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REGULATORY ASSISTANCE PROJECT

Energy Savings, Demand Savings and Time-Varying Value: Research and Recommendations

Prepared for the Public Service Commission of Wisconsin

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Executive Summary

In its November 2022 Final Decision concerning the Quadrennial Planning Process IV, the Public Service Commission of Wisconsin directed its staff to conduct research into a series of topics. In this context, the Regulatory Assistance Project (RAP) was engaged to conduct research on two topics, which are the subject of this brief.

1. "Emphasis between energy use and demand"

The commission found it reasonable for Focus on Energy, Wisconsin's statewide efficiency program, "to perform additional research ... to assess strategies for achieving greater demand savings and better understand the additional value of demand savings."[2]

2. "Time-varying value of energy efficiency and renewable resources"

The commission directed Focus on Energy to "investigate opportunities to integrate the time-varying value of energy efficiency and renewable energy into program operations."[3]

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[2] Public Service Commission of Wisconsin, Quadrennial Planning Process IV, Final Decision on November 14, 2022, pp. 10–11. https://apps.psc.wi.gov/ERF/ERFview/viewdoc.aspx?docid=453081

[3] Public Service Commission of Wisconsin, November 14, 2022, pp. 10–11.

RAP's research indicates that more-accurate data and methods can enable Focus to emphasize both energy and demand savings and begin the transition to a future where this data will be increasingly important. Specifically, Focus can make better-informed decisions during its program design and budget allocation cycles by using information that is more accurate and time-granular during measure characterization. Importantly, the cost-effectiveness of Focus' portfolio can be maintained while increasing the portfolio's contribution to system reliability.

Emphasizing demand and energy savings in this way will help manage the costs of ongoing electrification trends. It is also wholly consistent with Focus' enabling statute, which requires the commission to:

> "… give priority to programs that moderate the growth in electric and natural gas **demand and usage**, facilitate markets and assist market providers to achieve higher levels of energy efficiency, promote energy **reliability and adequacy**, avoid adverse environmental impacts from the use of energy, and promote rural economic development."[4]

Rationale for Equal Emphasis

The commission's inquiry into Focus' operational practices surrounding demand savings and time-varying value (TVV) is timely. Focus' programs are beginning to transition away from lighting measures as a primary source of savings in favor of other measures. In the residential sector, these measures include hot water and central air conditioning, both of which capture more demand savings and are more time-varying than lighting measures.

In addition, the benefits of demand savings and TVV have become clearer and increasingly urgent in the context of electrification trends. According to the Midcontinent Independent System Operator (MISO),

> "Unprecedented electric demand from transportation, heating, and other end uses (aka 'electrification') … will shift the time of MISO's greatest electricity demand from summer to winter. Additionally, the average daily load pattern will begin to show steep changes in the morning and evening. Planning, markets, and operations must consider the simultaneous transformation of both generation and load to ensure system reliability over the coming decades."[5]

Most energy efficiency measures simultaneously reduce both energy use and peak demand. Different measures, however, have different energy and demand savings characteristics. As the analysis in this research will show, **demand savings are substantial, and the relative size of the energy and demand savings not only**

[4] Public Service Commission of Wisconsin, November 14, 2022, p. 1. Emphasis added.

[5] Midcontinent Independent System Operator. (2021). *MISO electrification insights*. https://cdn.misoenergy.org/Electrification%20Insights538860.pdf

changes from measure to measure but is also sensitive to measure characterization assumptions. Two conclusions flow out of this observation.

First, the quality of the information that is available during measure characterization and program design is important. Accurate, time-granular information has a direct impact on the relative size of the energy and demand savings. Second, the availability of this information during budget allocation decisions can have an impact on the portfolio's balance of energy and demand savings. **Using a single life cycle energy savings metric, as is the case today, limits the scope of budget allocation decisions, which in turn determine the mix of energy and demand savings results.** RAP's research recommends best practices that can illuminate the value of allocating Focus' budget to programs that have substantial demand savings.

Following these best practices can also improve Focus' ability to meet its statutory objectives. For example, placing greater emphasis on demand savings would meet the statutory objective to "give priority to programs that moderate the growth in electric and natural gas demand and usage." **This objective implies a coequal relationship between moderating growth in demand and moderating growth in usage.**

Incorporating demand savings and TVV methods into Focus' operations can change its budget allocation decisions. If the value of demand savings is high for a particular program and *both* energy and demand savings are emphasized, such a program can be expected to receive more funding than it would in an energy-only budget allocation process. This, in turn, can further moderate growth in demand and usage.

Treating demand and energy savings as coequals would also "promote energy reliability and adequacy." Greater demand emphasis would be expected to reduce peak loads, and this promotes system reliability and adequacy. For the same reason, greater demand emphasis also helps "avoid adverse environmental impacts" (greenhouse gas emissions, for example) that are associated with electricity production during peak load hours.

Four Dimensions of Research

RAP's research was carried out in four parts, each described in a section of this brief and drawn upon for a forward-looking fifth section.

1. **Program operations, demand emphasis and TVV**

   This section summarizes Focus' current operational practices and explains how changes to demand emphasis and TVV can impact the energy efficiency program planning, design and evaluation cycle.

2. **Literature review**

   This section includes a synopsis of a series of recent publications that address demand emphasis and time-varying value, both in Wisconsin and in the MISO region.

3. **Jurisdictional scan**

   This section reviews the methods that support programs in three comparable jurisdictions: Michigan, Oregon and Vermont. It ends with an assessment of best practices.

4. **Time-varying value analysis**

   This section analyzes two specific measures, a solar array and a heat pump water heater. These measures represent a renewable resource and an energy efficiency resource and are used to illustrate the TVV of energy and capacity.

5. **Best practices and potential next steps.**

Finally, the appendices provide results of the jurisdictional scan interviews and detailed calculations used in RAP's TVV analysis.

1. Focus' Current Program Operations

In preparation for the jurisdictional scan, RAP interviewed several members of the Evaluation Work Group to understand how Focus currently operates its programs. Emphasis was placed on documenting how Focus treats demand savings and TVV; the following list summarizes these practices. RAP then used this outline to interview program staff from Michigan, Oregon and Vermont.

Emphasis on Demand Savings

- Demand savings are characterized during measure characterization and are included in cost-effectiveness testing and reported during evaluation.
- Consistent with past commission precedent, Wisconsin places its emphasis on life cycle energy savings. Demand savings are a secondary metric.
- The program administrator's contract, however, includes a bonus provision that is triggered if the commission-established goals for total Btu of life cycle energy savings (including fuel-specific savings thresholds) *and* demand savings are achieved. The total bonus amount increases incrementally with the achievement of life cycle energy savings beyond the commission's goal. However, achieving demand savings beyond the commission's goal does not increase the bonus amount.

