriate, however. For energy efficiency, there is no excess generation exported to the grid, as there is under the net-metering structure. This generation in itself can result in losses, particularly in constrained areas with significant amounts of generation on the distribution system. Distribution loss impacts of generation facilities are case specific and cannot be considered on a statewide basis.

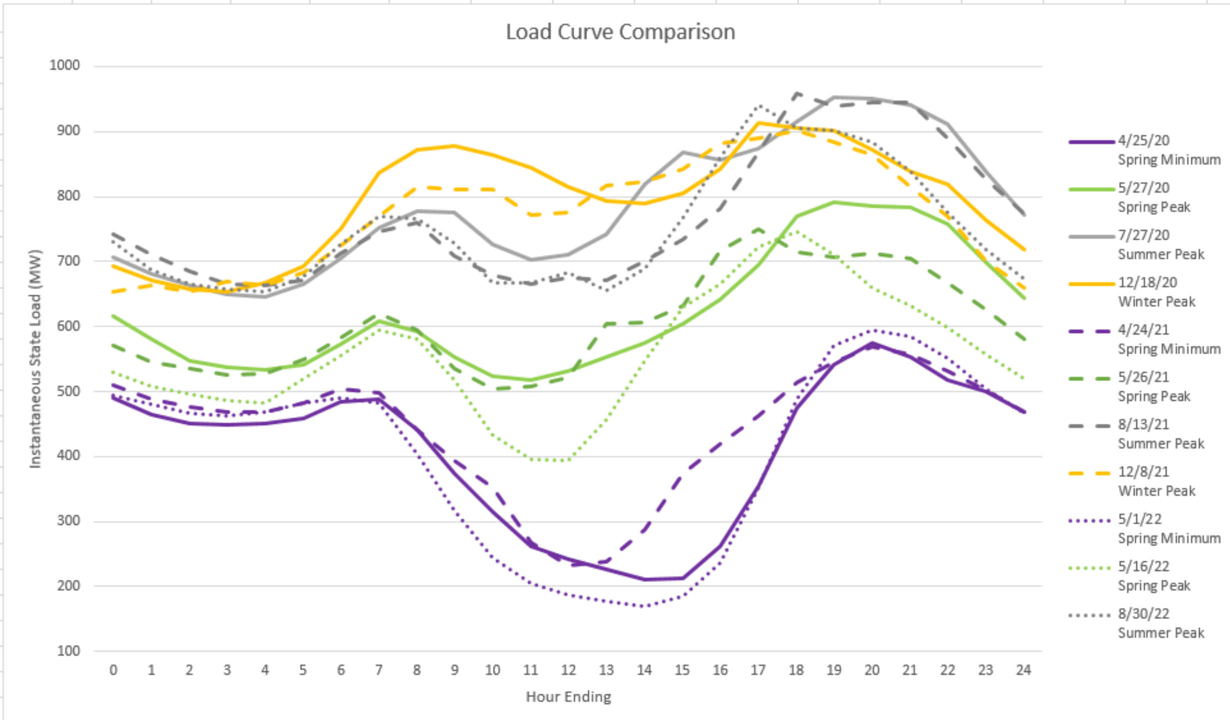


Figure 55: Sample of Vermont load shapes throughout the year, over the last three years [114]

In fact, it's increasingly clear that that net-metering will necessitate – rather than reduce – the need for additional electric infrastructure. This dynamic is directly related to the large amount of solar net-metering (317 MW) and other distributed solar (another 147 MW) in Vermont compared to daytime gross load (which can reach as low as about 650 MW), particularly on a localized basis, where solar penetration can be so high that at times, generation exceeds load at the distribution transformer. When that happens, a number of reliability issues and potential costs can arise. According to IEEE,

> *One of the more frequent issues utilities will have to address is the potential for a large amount of substation transformer backfeed stemming from reverse power flow on distribution circuits. Excess PV output on the distribution system during periods of minimum daytime loading causes a number of issues for utility planning and operation, such as temporary overvoltage conditions, the need for protection schemes modifications, and equipment failure from an increase in voltage regulation operations.*[115]

[114] Source: VELCO

[115] https://ieeexplore.ieee.org/document/8274081

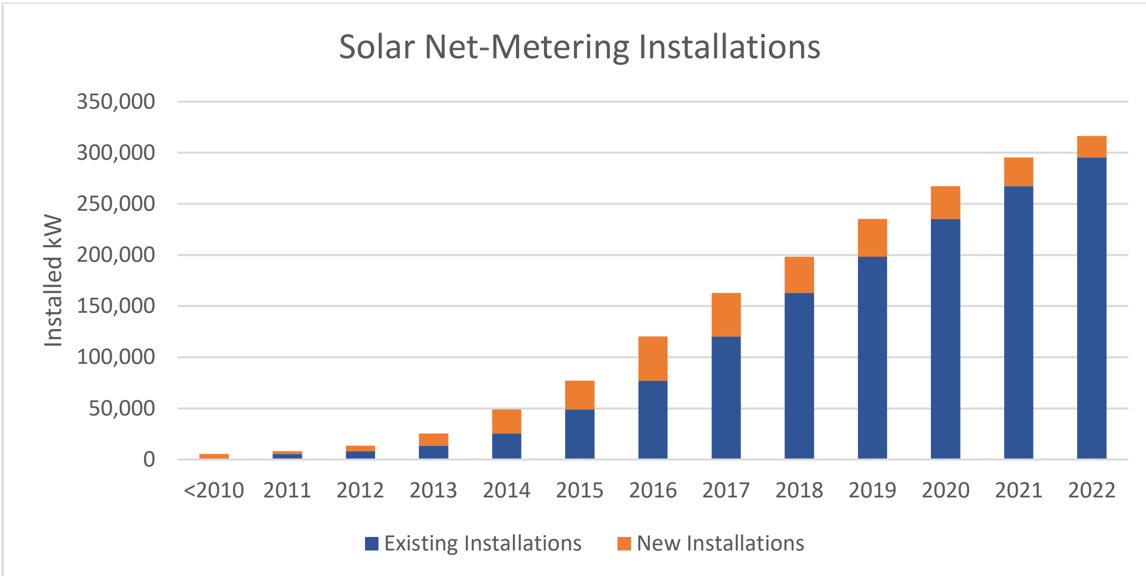


Figure 56: Vermont Solar Net-Metering Installations by Year [116]

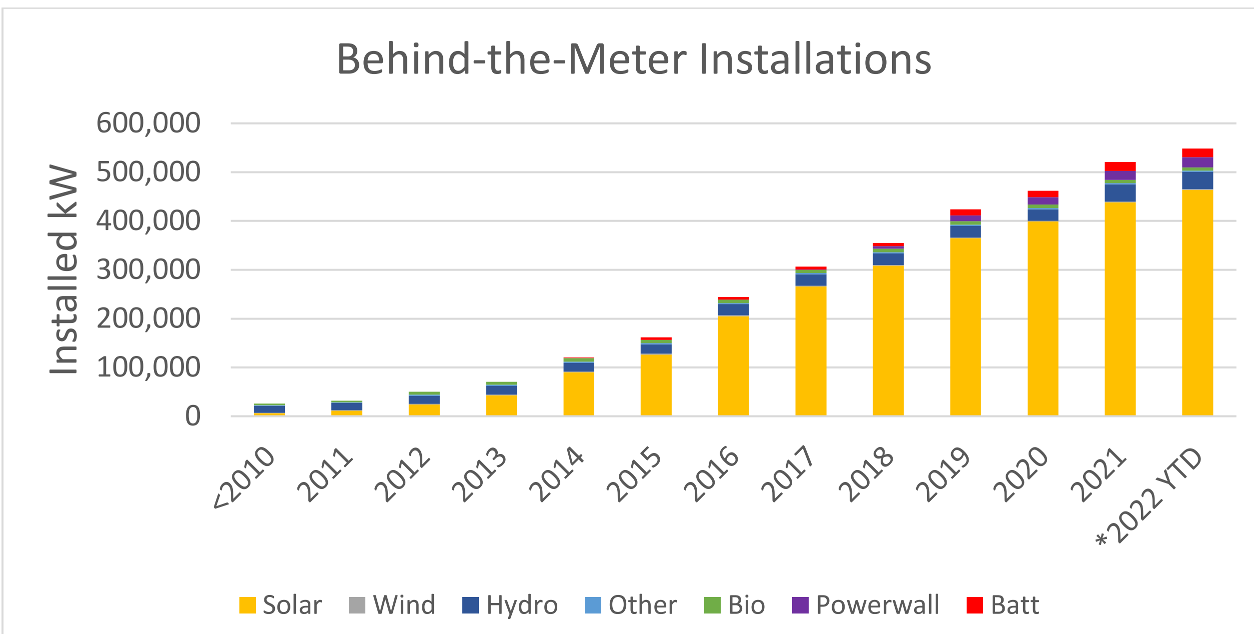


Figure 57: Vermont Behind-the-Meter Installations by Technology [117]

The blanket solution that could address so-called overgeneration is to upsize substation transformers – to the tune of several million dollars apiece. Historically, regulatory policy calls for assigning costs to cost causers. However, this becomes challenging in the case of net-metering, where the impact on the system is created by the cumulative effect of tens or hundreds

[116] Derived from utility monthly DG resource surveys to ISO-NE through October 2022

[117] Ibid.

of existing net-metering generators that slowly utilize the remaining headroom on a substation transformer. New approaches of distributing costs to interconnected DERs are emerging.[118]

In Green Mountain Power ("GMP") territory, for example, at least 22 of 164 substations are approaching or already at substation capacity. For at least one type of upgrade – Transmission Ground Fault Overvoltage or "TGFOV" – the Public Utility Commission has approved a methodology for addressing a potential grid liability by allowing GMP to collect an additional fee from interconnecting net-metering resources that goes into a fund used to pay for mitigating upgrades.[119] The map below shows circuits in GMP service territory, color-coded according to "room" on the substation transformer for additional generation. Projects proposed in areas outlined in gray are subject to the TGFOV fee; and the key explains limitations in other shaded areas (e.g., red circuits connect to the most highly generation-constrained substations).[120]

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118 https://www.nrel.gov/dgic/interconnection-insights-2018-08-31.html

119 See Case No. 19-0441-TF

120 GMP Solar Map, available at https://www.arcgis.com/apps/webappviewer/index.html?id=4eaec2b58c4c4820b24c408a95ee8956, accessed 12/14/20. Burlington Electric Department has a similar map available here: http://burlingtonvt.maps.arcgis.com/apps/Embed/index.html?webmap=bb1b9156d8294e308ecfe803131e8c00&extent=-73.2731,44.4574,-73.1094,44.5091&zoom=true&scale=true&legend=true&disable_scroll=false. And VEC's is here: https://www.arcgis.com/apps/mapviewer/index.html?webmap=3d526efbc62b4ab78aa5d2b56b3b8fef.

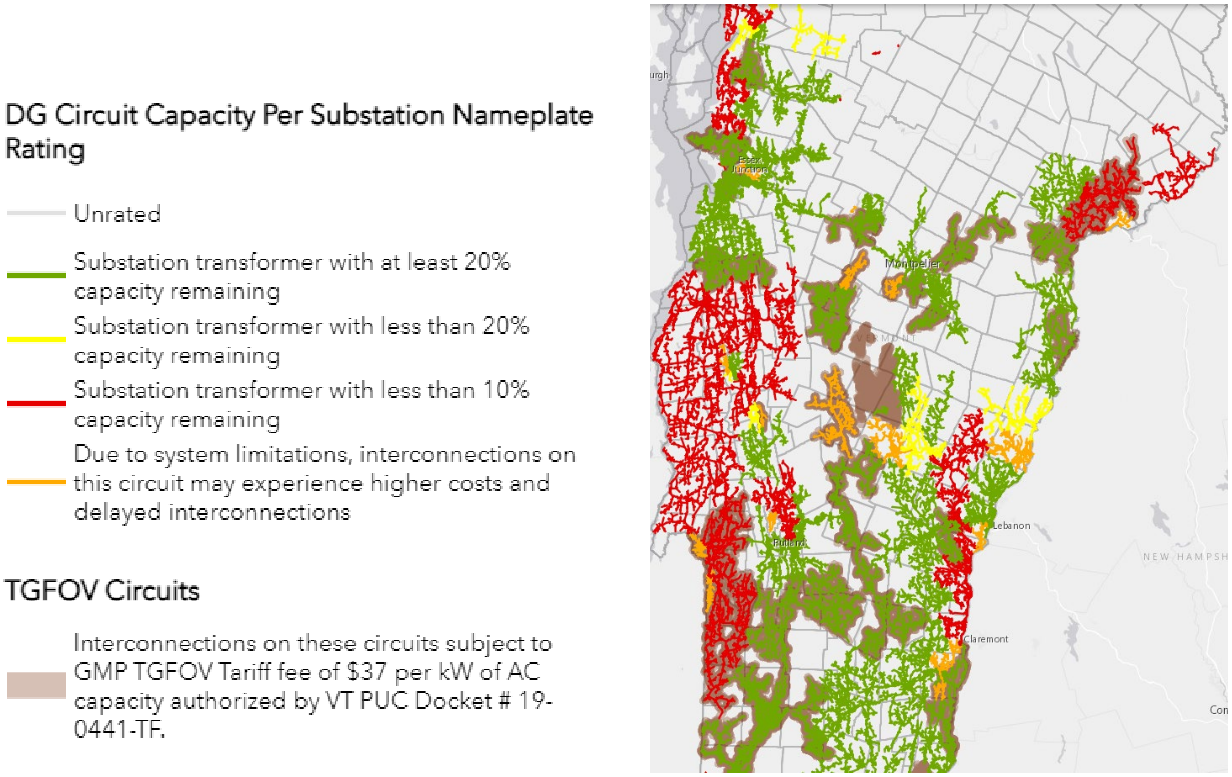


Figure 58: Green Mountain Power DG Circuit Capacity

One of the main challenges for Vermont policymakers, regulators, and utilities to address as net-metering (and other renewables programs) evolve is how to address such generation-constrained areas in the myriad renewables policies, programs, regulations, and tariffs, from net-metering to transmission planning and interconnection requirements. The TGFOV tariff is one example; another is the impact fee that larger-scale net-metering resources interconnecting in the so-called Sheffield Highgate Export Interface ("SHEI") area of Vermont's transmission system currently pay.[121] This area of northern Vermont has roughly ten times more generation than load, resulting in curtailment of generation – including ratepayer-funded generation – about 20% of the time (and every additional renewable generation source interconnected exacerbates the curtailment).[122] Because distributed renewable energy has also boomed in other New England states – with whom we share a transmission grid (and related expenses) to transport wholesale generation across the region – these questions are starting to matter to the region's transmission grid planner and operator, ISO-NE, too.