Approach to TVV

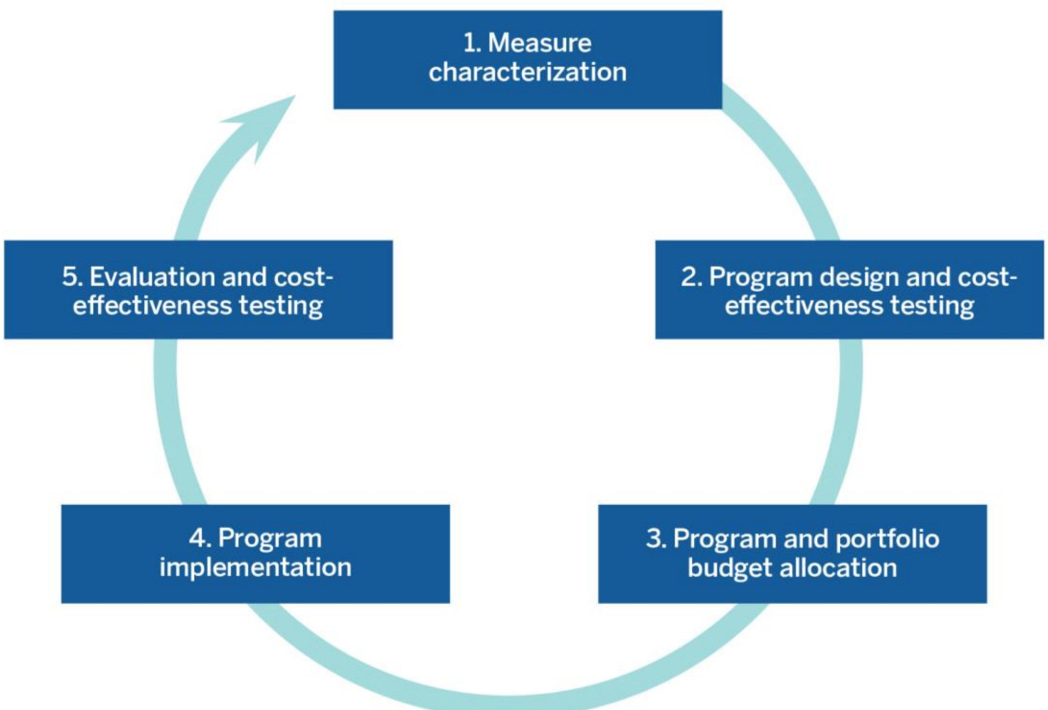
- **Avoided cost.** Wisconsin's avoided costs are recalculated and reviewed annually and adopted at least quadrennially.
- **Peak period definition.**
  - Energy avoided costs are measured by a single annual number.
  - Capacity avoided costs are measured during the summer season with on- and off-peak windows.
- **Load shapes.** Focus uses no load shapes in its measure characterization but does include a peak coincidence factor to estimate demand savings.

Tools, Methods and Operational Practices

- **Measure characterization.** Focus relies on its Technical Reference Manual (TRM) to standardize prescriptive measure assumptions across the state.
- **Cost-effectiveness testing and evaluation.** Focus uses a spreadsheet to conduct cost-effectiveness testing.
- **Integrated resource planning (IRP).** There is no IRP requirement in Wisconsin and no known coordination between Focus' program staff and its utility planning colleagues.
- **Fuel switching.** Fuel switching between regulated fuels is allowed by Wisconsin policy. However, fuel switching from unregulated fuels is prohibited from receiving program support. In practice, fuel switching from gas to electricity is not cost-effective, and the fuel switching programs that Focus does offer have not been popular with the public.
- **Anticipated changes.** Each quadrennial planning period represents an opportunity to update and improve Focus' programs. It is presently in the first year of its current planning cycle.

These practices all fit within the program operations cycle that most energy efficiency programs in the United States follow (see Figure 1). More-accurate data and methods can directly affect three of the five operational areas in the energy efficiency program cycle: measure characterization, cost-effectiveness testing and evaluation.

Figure 1. The energy efficiency program operations cycle



Accurately assessing demand and TVV requires comprehensive data at three levels.

1. System-level consumption and prices.
2. End-use consumption.
3. Measure-level load shapes.

In addition, some operational practices will need to change. First, time-granular load shapes and updated peak coincidence factors will need to be added or appended to the Technical Reference Manual so that they can be used during measure characterization. Second, cost-effectiveness testing tools will need to be modified to accept data that is more time-granular. Finally, all this information will need to be made available early in the program cycle, ideally during program design, so that it can impact budget allocation decisions.

Fortunately, the availability and quality of tools and information have improved in recent years. For example, hourly system-level consumption patterns have already been studied in the *Wisconsin Peak Period Analysis*,[6] and the hourly price of wholesale energy and of capacity are readily available through MISO.

Furthermore, hourly (and even subhourly) end-use consumption data are available through the National Renewable Energy Laboratory's (NREL) ResStock and ComStock datasets. This information is not only free and time-granular, but it is also specific to Wisconsin's building stock, climate zones and mix of end-use technologies. As such, it can help capture the geographic and population-weighted differences across the state.

This leaves modeling complexity as the remaining difficulty. On this front, there are multiple tools available to manage these datasets. Long-standing software tools like DSMore enable program administrators to handle hourly inputs for cost-effectiveness testing. Similarly, evaluation consultants (including Cadmus, Focus' evaluator) routinely use spreadsheet models that incorporate hourly data. Thanks to the capabilities of these software tools, the cost of managing more-voluminous datasets and complex assessment and evaluation processes is shrinking.

Measure Characterization

Increasing demand savings and using methods that include TVV affect measure characterization. For example, Focus' TRM includes summer coincident peak demand, annual energy savings, and life cycle energy savings. These data points are mostly static, and time-varying measures of peak demand and annual energy savings would be more accurate.

Furthermore, while demand savings are currently being characterized using a coincidence factor, the factor itself is confined to the peak summer season. This is out of sync with the *Wisconsin Peak Period Analysis*, which identifies two peak periods during the winter season, as well as with the *MISO Electrification Insights* publication. Both reports illustrate how winter season peaks are evident in the current data and future forecasts.

[6] Cadmus. (2021a). *Wisconsin peak period analysis*. https://focusonenergy.com/evaluation-reports/peak-period-research

As MISO points out, "the average daily load pattern will begin to show steep changes in the morning and evening, suggesting benefits from flexible generation and load."[7]

Focus' programs are a source of such flexible load (albeit at annual time scales) because most measures reduce both energy use and peak demand. Increasing these demand savings and using methods that include TVV are a win-win proposition. They provide a benefit to Focus, in the form of more cost-effective programs, and a benefit to the system operator, who can more easily provide reliable electric service as a result of a flatter, less variable system load.

Cost-Effectiveness Testing

At a high level, the primary benefits of energy efficiency programs are the product of:

1. A price ("P," in dollars per MWh), and
2. A volume ("V," in kWh per year), that
3. Results in a cost or a benefit as measured in dollars ($).