As solar penetration has increased across the region, resulting load patterns reflect the "bite" behind-the-meter solar has taken out of midday electricity demand – meaning once the sun sets, demand that had been served (and "masked") by distributed solar suddenly "reappears" to grid

[121] See Case No. 20-3304-PET. The fee for recent projects has been ~$75/kW and is calculated to make ratepayers whole for utility-owned generation curtailments based on present generation, load, and transmission conditions in the SHEI.

[122] https://www.vermontspc.com/grid-planning/shei-info.

operators and must be served by other types of resources. This phenomenon, first observed in California, is commonly known as the "duck curve."[123] In the screen capture of ISO-NE's dashboard below (taken 12/21/22), the curve is apparent.

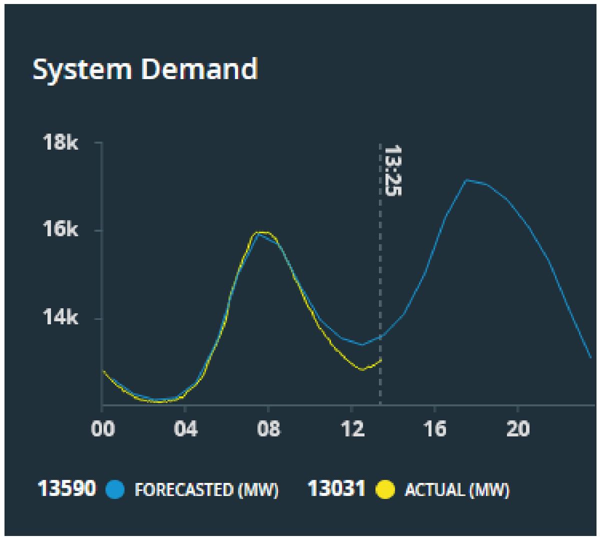


Figure 59: ISO-NE Energy Dashboard [124]

A decade or so ago, distributed solar had just started eating into mid-day peak demand in the region. ISO-NE recently analyzed solar penetration and demand from 2012 to 2015, in order to estimate demand reductions from each increment of solar installed going forward. Figure 11 shows estimated peak reductions per MW of installed solar and demonstrates the diminishing returns as penetration increases. (This assumes no change in the demand profile of load or the generation profile of solar – both of which are, however, becoming increasingly likely as flexible load and energy storage technologies rapidly evolve and come down in cost.)

123 https://www.nrel.gov/news/program/2018/10-years-duck-curve.html
124 https://www.iso-ne.com/ (retrieved 12/21/22 at 1:31 p.m.)

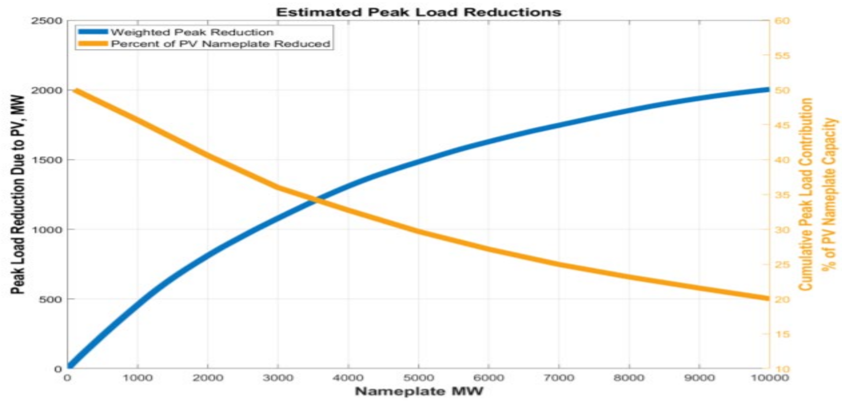


Figure 60: ISO-NE Peak Load Reductions Due to Solar [125]

ISO-NE has spent considerable time conducting its Transmission Planning for the Clean Energy Transition (TPCET) initiative in recognition of the growing penetration of distributed solar and other DERs and the commensurate complexities in planning a reliable transmission system around potentially millions of resources it cannot see or control.[126] ISO-NE anticipates incorporating additional study conditions beyond peak demand, including the intersection of high/low demand with high/low solar production, as it begins to observe extremely low midday net loads. Additionally, ISO-NE is evaluating tradeoffs between flexibility and reliability, including risks of fleets of DERs tripping offline in response to transmission faults, and other novel conditions related to high penetrations of inverter-based resources, including grid stability and inertia. ISO-NE is also commencing a second phase to this effort, Economic Planning for the Clean Energy Transition, which will address such topics as the input assumptions and capabilities of tools used for economic analyses and will perform a dry-run of new economic study process improvements.[127] In its upcoming study of the Vermont system (called a Needs Assessment), ISO-NE will evaluate the transmission reliability impacts of high amounts of distributed renewable generation production that coincides with low load levels, incorporating those lessons learned and methodologies derived from the TPCET.

To enable growing penetrations of distributed generation in Vermont, the Department and others are examining more precise, less expensive ways to address the issue of overgeneration than upsizing substation transformers. These all focus on better orchestration of generation and load and range from directing generation toward or away from particular locations to time-shifting generation or load with storage, to maximizing the abilities of "smart inverters" to curtail excess generation. The key to many of these solutions is implementation of rate signals that direct the

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125 See https://www.iso-ne.com/static-assets/documents/2020/03/3_peak_load_reductions_update.pdf

126 https://www.iso-ne.com/static-assets/documents/2022/05/a10_tpcet_follow_up_and_roadmap_for_future_needs_assessments.pdf

127 https://www.iso-ne.com/static-assets/documents/2022/08/a7_epcet_pilot_study_new_modeling_features_and_initial_benchmark_scenario_results.pdf

owner of a DER, including a flexible load resource, to alter its behavior in response to a price signal associated with a grid requirement. A complementary tool is direct control of DERs by a utility (or third party on behalf of a utility), though given the proliferation of DERs, this is likely going to require investment in real-time situational awareness, monitoring, and control tools, some of which are not yet commercially available. In 2019, the Department undertook a Rate Design Initiative to explore some of these concepts, which culminated in a report recommending strategies to implement rates.[128] An ad-hoc subcommittee of the Vermont System Planning Committee began examining how flexible loads, energy storage, and curtailment can be used – singly or in concert – to enable additional distributed generation on a constrained circuit.[129] This and similar work will be picked up by the emergent Technical Working Group initiated by the Department and housed under the Vermont System Planning Committee.[130] The Department's proposal to reform net-metering compensation to value production consumed on-site higher than production exported beyond the customer meter would also have the effect of mitigating overgeneration and related infrastructure costs.[131]

## Benefits of Connecting to Distribution System

Net metering, as defined in statute, only works when the customer is connected to and benefiting from their electric utility's distribution system:

> ***30 V.S.A. 8002(15):*** *"Net metering" means measuring the difference between the electricity supplied to a customer and the electricity fed back by the customer's net metering system during the customer's billing period.*

As electric customers are generally subject to a monthly billing period, the "netting" generally takes place over a month. Under the current net-metering rule,[132] small systems located at customer premises generally serve load in real time (i.e., "spin the meter backward), and either send "excess" kilowatt-hours ("kWh") back into the grid or pull additional electricity from the grid to serve demand that is higher than (or needed at a different time than) production. Customer electric meters can measure both of these flows and at the end of the month utility billing departments net excess kWh with utility-delivered kWh. If there are net kWh delivered, they are billed at the residential or other applicable rate. If there are excess kWh generated, those are credited to the customer at the applicable base rate (for most customers, this will be a blend of the statewide residential rates).