The accuracy of this equation (P * V = $) is limited by the accuracy and time-granularity of the inputs. Greater accuracy can be gained by using more-granular, time-varying data for both price and volume, and greater accuracy can translate into changes in budget allocation decisions over time.

Using more-accurate data can yield cost-benefit ratios that are higher or lower than those developed using current methods. As Focus assesses the cost-effectiveness of its programs with the evaluation team each year, better information about the source and timing of a program's cost-effectiveness may cause Focus' staff to fund and (re)design future programs, especially in the context of electrification trends that will be changing the shape of the system load.

Evaluation

Better information and methods affect program evaluation. More-accurate and time-granular volume information will require updates to improve gross savings estimates and give evaluators more insight into how Focus' processes may be improved.

Fuel Switching

According to MISO, electrification is an imminent trend. Furthermore, the major end uses that are impacted include space heating, water heating, cooking and transportation — and fuel switching measures exist for each of these end uses. These include heat pumps for space and water heating, induction cook tops and electric vehicles. **Wisconsin is among about a dozen states whose policies allow fuel switching as part of energy**

[7] Midcontinent Independent System Operator, 2021.

efficiency programs. The American Council for an Energy-Efficient Economy (ACEEE) summarizes Wisconsin's policy this way:

> "As of July 1, 2021, the *Focus on Energy Policy Manual* includes language that allows fuel switching: 'Fuel switching projects may qualify for incentives provided the project results in a decrease in overall MMBTU at the customer's site, is cost-effective, and that the fuel to which the customer is switching is purchased from a participating Focus on Energy utility.' This includes natural gas to electric conversions."[8]

In practice, Focus' fuel switching programs are limited for three reasons. First, Focus is prohibited from incentivizing fuel switching from unregulated fuels; second, fuel switching from natural gas is only marginally cost-effective at current rates. Consequently, customer uptake of the existing fuel switching programs has been limited. Third, the program administrator faces a disincentive to allocate its budget to these programs because it has separate electric and gas goals. Since electric and gas savings are calculated separately, fuel switching from gas to an electric heat pump water heater yields an increase in gas savings but a decrease in electric savings. Adopting a fuel-neutral savings metric could address this disincentive by creating a net positive savings calculation.

Fuel switching measures do increase electricity demand, which works against the statutory requirement to moderate growth in electric demand and usage. Such increases in electricity demand could be managed by integrating demand response into fuel switching programs, but Focus is prohibited from designing demand response programs.

The commission could encourage fuel switching by adopting a two-part approach. First, the commission could rely on the parts of Focus' enabling statute that support electrification. These include avoiding adverse environmental impacts and achieving higher levels of energy efficiency. Electrification measures contribute directly to both of these objectives. Second, the commission could direct Focus and the utilities to integrate demand response into their electrification programs. This would satisfy the statutory requirement to promote energy reliability and adequacy and would help Wisconsin develop the flexible loads identified in the *MISO Electrification Insights* report.

2. Literature Review

A series of publications is relevant to assessing demand emphasis and TVV for Wisconsin. A paper by Lawrence Berkeley National Laboratory (LBNL) illustrates that the value of the demand savings can be as large as the energy savings and that the savings are quite sensitive to the accuracy of the data. The *Wisconsin Peak Period Analysis* shows when the peak periods presently occur, while the *MISO Electrification Insights* paper illustrates how these peak periods are expected to change. A Cadmus study highlights the measures

[8] American Council for an Energy-Efficient Economy. (2022). *State policies and rules to enable beneficial electrification in buildings through fuel switching*. https://www.aceee.org/sites/default/files/pdfs/state_fuel-switching_policies_and_rules_7-21-22.pdf

that hold the greatest potential for future energy savings, and an ACEEE policy brief on fuel switching summarizes Wisconsin's policy on this cross-cutting topic area.

Time-Varying Value of Energy Efficiency in Michigan

In 2018, LBNL applied its TVV methodology in Michigan and concluded that **"... accounting for both the seasonal time-varying value of energy savings and its impact on the need to invest in additional capacity can significantly affect the total value of energy savings."**[9] Furthermore, measures like central air conditioning are not only highly time variable, but the value of their demand savings (also known as capacity-related value) is actually higher than the value of energy savings.

To support this conclusion, LBNL analyzed measure-level results using different input assumptions from other jurisdictions, as shown in Table 1.[10] LBNL found that the TVV for the selected measures was concentrated in two high-level avoided-cost categories, which are highlighted with dashed lines in the following table. The energy-related value is its own category and reflects the value of avoiding wholesale energy supply costs. The capacity-related value is a sum of generation capacity, transmission and distribution, all of which create value when peak demand is reduced.

Table 1. TVV of exit sign, residential hot water and air conditioning savings in Michigan

Resource benefit	Exit sign	Residential air conditioning (MEMD)	Residential air conditioning (PNW)	Residential hot water (MEMD)	Residential hot water (PNW)
Energy-related value	$56	$108	$127	$65	$58
Generation capacity	$9	$39	$60	$13	$6
Reserves/ ancillary services	$0	$2	$3	$1	$0
Transmission	$10	$44	$67	$14	$7
Distribution	$0	$0	$0	$0	$0
Capacity-related value subtotal	$19	$84	$129	$27	$13
Total value	**$74**	**$192**	**$256**	**$92**	**$70**

Note: The avoided distribution capacity value is zero because its value is bundled into the transmission value. Values in table may not add up due to rounding.
MEMD = Michigan Energy Measures Database coincident factors
PNW = Pacific Northwest metered load shapes

Source: Frick, N. M., Eckman, T., and Schwartz, L. C. (2018). *Time-Varying Value of Energy Efficiency in Michigan*

[9] Frick, N. M., Eckman, T., & Schwartz, L. C. (2018). *Time-varying value of energy efficiency in Michigan* [Technical brief]. Lawrence Berkeley National Laboratory, p. 18. https://emp.lbl.gov/publications/time-varying-value-energy-efficiency