Separately, "gross" kWh produced by the net-metering system – measured by a separate production meter – are multiplied by applicable adjustors, which can either be positive or negative depending on the system's size and siting. The resulting credit (or debit) is also applied

[128] https://publicservice.vermont.gov/content/rate-design-initiative
[129] https://www.vermontspc.com/vspc-at-work/subcommittees
[130] https://www.vermontspc.com/library/document/download/7631/22%20Oct%2026%20VSPCagenda_cleaned.pdf
[131] See Case No. 19-0855-RULE, 11/1/19 *Department of Public Service Report on Public Utility Commission Net-Metering Information Requests*
[132] Net-Metering Rule Effective 07-01-2017 - 5100-PUC-nm-effective-07-01-2017_0.pdf

on customer bills. Credits cannot be used toward "fixed charges" such as the customer charge,[133] but they can roll over for a 12-month period, which enables customers to carry over excess production from summer to winter months *on paper*. For group net-metering systems – often larger, 150 kW or 500 kW – more often than not, all production is considered to be excess and is generally applied as a credit to all subscribers of the system, who can be located anywhere in a utility service territory.

In addition to relying entirely on the distribution system for the mechanics of net-metering, net-metering customers are also reliant on the distribution system to serve load that their net-metering systems are unable to meet: in real time, throughout the day, at night, and over the course of the year. If a customer wanted to rely entirely upon their own distributed generation, they would need to add battery storage and size their overall system to meet their power needs throughout the year. Utilities are obliged to serve their customers, safely and reliably, and must ensure they have resources to meet and serve customer demand regardless of the existence and behavior of that customer's net-metering system.

Group systems generally send all of their production directly to the distribution grid. None of it is offsetting on-site load, and utilities therefore treat it all as "excess," allocating monetary credits to subscribers based on total production multiplied by the applicable base rate and by the applicable adjustors. Customers of these systems are entirely dependent on the grid and utility to supply their electricity demand. Without the net-metering construct, these customers would not be able to associate the virtual net-metering system with their home or business accounts.

Net-metering customers in Vermont participate in the program for a variety of reasons, from reducing their electric bill to participating in the state's renewable expansion and decarbonization. Because the state's electricity mix is highly renewable overall (71%, and 100% in some utility territories), and the greatest opportunity reduce emissions is in the transportation and heating sectors (including by electrification), it may be more impactful at this point in time for customers to instead invest in electric vehicles and heat pumps – and for policymakers to work to limit the rate impacts from net-metering in order to encourage use of electricity for these purposes.

## Costs and Benefits of Reliability and Supply Diversification

Electric grid reliability is governed by specific requirements and standards, at both the bulk and distribution system levels – and net-metering systems have potential impacts, both positive and negative, on both. The primary reliability authority is the Federal Energy Regulatory Commission ("FERC"): "All users, owners and operators of the bulk power system must comply with the mandatory Reliability Standards developed by the electric reliability organization and approved by FERC."[134] ISO-NE, Vermont Electric Power Corporation (VELCO, Vermont's

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[133] Systems installed under pre-2017 rules were allowed to apply credits toward fixed charges and continue to be able to do so for ten years from their commissioning date, at which point they revert to net-metering tariffs in place at that time.

[134] https://www.ferc.gov/sites/default/files/2020-04/reliability-primer_1.pdf, p. 39.

transmission system operator), and others subject to this definition must comply with reliability standards set by the North American Electric Reliability Corporation ("NERC"),[135] and the Northeast Power Coordinating Council ("NPCC").[136] Distribution utilities are further subject to regulation by the Vermont Public Utility Commission and are required to file Service Quality and Reliability Plans, with reporting on metrics such as the frequency and duration of outages.

At each of these levels, distributed energy resources such as net-metered solar are bubbling up as an area for greater attention and focus. For instance, see NPCC's *DER Guidance Document, Distributed Energy Resource (DER) Considerations to Optimize and Enhance System Resilience and Reliability*.[137] These two concepts – resilience and reliability – are often used interchangeably, but the Department believes careful usage and definition of each term is essential to ensuring that stakeholders discussing impacts of a resource such as net-metering on reliability, or resiliency, are not talking past each other. Reliability is a core tenet of Vermont energy policy:

> *30 V.S.A. § 202a: It is the general policy of the State of Vermont:*
>
> *(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.*

It is also a core tenet of the concept of "energy assurance," as articulated in Vermont's Energy Assurance Plan (itself part of the state's Emergency Operations Plan) where energy assurance is defined as:

> "*The ability to obtain, on an acceptably **reliable** basis, in an economically viable manner, without significant impacts due to Energy Supply Disruption Event(s), or the potential for such events, sufficient supplies of the energy inputs necessary to satisfy Residential, Commercial, Governmental, and non-governmental requirements for Transportation, Heating (space and process heat), and Electrical Generation."*[138]

In other words, reliability is a strictly defined term subject to specific standards (e.g., SAIDI, CAIDI, SAIFI), metrics, reporting, enforcement, and penalties. It is, foundationally, about avoiding "loss of load," or power outages, both in number and duration, during day-to-day operations, with metrics focusing on reliability performance over a specified period of time. NERC defines a reliable bulk power system as, "one that is able to meet the electricity needs of end-use customers even when unexpected equipment

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135 https://www.ferc.gov/industries-data/electric/industry-activities/nerc-standards

136 https://www.npcc.org/program-areas/standards-and-criteria/regional-standards

137 https://www.npcc.org/content/docs/public/program-areas/standards-and-criteria/der-forum/2020/der-v2-11-20-2020.pdf

138 https://publicservice.vermont.gov/sites/dps/files/documents/VT%20Energy%20Assurance%20Plan%20August%202013.pdf

failures or other factors reduce the amount of available electricity."[139] The concept includes both *resource adequacy* – i.e., sufficient supply – and *security*, or the ability to withstand sudden, unexpected disturbances, either natural or man-made.

Resilience (or resiliency), on the other hand, is more of a term of art, subject to a variety of proposed definitions, with an evolving landscape of potential metrics, but without specific regulatory "teeth."