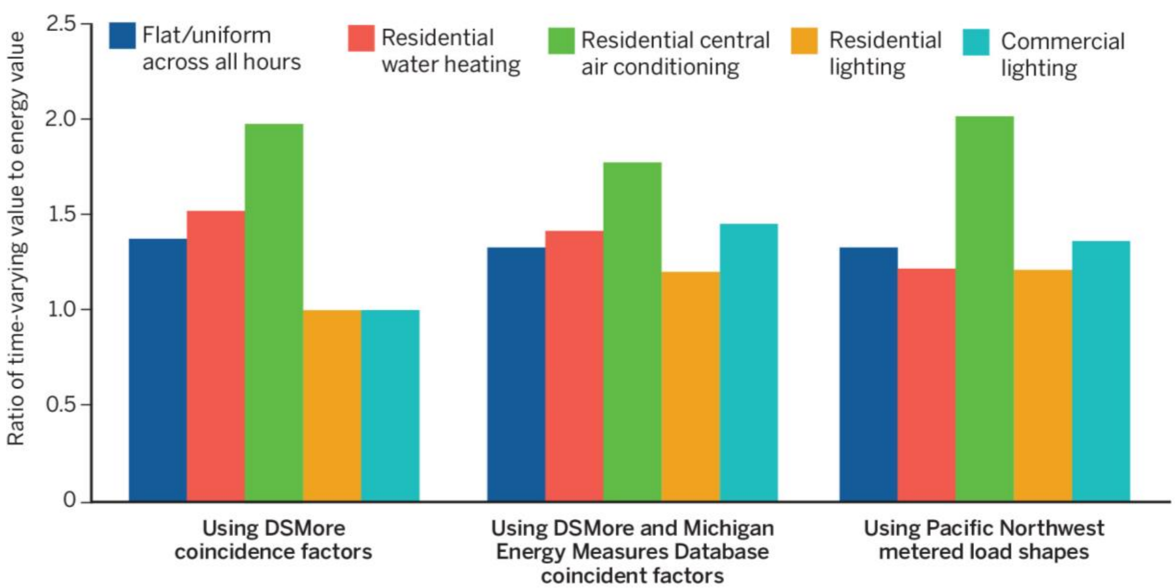
[10] Frick et al., 2018, p. 14.

Energy-related value is measured hourly here and requires a dataset that includes values for all 8,760 hours of the year. However, some jurisdictions use seasonal on- and off-peak averages. Capacity-related value is measured seasonally (summer and/or winter typically). The value is realized within daily windows — typically four hours in duration — when the coincident peaks have historically occurred. As a result, measuring capacity-related value requires a still-hourly, but smaller, dataset that ultimately is reduced to the relevant four-hour windows for each of the peak seasons.

LBNL also displayed its results using a ratio of total value to energy-related value (the last row in Table 1 divided by the first row). The results are shown in Figure 2.[11] When the ratio is greater than 1, this means that there is capacity-related value for the measure. When the ratio is greater than 2, the capacity-related value is larger than the energy-related value. In Michigan, the ratios most often ranged from 1 to 1.5 but did rise to 2 for central air conditioners, whose savings are highly coincident with peak electricity demand.

The figure also shows that the TVV ratio changes by 10%-25% when different coincidence factors are used in the analysis. This is an important conclusion of LBNL's analysis. **The accuracy of the data has a direct impact on the total value of a measure.**

Figure 2. Ratio of total time-varying value of energy savings to energy-only value



Note: Data are for Consumers Energy and DTE Energy.

Source: Excerpted from Frick, N. M., Eckman, T., and Schwartz, L. C. (2018). *Time-Varying Value of Energy Efficiency in Michigan*

Based on this analysis, LBNL concluded that, "(1) overall, the ratio of the total utility system value of energy savings to their energy-related value in Michigan aligns with other states with similar system load shapes."[12] Because Wisconsin and Michigan are

[11] Frick et al., 2018, p. 13.

[12] Frick et al., 2018, p. 1.

neighboring states with similar climates and load shapes, it is reasonable to assume that the Focus on Energy program would see similar results as the Michigan utility programs.

The best practice that can be inferred from the LBNL analysis is this: **End-use load research enables a more accurate analysis of the TVV of efficiency.** Because this information is often unavailable in the short term, LBNL offered a second-best alternative.

> "Until such time that statistically representative, metered data on end-use load shapes in Michigan are available, data from regions with similar energy consumption characteristics should be considered for adoption."[13]

LNBL's analysis supports placing a greater emphasis on capacity-related value (i.e., demand savings) because those savings are both time-varying and sometimes as valuable as the energy-related value. The analysis also supports using data from similar jurisdictions to enable a more accurate analysis of TVV.

Wisconsin Peak Period Analysis

In 2021, Cadmus published its *Wisconsin Peak Period Analysis*,[14] which used MISO load data to identify three Wisconsin-specific electricity consumption peak periods, one in the summer and two in the winter. Its conclusions were threefold.

1. **Summer demand peaks.** The summer season (June through September) continues to set the annual peak, but the peak hours have shifted to the period between 2 and 6 p.m. Previously, the peak hours were 1 to 4 p.m.
2. **Winter demand peaks.** There is a substantial amount of demand in the core winter months (December through February) in the hours from 8 a.m. to noon and 5 to 9 p.m.
3. **Carbon emissions.** The months identified for the peak period seasons (December, January and February in winter; June, July, August and September in summer) also include the months with the highest carbon intensity of generation.

As a result of this analysis, Cadmus recommended that the commission adopt the summer and winter peak period definitions above for the purpose of evaluating Focus' programs.

MISO Electrification Insights

In 2021, MISO published its analysis of electrification trends within the control region. The two leading highlights were:

1. "Unprecedented electric demand from transportation, heating, and other end uses brings new opportunities and challenges for the MISO system."
2. "Electrification will shift the time of MISO's greatest electricity demand from summer to winter. Additionally, the average daily load pattern will begin to show steep changes in the morning and evening, suggesting benefits from flexible generation and load."[15]

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[13] Frick et al., 2018, p. 1.

[14] Cadmus, 2021a, p. 4.

[15] Midcontinent Independent System Operator, 2021, p. 2.

These conclusions are wholly consistent with the *Wisconsin Peak Period Analysis*. They confirm the expectation that the winter demand peak period will equal or exceed the summer one in the coming decades. Finally, MISO pointed out several examples of "flexible load," including electric vehicles, water heaters and space heating. These kinds of load are excellent candidates to include in demand response programs because they are controllable (flexible) and can be managed in such a way that the customer never experiences an interruption in or degradation of service.

It is important to note that some of these electrification measures may not have high value now, but they are anticipated to be increasingly valuable in the future. Policies put in place now will provide regulators with time to gain experience and will place Wisconsin in an excellent position to cost-effectively integrate increased electrification load in a decade.

Energy Efficiency Potential Study Report

In 2021, an energy efficiency potential study was completed for the Focus on Energy programs. The end uses with the highest electricity savings potential were:[16]

- Residential: hot water and central air conditioning.
- Commercial: lighting and refrigeration.

Three of these four measures were assessed in LBNL's Michigan analysis: residential hot water, residential central air conditioning and commercial lighting. The remaining measure, commercial refrigeration, has a relatively flat load shape[17] that is similar to the "Flat/Uniform Across All Hours" shape in LBNL's analysis. As a result, the ratio of capacity-related value to energy-related value for the highest potential measures in the study is known.

3. Jurisdictional Scan

RAP interviewed program administrators in three leading jurisdictions. Oregon and Vermont were chosen because they operate mature statewide programs and are similar to Wisconsin on these points. Michigan was chosen to represent a neighboring jurisdiction. The interviews focused on three topic areas.

1. The emphasis they place on achieving demand savings.
2. Their approach to TVV.
3. The tools and methods they use during their program planning cycles.

Importantly, the interviewers inquired about current operational practices and any anticipated changes to these practices. The results of the interviews appear in Appendix A.

[16] Cadmus. (2021b). *2021 Focus on Energy energy efficiency potential study report*, p. 73. https://focusonenergy.com/about/2021-Potential-Study-Documents

[17] Based on a visual inspection of: Electric Power Research Institute. (n.d.). *Load shape library 8.0*. https://loadshape.epri.com

Overview

In preparation for the interviews, RAP conducted research to identify the high-level similarities and differences between the jurisdictions. We began this comparison with the time-varying definition of avoided costs (see Table 2) and found a single inconsistency.

- **Energy time periods**: Wisconsin is the only state that uses an annual avoided cost for energy. The other states use at least an annual on- and off-peak definition, and two use a monthly or seasonal on- and off-peak period. The approaches that are more time-granular capture the seasonal and diurnal pattern of today's electric energy consumption and costs.
- **Capacity time periods**: While the time-varying definition of capacity did differ in the details, the broad approach to using a seasonal definition with hourly peak windows was found to be broadly similar for all four states.

Table 2. Avoided cost and peak period definitions by jurisdiction

	Michigan[18]	Oregon	Vermont	Wisconsin
Energy time periods	Annual, using MISO's on-/off-peak hours	Monthly, using the utilities' on-/off-peak hours	Summer/winter, using ISO New England's on-/off-peak hours	No peak periods, annual MWh only
Capacity time periods	July, 3 to 6 p.m.	August, 1 to 9 p.m. December and January, 7 to 10 a.m. and 5 to 9 p.m.	June through August, 1 to 5 p.m. December and January, 5 to 7 p.m.	June through September, 2 to 6 p.m. weekdays

The next steps in preparing for the interviews were to consult the Database of Screening Practices[19] and compare the four jurisdictions' avoided-cost categories, cost-effectiveness tests and societal impacts considered.

[18] Michigan's utilities do not disclose their avoided costs, but the state's measure database indicates that the peak definition is based on the month of July from 3 to 6 p.m.

[19] The Database of Screening Practices — A Resource of the National Energy Screening Project, managed and owned by E4TheFuture. National Energy Screening Project, (n.d.). *Database of screening practices (DSP).* https://www.nationalenergyscreeningproject.org/state-database-dsp/database-of-state-efficiency-screening-practices/

As Table 3 shows, the top four categories of avoided costs that are included in the cost-effectiveness tests are identical in all four jurisdictions.[20] Ancillary services costs are not included in any of the jurisdictions. Given their small contribution to the avoided costs, this presently makes sense. However, as renewable resources penetrate the electric grid, the value of ancillary services (reserves and flexible resources generally) may increase.

Table 3. Primary avoided-cost categories

	Michigan	Oregon	Vermont	Wisconsin
Avoided marginal energy costs	**Yes**	**Yes**	**Yes**	**Yes**
Avoided generating capacity costs	**Yes**	**Yes**	**Yes**	**Yes**
Avoided transmission and distribution costs	**Yes**	**Yes**	**Yes**	**Yes**
Avoided transmission and distribution line losses	**Yes**	**Yes**	**Yes**	**Yes**
Avoided ancillary services	No	No	No	No
Wholesale price suppression effects	No	No	No	No
Avoided costs of complying with renewable portfolio standard	No	No	**Yes**	No
Avoided environmental compliance costs	No	**Yes**	**Yes**	**Yes**
Avoided credit and collection costs	No	No	**Yes**	**Yes**
Reduced risk	No	**Yes**	**Yes**	No
Increased reliability	No	No	No	No
Market transformation	**Yes**	No	No	No

Source: National Energy Screening Project. (n.d.). *Database of Screening Practices (DSP)*

The cost-effectiveness tests that are being used in each jurisdiction do differ, as shown in Table 4 on the next page.[21] The table also shows at what level the assessment is carried out, which is important because it impacts program operations. Cost-effectiveness testing is predominantly carried out at the portfolio and program levels. Oregon and Vermont, however, both use measure-level testing, which is a more stringent approach.

[20] National Energy Screening Project, n.d.

[21] National Energy Screening Project, n.d.

Table 4. Cost-effectiveness tests by jurisdiction

	Michigan	Oregon	Vermont	Wisconsin
Primary test	Utility cost test	Total resource cost, utility cost test	Societal cost test	Total resource cost
Secondary tests	Total resource cost, participant cost test, rate-payer impact measure	None	Utility cost test	Utility cost test, total resource cost, expanded total resource cost, societal cost test
Primary assessment level	Portfolio	Measure	Portfolio	Portfolio
Other assessment levels	Program	Program	Measure	Program
Discount rate	Low-risk	Weighted average cost of capital	Low-risk	Low-risk
Analysis period	Measure life	Measure life	Measure life	Measure life

Source: National Energy Screening Project. (n.d.). *Database of Screening Practices (DSP)*

Finally, Table 5 shows the societal impacts considered in each jurisdiction.[22] Wisconsin and Vermont are similar in that they consider both public health[23] and economic development impacts. Wisconsin is presently an outlier on low-income customer impacts, but this issue is in front of the utility commission, which will make a decision soon.

Table 5. Societal impacts by jurisdiction

	Michigan	Oregon	Vermont	Wisconsin
Low-income customers	**Yes**	**Broadly**	**Yes**	No
Greenhouse gas emissions	No	No	No	No
Other environmental	No	No	No	No
Public health	No	No	**Yes**	**Yes**
Economic development and jobs	No	No	**Yes**	**Yes**
Energy security	No	No	No	No

Source: National Energy Screening Project. (n.d.). *Database of Screening Practices (DSP)*

[22] National Energy Screening Project, n.d.

[23] Note that the value of public health benefits is substantial in Wisconsin and is similar in size to energy benefits. For more information, see Seidman, N., Shenot, J., & Lazar, J. (2021). *Health benefits by the kilowatt-hour: Using EPA data to analyze the cost-effectiveness of efficiency and renewables*, pp. 8, 19. Regulatory Assistance Project. https://www.raponline.org/knowledge-center/health-benefits-kilowatt-hour-epa-data-cost-effectiveness-efficiency-renewables/

Insights and Best Practices

The information from Michigan, Oregon and Vermont was compared to each other and to Wisconsin to produce the following insights and best practices.

Emphasis on Demand Savings

- **Insight:** Wisconsin is similar to both Michigan and Oregon on this point. All three jurisdictions prioritize achieving energy savings.
- **Best practice:** Vermont not only prioritizes demand savings, but it also adopts explicit performance metrics to achieve them. In the context of ongoing electrification trends that are expected to shift and increase peak loads,[24] having explicit performance indicators that emphasize demand savings can be considered a best practice.
- **Next step for Wisconsin:** Consider adopting forward-looking demand savings goals that are coequal with the energy savings goals.