FERC has proposed the following definition of resilience, which has been adopted by NERC: "The ability to withstand and reduce the magnitude and/or duration of disruptive events, which includes the capability to anticipate, absorb, adapt to, and/or rapidly recover from such an event."[140] Resilience, unlike reliability, is usually thought of in terms of a specific, low-probability, high-impact event. But without imposition of a measurement or valuation framework, it is not particularly meaningful to describe a grid as resilient, or to describe a resource as providing grid resilience. The U.S. Department of Energy, national labs, academia, and industry organizations are working on various frameworks to value resilience, but none has yet emerged as an industry standard, or been adopted in Vermont as a guiding framework. Ongoing metrics-defining work of the Department, utilities, and Climate Council – described further in Chapter 4 of the 2022 CEP[141] – should help in this regard, with time.

Net-metering, as a financial mechanism for incentivizing development of renewable energy systems by crediting customer bills for the production from those systems, does not have any defined relationship with the concepts of either reliability or resiliency. Small, distributed solar – the predominant type of system being incentivized with the net-metering program – potentially impacts both, in positive as well as negative ways. Distributed solar on its own is not going to keep customers' lights on if the grid goes down, unless additional investments in storage and protections are made in specific areas of the grid to benefit specific customers – such as in the case of those customer-sited battery storage programs or community microgrids.[142] A customer – or group of customers, in the case of a microgrid – with a battery storage system may be able to continue to power specific loads for 1-2 days, longer if their "island" includes a solar system. In that sense, many net-metered systems can be considered to be a *precursor* to enhanced reliability (or, potentially, resiliency).

In terms of individual generation projects, impacts on grid reliability are reviewed through the interconnection process, which is required for a system to obtain a Certificate of Public Good and to interconnect to the grid.[143] A system might be required to install specific protective

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139 https://www.nerc.com/AboutNERC/Documents/NERC FAQs AUG13.pdf

140 https://elibrary.ferc.gov/eLibrary/#, Order Terminating Rulemaking Proceeding, Initiating New Proceeding, and Establishing
Additional Procedures, 162 FERC ¶ 61,012, para. 14, FERC Dkt. No. AD18-7-000 (Jan. 8, 2018). Pp. 12-13.

141 https://publicservice.vermont.gov/about-us/plans-and-reports/department-state-plans/2022-plan

142 In those programs, customers pay for the enhanced personal grid reliability offered by the battery storage, while all the utility's customers both pay for and gain benefit from the other values provided by the storage in the aggregate, such as reducing peak-related charges. https://greenmountainpower.com/rebates-programs/home-energy-storage/; https://vermontelectric.coop/flexible-load

143 https://Commission.vermont.gov/document/commission-rule-5500-electric-generation-interconnection-procedures

equipment in order to demonstrate it will not adversely impact system stability and reliability – though small, customer-sited net-metered systems are unlikely to trigger such requirements. However, like the aggregated impacts on grid infrastructure discussed earlier, the cumulative impact of many small systems can eventually impact grid reliability in ways that are impossible to associate with any one individual system.

Another way net-metered systems act as a precursor to enhanced grid reliability lies in the inverters tying these systems to the grid. What is currently viewed as a reliability liability from the growing fleet of these resources – the potential for a fault on the grid to trip the fleet offline like so many dominoes, taking a chunk of supply offline all at once – can be mitigated with upgrades to inverter equipment or modification of settings. Most net-metered solar in Vermont is tied to the grid with inverters (converting DC production to AC supply aligned with the grid) that signal the system to trip offline if they sense a grid perturbance. This is a safety function – if the power fails and a net-metered system is still energized, lineworkers coming into contact with the facility could be electrocuted. However, to encourage systems to stay offline in conditions shy of power outages and thus support the system, ISO-NE has issued a so-called "Source Requirements Document" ("SRD"), specifying inverter settings during the interconnection process to ensure inverters ride through grid perturbances.[144] Most – if not all – utilities in Vermont require interconnecting customers to follow the SRD specifications. As advanced inverters enter the marketplace, distributed solar employing these inverters (new systems and replacements for existing systems at the end of inverter life) hold potential to become a newfound source of grid support services, particularly if interconnection standards encourage them to do so.[145]

At the Vermont System Planning Committee October 22, 2022, quarterly meeting, VELCO shared details from a July transmission event where an outage in New York caused grid frequency to rapidly fall and net load to increase in New England.[146] About half of the load increase was in Vermont, and this was likely due to distributed solar PV units tripping offline as a result of sub-optimal inverter settings. Ensuring use of smart inverters compliant with IEEE 1547-2018, full implementation of that standard by distribution utilities, and considering ways to update settings on existing inverters and incent/confirm settings on new or replacement inverters are all important steps to ensuring Vermont's fleet of net-metering resources enhances – and does not degrade – grid reliability and resilience. The Technical Working Group being led by the Department should help advance this conversation.

144 https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwj68rK0vMTtAhVYVs0KHTd7CxQQFjACegQIBBAC&url=https%3A%2F%2Fwww.iso-ne.com%2Fstatic-assets%2Fdocuments%2F2018%2F02%2Fa2_implementation_of_revised_ieee_standard_1547_presentation.pdf&usg=AOvVaw1XF4tUehcQv9wj9zRgdIRg

145 https://www.energy-storage.news/blogs/the-long-awaited-ieee-standard-that-paves-the-way-for-more-energy-storage-o

146 https://www.vermontspc.com/library/document/download/7632/VSPC_Event_tripping_DG.pdf

Other ways to harness the net-metered solar fleet to enhance grid reliability include coupling systems with on-site or upstream storage to firm production or to store-and-release production to better match loads; encouraging system sizing to match on-site or area load; and implementing real-time grid visibility tools to enable situational awareness by system operators. These actions all require additional investment. It is inconsistent with least-cost planning principles to require ratepayers who already pay nearly twice as much for net-metered solar as they would for other RES-eligible solar to also have to bear costs associated with better integrating this fleet of resources in order to maintain or enhance grid reliability. This is especially true when there are many other reliability investments that could yield greater benefits for the same amount of investment, including the basics such as tree trimming, moving cross-country poles to roadsides, animal protections, looping radial lines, and even undergrounding lines.

In general, having more diversity in type, size, scale, and vintage of resources is generally considered to bolster grid reliability and the robustness of resource portfolios (i.e., avoiding the problem of all the eggs in one basket). Distributed solar has increased these types of diversity in Vermont and the New England region over the last decade, but if solar continues to dominate as a resource type, benefits associated with that particular type of diversity will diminish. Distributed solar reduces Vermont's net loads and the need to purchase energy to serve load, when the solar fleet is producing. However, in the region as a whole, each additional MW is shifting out the peak further into the evening, meaning incremental new solar will deliver energy at times it is not needed, necessitating utilities to resell excess supply at times when regional market prices are low (because everyone is doing the same thing). This issue is heightened in Vermont where utilities have invested through utility-owned generation or long-term contracts in non-solar renewable generation in order to fulfill statutory requirements.