Approach to TVV

Avoided Cost

- **Insight:** Avoided costs in all the jurisdictions are updated regularly, every one to four years.
- **Best practice:** Updating avoided costs in preparation for each planning or performance cycle can be considered a best practice. This keeps the "goal posts" for the program administrator consistent and captures changes to the avoided costs on a regular basis.
- **Next steps for Wisconsin:** Continue to adopt updated estimates of avoided cost every four years.

Peak Period Definition

- **Insight:** Peak periods are typically defined seasonally with on- and off-peak periods for energy and seasonally with hourly windows for generation, transmission and distribution capacity.

  Wisconsin is the only jurisdiction that uses a single annual number for energy savings instead of a seasonal on- and off-peak definition.
- **Best practice:** Seasonal (or monthly) definitions with on- and off-peak periods for energy and seasonal definitions with hourly peak windows appear to be the current best practice.
- **Next steps for Wisconsin:** Consider adopting energy peak periods that are defined seasonally and with on- and off-peak periods. Consider adopting capacity peak periods that include the winter season, as proposed in the *Wisconsin Peak Period Analysis*.

[24] Midcontinent Independent System Operator, 2021.

This next step implies several changes to Focus' program operations. First, the Technical Reference Manual will need to add load shapes that match the definition of the energy periods. Second, avoided-cost calculations will have to be aligned with the new time definitions. Finally, the cost-effectiveness calculator will need to be updated to accept the new TRM and avoided-cost data.

Load Shapes

- **Insight:** The jurisdictions differed widely on this topic. Michigan recently moved to using hourly load shapes, while Vermont uses a seasonal, on- and off-peak load shape. Oregon reduces its load research down to a single number. In this context, Wisconsin's practice is consistent with Oregon's.
- **Best practice:** Because of the disparity between the jurisdictions, no best practice is evident. Hourly load shapes can, however, be considered a best practice based on the conclusions from LBNL's TVV analysis in Michigan:

  > "Quantifying the time-varying value of energy efficiency is necessary to properly account for all of its benefits and costs and to identify and implement efficiency resources that contribute to a low-cost, reliable electric system. … [Without] statistically representative metered end-use load shape data in Michigan (i.e., the hourly or seasonal timing of electricity savings), the ability to confidently characterize the time-varying value of energy efficiency savings … is limited."[25]

- **Next steps for Wisconsin:** Consider adopting hourly load shapes during measure characterization and evaluation using NREL's ResStock and ComStock data. Consider investing in metered end-use load shape data and sharing the costs with a neighboring jurisdiction, such as Michigan.

Tools, Methods and Operational Practices

Measure Characterization

- **Insight:** All the jurisdictions use TRMs or their functional equivalent to help standardize measure characterization for both prescriptive and custom measures. In this context, Wisconsin's practice is consistent with other jurisdictions.
- **Best practice:** Publish statewide inputs and methods for measure characterization.
- **Next steps for Wisconsin:** Continue to document and standardize methods and assumptions for Focus' programs.

Cost-Effectiveness Testing and Evaluation

- **Insight:** While the primary cost-effectiveness test differed across the jurisdictions, they all used a variety of secondary tests as well. The difference between them was the level at which the tests were applied. Most testing takes place at the portfolio and

[25] Frick et al., 2018, p. 18.

program level. However, Oregon and Vermont both use measure-level testing, which is a more stringent standard.

- **Best practice:** Continue to apply the cost-effectiveness tests at the program and portfolio levels.
- **Next steps for Wisconsin:** Revise the existing cost-effectiveness tool and/or evaluate using other software that can accept data inputs that are more time-granular.

Integrated Resource Planning

- **Insight:** Both Michigan and Oregon mentioned their IRP process as a motivation to adopt methods that include TVV and demand emphasis. In Vermont, the energy efficiency utility's programmatic efforts are explicitly embedded in the state's long-range transmission and IRP processes. Wisconsin has no IRP requirement, but utility resource planning is inherently an hourly analysis that is concerned with both TVV and demand. As a result, there is a natural opportunity to align and integrate Focus' processes with utility load forecasting and resource planning processes.
- **Best practices:**
  - Aligning the program administrator's time granularity with the time granularity that is being used by the state's utility planning processes can be considered a best practice.
  - Integrating the program administrator's demand savings results into utility load forecasting processes can be considered a best practice.
- **Next steps for Wisconsin:** Consider using hourly data and methods that align with utility resource planning data and methods. Consider sharing Focus' planning information with utility resource planners and vice versa.

Fuel Switching

- **Insight:** Wisconsin policy supports fuel switching, but in practice these programs are unpopular because natural gas prices are so low.
- **Best practices:**
  - Enact supportive fuel-switching policies for all fuels, both regulated and unregulated.
  - Align program and utility incentives to support fuel switching programs.
- **Next steps for Wisconsin:** Consider a two-part approach that emphasizes avoiding adverse environmental impacts and achieving higher levels of energy efficiency over moderating electric demand. Then enable Focus and the utilities to integrate demand response into their fuel switching programs.

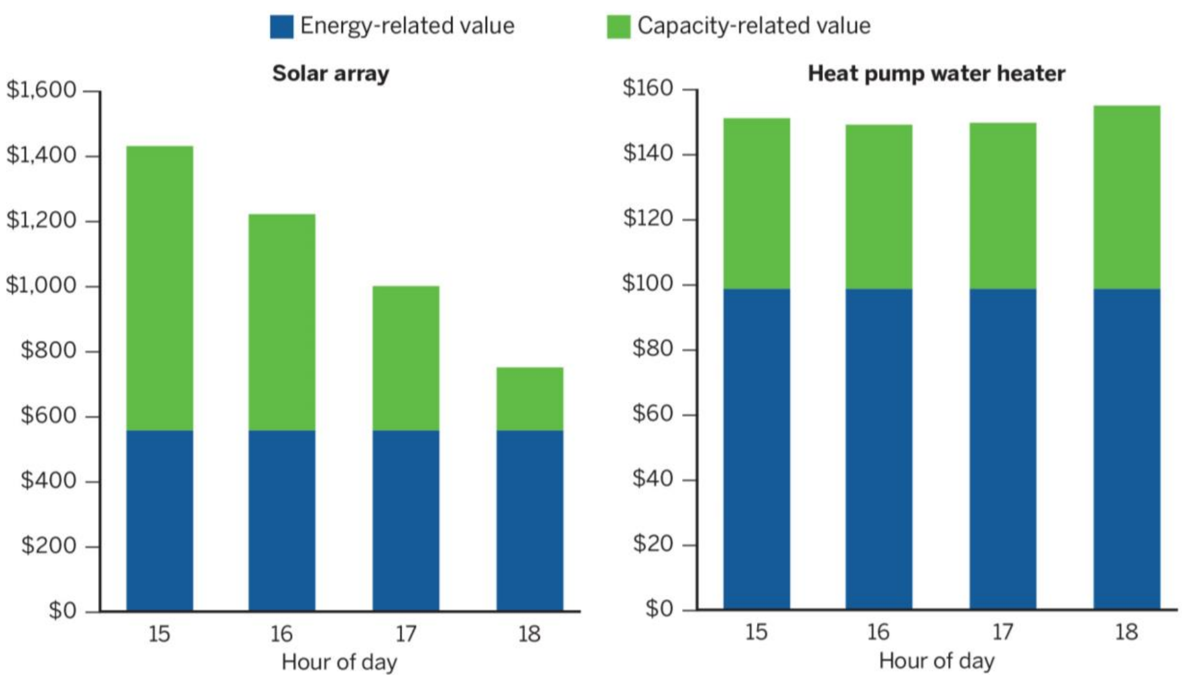
4. Time-Varying Value Analysis

To illustrate the TVV of a renewable and an energy efficiency resource, RAP applied LBNL's TVV methodology to two new measures: a 10 kW DC solar array and a residential heat pump water heater. Both measures are currently included in Focus programs, but neither was part of LBNL's TVV analysis in Michigan. The high-level results appear below; a more detailed discussion and data sources can be found in Appendix B.

Solar Array and Heat Pump Water Heater

The results are in alignment with LBNL's work in Michigan. As shown in Figure 3, the solar array's capacity-related value can vary significantly by hour during the summer peak window and is 33%-150% of the energy-related value during this time. The reason for this variability is the coincidence factor. When the peak hour changes, so does the coincidence factor, and this is a primary determinant of the capacity-related value.

Figure 3. Time-varying value of a solar array and a heat pump water heater by hour

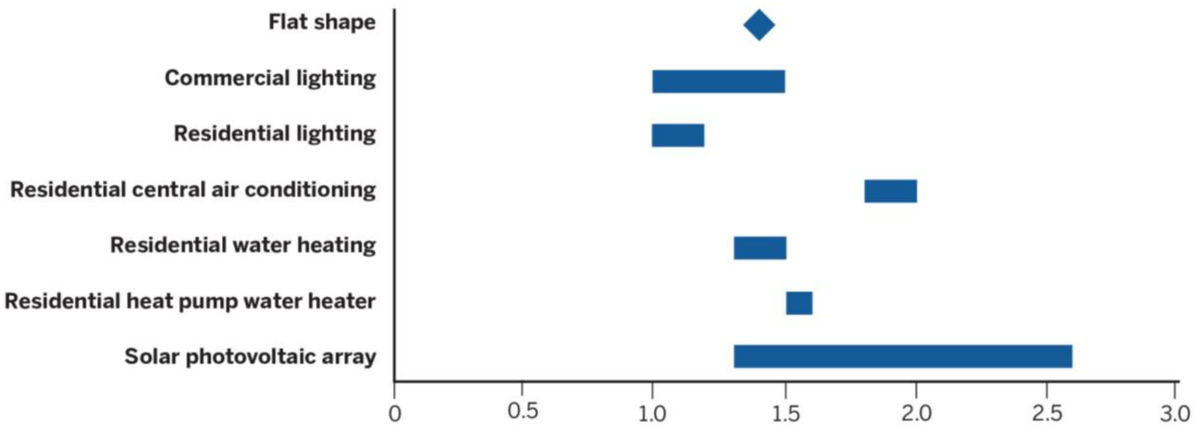


The implication for Focus' programs is that the capacity-related value can be as large as or larger than the energy-related value. In addition, the value is highly dependent on the measure's coincidence with the summer peak, which is likely to continue moving into the late afternoon hours due to increasing solar penetration. As a result, it will be important for Focus to monitor the timing of the summer peak and update coincidence factors for measures that are sensitive to it, such as the solar array.

All Seven Measures

Figure 4 summarizes the ratio of total value to energy-related value for seven different measures — five from LBNL's analysis and two from the analysis in this section. Note that the flat shape serves as a reference point for the other six measures as well as a proxy for the commercial refrigeration measure, whose shape is nearly flat. In all cases, the difference between the low, middle and high estimates arises from different volume inputs, primarily the peak coincidence factor. The price-side inputs were held constant, and as a result, the figure illustrates the importance of using volume data that are more accurate and time-granular.

Figure 4. Ratio of total value to energy-related value — all measures



A series of observations can be drawn from this figure.

Capacity-Related Value Is Substantial

Whenever the ratio of total value to energy-related value is greater than 1, there is capacity-related value, and when this ratio is greater than 2, capacity-related value exceeds energy-related value. As the figure shows, capacity-related value is almost always positive, and it can be equal to or greater than energy value for measures whose peak coincidence is high (PV arrays and air conditioning). As a result, **failing to account for this value during program design and budget allocation decisions will likely lead to a suboptimal allocation of funding.**

Volume-Side Inputs Cause TVV to Differ

Higher variability in volumes leads to higher variability in the TVV.

Because the price-side (avoided costs) variables in the P * V = $ equation are held constant, this sensitivity is a result of the volume inputs, specifically the load shape and peak coincidence of each measure.

As a result, **the accuracy of the volume inputs is an important determinant of the total value of a measure.**

5. Best Practices and Next Steps

The research points to a series of best practices and an array of potential next steps, which are described in Table 6.