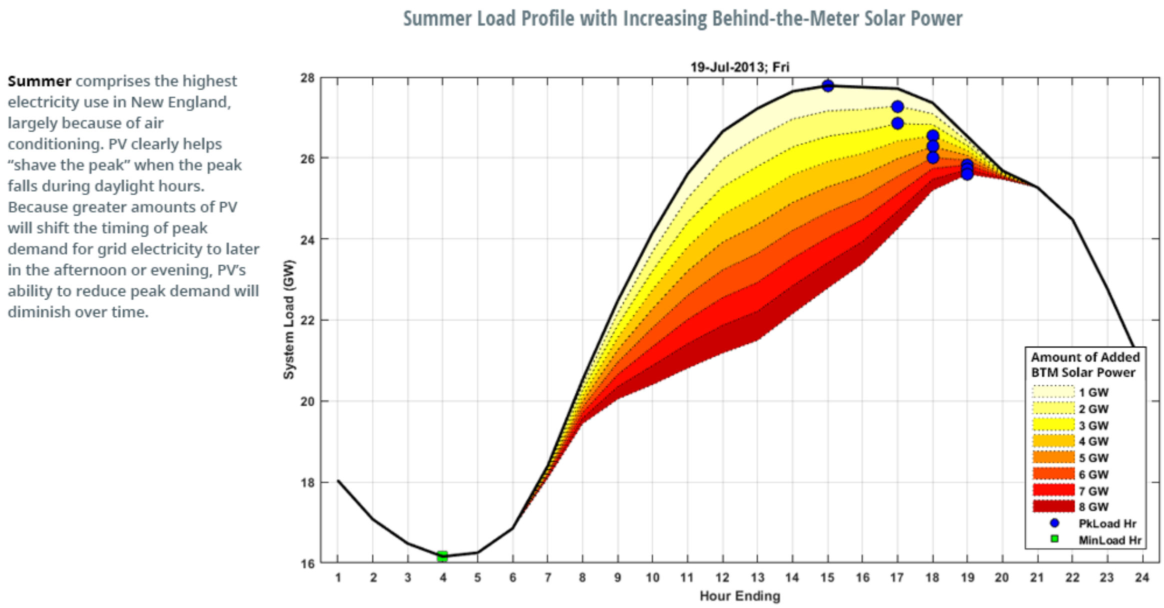


Figure 61: ISO-NE Summer Load Profile with additional behind-the-meter solar [147]

Figure 12 from ISO-NE shows the impact solar has had on net loads visible to the regional system operator, pushing them out into evening – a shape that will be exaggerated with the addition of electric vehicles that want to charge in the evening.

In addition, utilities and system operators need to ensure sufficient resources are online to meet load regardless of the weather. Weather forecasting is becoming an increasingly powerful and accurate tool for assessing next-day and real-time demand in order to ensure sufficient resources are lined up to meet that demand, but long-term, day-to-day and minute-by-minute variability in storms and cloud cover for non-firm solar resources means grid planners and operators may need to discount solar's availability (and thus contribution to meeting load and supplanting other resources). Figure 13 below shows the contribution (and resulting net load shapes) of solar on a cloudy vs. A sunny spring day, and the screen-capture of the regional system in real time just below that, Figure 14, shows the impact of winter storm Gail's snow cover on forecasted demand.

[147] https://www.iso-ne.com/about/what-we-do/in-depth/solar-power-in-new-england-locations-and-impact

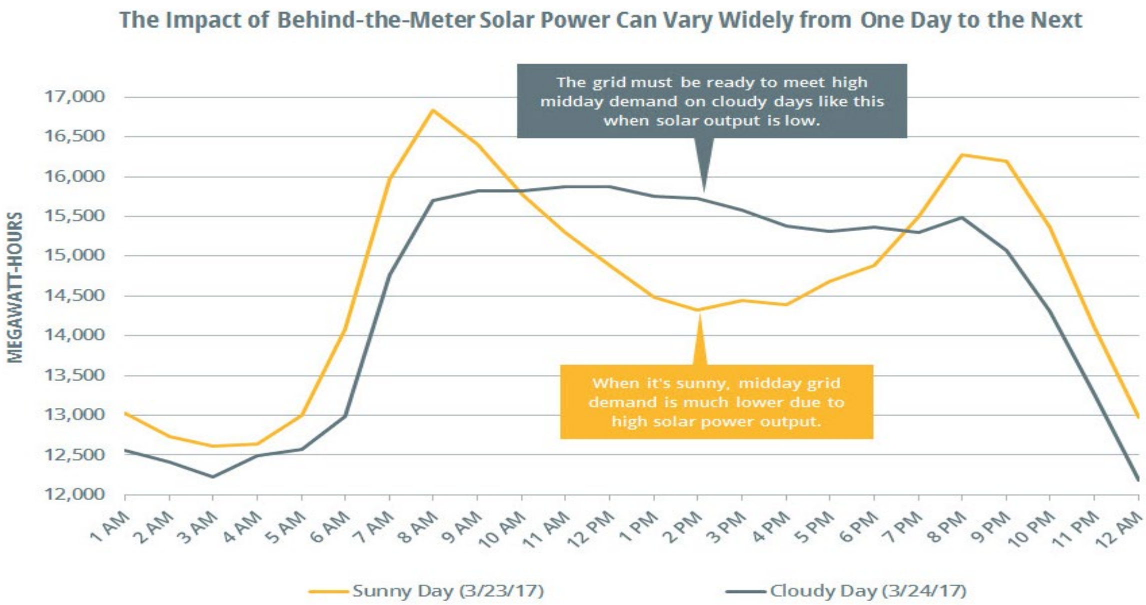


Figure 62: ISO-NE load shape with and without solar [148]

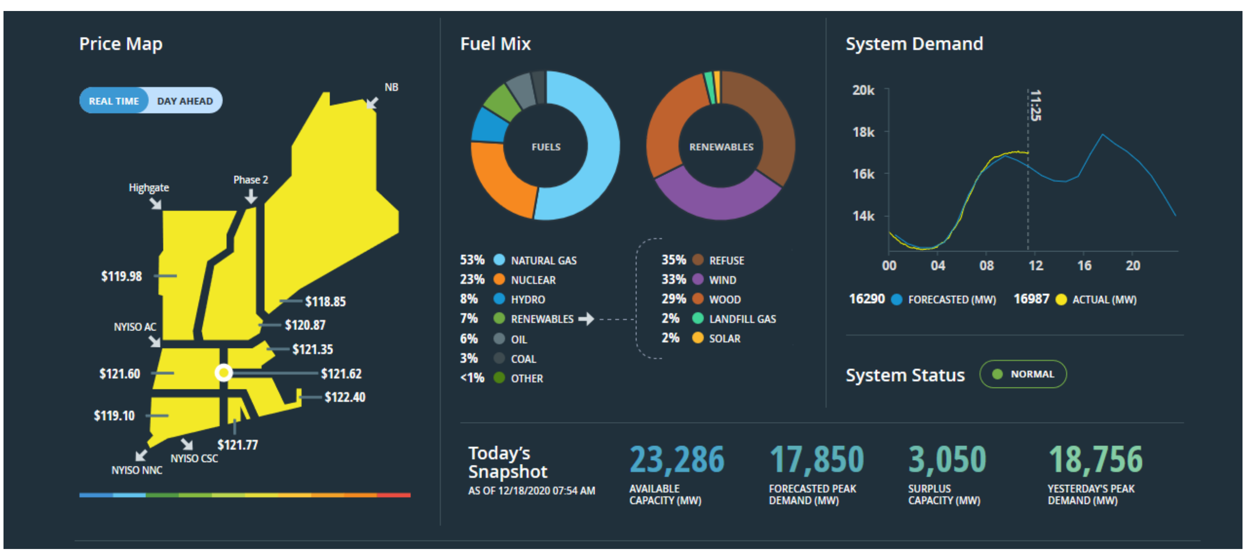


Figure 63: ISO-NE Energy Dashboard [149]

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148 See note 36.

149 ISO-NE.com, screenshot taken at 11:30 a.m. On 12/18/20, the day after winter storm Gail. Relatively sunny conditions prevailed across the region, which ISO-NE likely took into account when they forecasted solar output decreasing midday-demand. The actual demand remained high, however, leading to increased prices and fossil fuel generation coming online. The Department interprets this chart to indicate many solar installations remained covered in snow, and it's unclear when they would start to again contribute to reducing loads.

While net-metering deployment has diversified resource supply in terms of size, it has been almost entirely composed of solar with uniform generation profiles that are becoming less well aligned with customer, circuit, utility, and regional load profiles as penetration increases.

In other words, distributed solar is becoming one of the single biggest resources in Vermont's portfolio, with an installed capacity at over 45 percent of state peak load (higher when considering average or low load days and months), with even higher penetrations in some areas. Without changes to programmatic frameworks to better align production with loads (and vice versa), the value provided by net-metered solar will become increasingly disconnected from the compensation it is paid. Additive to the gulf between what ratepayers are paying for this resource and its value are costs to integrate the solar fleet as it stresses the distribution system. Meanwhile, costs to serve load during non-solar hours and days remain. All these additional costs add to rate pressure, and keeping electric rates low is one of the most important measures Vermont can take to encourage electrification – and thus decarbonization – of the carbon-heavy heating and transportation sectors. A comprehensive approach to decarbonization, electrification, increasing renewables, grid modernization, and managing rates and costs is thus imperative to achieving Vermont's energy and climate goals in a least-cost manner.

## Best Practices in Net Metering

Nationally, traditional net-metering – which typically involves crediting a customer for excess generation at the full retail rate the customer pays for energy services from the grid – is the most common program for customers who deploy small-scale generation. According to the North Carolina Clean Energy Technology Center, as of August 2021, 39 states, the District of Columbia, and four U.S. Territories had mandatory rules regarding net-metering programs.[150]

[150] North Carolina Clean Energy Technology Center, DSIRE. N*et Metering Policies (Updated June 2020)*. Retrieved from https://www.dsireusa.org/resources/detailed-summary-maps/

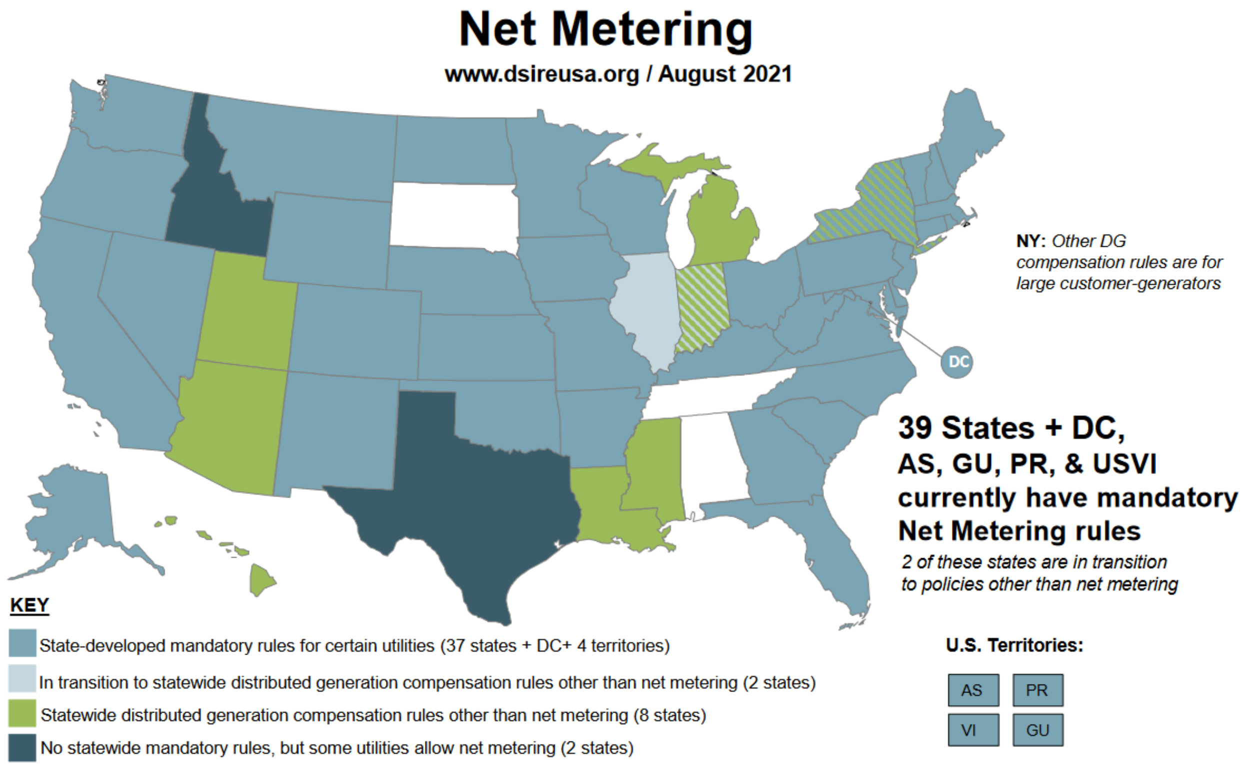


Figure 64: Summary of states with net metering rules

While traditional net-metering programs have helped stimulate the markets for small-scale, renewable distributed generation, as these programs have matured, a growing number of states (including Vermont) have started to explore and/or transition to alternative programs to support these resources. These reviews have been spurred by numerous reasons including:[151]

- Hitting previously established aggregate systems caps for traditional net-metering
- Proposals by utilities for alternative structures that better reflect the value these resources provide to the grid
- Concerns that net-metering customers are not fairly contributing to utility fixed costs and/or are being subsidized by non-participating customers
- Other legislative or regulatory requirements

Outside of Vermont, a growing number of states either have transitioned or are in the process of transitioning to alternative compensation structures for distributed generation. New net-metering and distributed generation programs focus on shifting several aspects of traditional net-metering rate designs in efforts to more accurately reflect the value of these resources to the grid and cost-shifts among customers, including: the rate at which excess generation is compensated; treatment of fixed charges and minimum bills for customers; and even creating separate customer classes

[151] Stanton, T. (2018). R*eview of State Net Energy Metering and Successor Rate Designs.* Retrieved from https://pubs.naruc.org/pub/A107102C-92E5-776D-4114-9148841DE66B/

for customers who own distributed generation resources.[152] In Q3 of 2022 alone, 40 states and the District of Columbia took 174 actions on distributed solar policy and rate design, with the top three actions involving distributed generation compensation rules (taken by 26 states, 33% of actions), community solar (22 states + DC, 26% of actions), and residential fixed charges or minimum bill increase (18 states, 16% of actions).[153]

As markets for solar and other distributed generation technologies have matured, many states have made concerted efforts to move away from traditional net-metering programs and identify alternative compensation mechanisms. These new programs aim to reflect the value these resources currently provide to the grid more accurately and reduce cost shifts to non-participating customers. The prior version of this report provided a detailed list of alternative structures under consideration by various states.[154] This report focuses on the most significant recent change in the last year: the modifications made to California's net-metering program finalized in mid-December 2022.

On December 15, 2022, the California Public Utilities Commission ("CPUC") adopted a proposal to shift from a net-metering framework to a net-billing framework for new systems starting in April 2023.[155] In a net-metering framework, a customer's net-metering system production is netted with their consumption, and any excess generation is credited at (or based on) the customer's retail rate. Customers with systems that are oversized for their load can therefore use full-retail-rate-value credits to offset their consumption even when their systems aren't producing any power, and they are physically leaning on grid power (in the winter, for example). Further, production from large, virtual systems – which are directly connected to the grid don't physically supply their associated customers at all – is entirely credited at a retail-based rate. In a net-billing framework, compensation for excess generation is made at a rate other (and usually lower) than the retail rate.

The CPUC's net-billing framework consists of the following primary elements:

- Requires participating customers to be on "electrification rates." Net-metering customers were already required to be on time-of-use rates; electrification rates exaggerate the delta between peak- and off-peak pricing, encouraging customers to use their solar plus battery storage, to time-shift consumption away from high-demand hours (which are also the most expensive, highest-emission hours).

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[152] Stanton, T. (2018). R*eview of State Net Energy Metering and Successor Rate Designs. R*etrieved from https://pubs.naruc.org/pub/A107102C-92E5-776D-4114-9148841DE66B/

[153] North Carolina Clean Energy Technology Center, The 50 States of Solar: Q3 2022 Quarterly Report, October 2022. Retrieved from https://www.dsireinsight.com/s/Q3-22_SolarExecSummary_Final.pdf

[154] https://publicservice.vermont.gov/sites/dps/files/documents/Pubs_Plans_Reports/Legislative_Reports/2021%20Annual%20Energy%20Report%20Final.pdf, Appendix E

[155] https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/demand-side-management/net-energy-metering/nem-revisit

- Credits excess generation based on its time of export to the grid, which is in turn based on the avoided cost to the utility of procuring energy at that time.
- Provides extra bill credits to participating customers for the next five years, as well as to low-income customers[156]

The CPUC wrote in their final decision:

> *A review of the current net energy metering tariff, referred to as NEM 2.0, found that the tariff negatively impacts non-participating ratepayers, disproportionately harms low-income ratepayers, and is not cost-effective. This decision determines that, to address the requirements of the guiding principles and the findings related to the NEM 2.0 tariff, the successor tariff should promote equity, inclusion, electrification, and the adoption of solar paired with storage systems, and provide a glide path so that the industry can sustainably transition from the current tariff to the successor tariff and from a predominantly stand-alone solar system tariff to one that promotes the adoption of solar systems paired with storage.*
>
> *In the successor tariff, the structure of the NEM 2.0 tariff is revised to be an improved version of net billing, with a retail export compensation rate aligned with the value that behind-the-meter energy generation systems provide to the grid and retail import rates that encourage electrification and adoption of solar systems paired with storage. The successor tariff applies electrification retail import rates, with high differentials between winter off-peak and summer on-peak rates, to new residential solar and storage customers instead of the time-of-use rates in the current tariff. The successor tariff also replaces retail rate compensation for exported energy with Avoided Cost Calculator values that vary according to grid needs. The high differential electrification retail import rates in combination with the variable retail export compensation rates provided by the Avoided Cost Calculator send strong price signals to customers to shift their use of energy from the grid to mid-day and export electricity during the evening hours, which promotes the installation of storage with the solar systems. These price signals also benefit customers who electrify their vehicles, home devices, and appliances. The changes will improve the reliability of electricity in California and reduce greenhouse gas emissions.*[157]

In Case 19-0855-RULE, the Commission explored net-metering compensation, in addition to other aspects. In its November 1, 2019, comments,[158] the Department recommended moving to a compensation structure that would minimize cost-shifts of Vermont's net-metering program, estimated to be $49 million in above-market costs in 2021 alone (see Table 3 above). The

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[156] https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/demand-side-management/net-energy-metering

[157] https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M500/K043/500043682.PDF

[158] November 1, 2019: Department of Public Service Report on Public Utility Commission Net-Metering Information Requests (19-0855-RULE), pp. 14-18

recommended structure is simpler than that adopted in California: it would value excess generation based on a levelized value of avoided cost, set at the time the project is permitted and fixed for 10 years. Customers with behind-the-meter systems would still net out consumption – in real time and in a billing cycle – at retail rate, so they would see very little change in the system economics. Large, virtual systems would be compensated at a value closer to that any other large, standalone solar system (such as a Standard Offer project) would receive, which would dramatically lower the above-market costs ratepayers pay for the net-metering program, given the degree of excess generation in the program (over 75% of generation from net-metered systems, per Table 3 above).

In its May 27, 2022 comments in the same case, the Department recommended that the Commission open a proceeding once the CPUC had issued a final order in its net-metering rulemaking – given similarities in the issues under consideration in both states – to look specifically at reforming net-metering compensation.[159] In its December 7, 2022 Order in 19-0855-RULE, the Commission asked for comments on further changes to Rule 5.100 and indicated that it intends to address compensation through a different proceeding. [160] The Department looks forward to the opportunity presented by this proceeding to better align net-metering compensation with its value to ratepayers, to ensure the program's sustainability and positive contribution to meeting Vermont's energy and climate requirements.

## Conclusion

Net-metering has made important contributions to Vermont's energy supply mix; however, after more than 20 years, hundreds of megawatts of installed projects, and an understanding of the premium paid by ratepayers for resources in this program, it is past time for an overhaul of the net-metering compensation structure. The primary resource developed under net-metering is solar generation, which is also being developed through competitive solicitations at substantially lower costs. It is imperative that the state be willing to take an objective view of current programs in order to properly evaluate what programs will meet Vermont's future energy policy and best serve Vermonters. The Department has embarked on a stakeholder process to review Vermont's electricity procurement programs, including the Renewable Energy Standard and its supporting programs such as net-metering, Standard Offer, and utility-owned or contracted projects. The Department looks forward to engaging with many different types of stakeholders to discuss attributes of a modern, sustainable, adaptable, grid-friendly compensation framework for distributed generation.[161]

[159] May 27, 2022: Department of Public Service Comments to the Vermont Public Utility Commission's Request for Comments on Draft Rule, pp. 1-2

[160] December 2, 2022: Order Regarding Further Proposed Revisions to Commission Rule 5.100 and Request for Comments (Case No. 19-0855-Rule), p. 18

[161] http://publicservice.vcms9.vt.prod.cdc.nicusa.com/announcements/psd-releases-proposed-public-engagement-plan-review-vt-renewable-electricity-policies