Table 6. Best practices and potential next steps

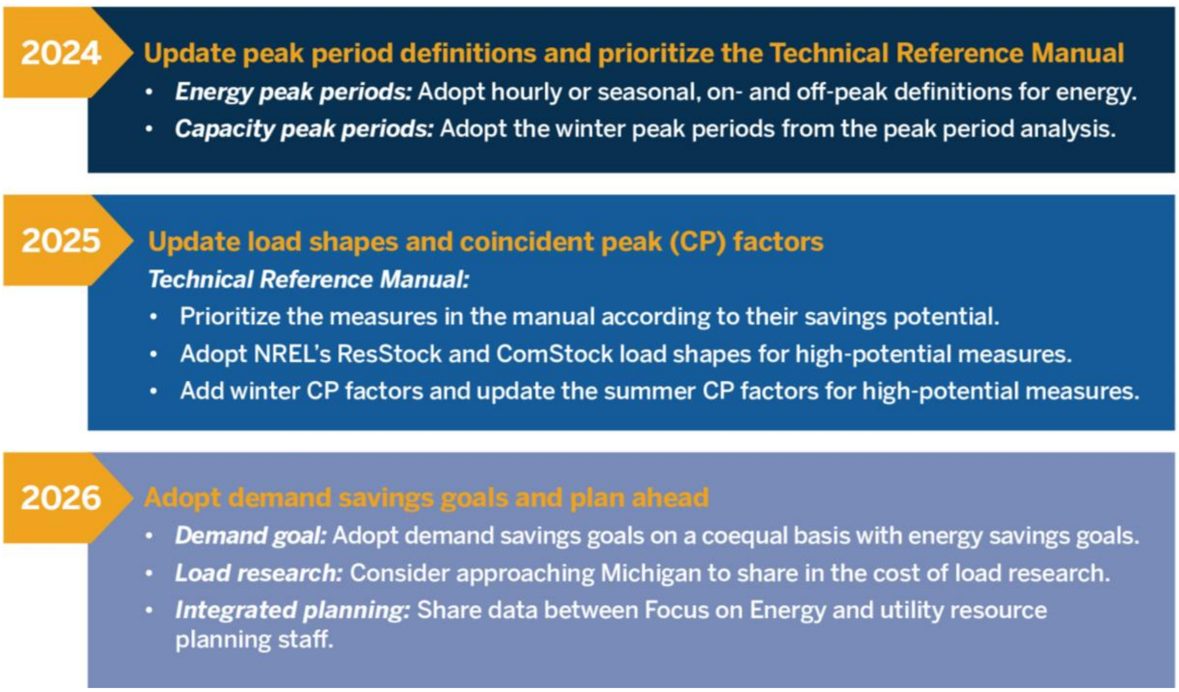
Topic and subtopic	Best practices	Potential next steps
Emphasis on demand savings		
Coincidence factors	• Adopt and update coincidence factors for both summer and winter periods.	• Prioritize the measures in the TRM according to their savings potential. • Update the summer and winter coincidence factors.
Setting goals	• Place demand on coequal footing with energy by adopting demand savings goals.	• Recommend to the commission that forward-looking demand savings goals be adopted.
Approach to time-varying value		
Avoided costs	• Update avoided costs in alignment with the program planning, performance and evaluation cycle.	• Continue to update avoided costs at intervals that align with the program's planning, performance and evaluation cycle.
Peak period — energy	• Use hourly load data from publicly available sources such as MISO, NREL and neighboring states.	• Adopt either an hourly or seasonal on- and off-peak definition for energy peak periods. • Calculate avoided-cost estimates using the same definition.
Peak period — capacity	• Define peak periods for both the summer and winter periods.	• Adopt the winter peak period definition that was identified in the *Wisconsin Peak Period Analysis*.
Load shapes	• Adopt hourly load shapes for use during measure characterization and evaluation. • Conduct load research using statistically representative, metered data on end-use loads.	• Prioritize the measures in the TRM according to their energy savings potential, and adopt NREL's ResStock and ComStock load shapes for these measures. • Consider approaching Michigan and/or Minnesota to share in the cost of load research.

Tools and methods of fuel switching		
Measure characterization	• Adopt and document standard methods and assumptions.	• None. Continue to standardize and document measure characterization methods and assumptions.
Cost-effectiveness testing	• Assess cost-effectiveness using multiple tests. • Apply the cost-effectiveness test at the program and portfolio levels.	• None. Continue to assess cost-effectiveness using multiple tests. • None. Continue applying the tests at the portfolio and program levels. • Update existing cost-effectiveness tools to accommodate load shape and coincident peak data that are more time-granular.
Integrated planning	• Share data between Focus and the utility resource planning staff. • Adopt complementary methods and data granularity. • Integrate planning processes with load forecasting as the unifying process.	• Share planning data and assumptions. • Set up a collaborative process to identify complementary methods, data and processes.
Fuel switching	• Adopt policies to support fuel switching from both regulated and unregulated fuels.	Although Wisconsin recently evaluated its fuel switching policy[26] and will not support unregulated fuel switching for the foreseeable future, it could: • Rely on the parts of Focus' enabling statute that do support electrification: avoiding adverse environmental impacts and achieving higher levels of energy efficiency. • Integrate demand response into electrification programs, which would satisfy the statutory requirement to promote energy reliability and adequacy.

[26] Public Service Commission of Wisconsin, November 14, 2022, p. 18.

Many of the next steps in Table 6 could be implemented over the remaining quadrennial period. Figure 5 illustrates what a three-year implementation schedule might look like. For example, 2024 could be used to adopt the summer and winter peak periods in the *Wisconsin Peak Period Analysis* and to prepare the analysis of NREL's ResStock and ComStock load shapes. 2025 could be used to update the load shapes and coincidence factors in the TRM. The final year could be used to adopt demand savings goals that are on equal footing with the energy savings goals, to initiate a load research program, and to begin sharing data between Focus and utility resource planning staff.

Figure 5. Illustrative schedule of potential next steps



Appendix A: Jurisdictional Scan Interviews

Michigan

Emphasis on Demand Savings

- Michigan's enabling legislation frames the goal for the state's energy efficiency programs in terms of avoiding new power plant construction.
- However, the primary performance metric for the energy waste reduction program is based on energy or kWh savings and is reported in lifetime cents per kWh.
- Michigan completed a statewide potential study for its energy waste reduction programs in 2021, and it published potential estimates for both energy (GWh) and demand (MW) savings.
- DTE Energy's 2020 energy waste reduction annual report published both energy and demand savings results.

Approach to TVV

- **Avoided cost.** Michigan's utilities do not publish their avoided costs.
- **Peak period definition.** The 2021 potential study indicates that the peak definition is based on the summer season using hourly windows; however, no explicit definition is published.
- **Load shapes.** Michigan recently invested in hourly load shapes. According to Cadmus' presentation to the Evaluation Work Group, the load shapes will be used for cost-effectiveness testing, program planning, load forecasting and integrated resource planning.

Tools, Methods and Operational Practices

- **Measure characterization.** The Michigan Energy Measures Database functions as the state's TRM, and it includes standardized, statewide assumptions for both energy and demand savings.
- **Cost-effectiveness testing and evaluation.** Michigan's utilities use DSMore to assess cost-effectiveness during program planning, and they use independent evaluators to report results annually.
- **Integrated resource planning.** Michigan's utilities are required to file IRPs. From the perspective of commission staff, a primary reason for moving to hourly shapes was to integrate better with the IRP process.
- **Fuel switching.** Michigan has no fuel switching policy, but its utilities have received approval for some fuel switching programs.

- **Anticipated changes.** Amended legislation is in process that may support fuel switching and electrification measures. It may also substantially increase the annual spending or savings goal and increase the utility performance incentive.

Oregon

Emphasis on Demand Savings

- Energy Trust of Oregon's enabling law focuses on minimizing energy costs. Demand savings are secondary as a result.
- This emphasis was made explicit as part of Energy Trust's 2020 impact evaluation report, which recommended:

> "The peak multiplier method currently employed by Energy Trust to estimate demand savings is not sufficiently rigorous to accurately account for demand impacts. … We recommend that Energy Trust examine demand savings methods employed in technical reference manuals for comparable states … ."[27]

Approach to TVV

- **Avoided cost.** Oregon conducts an annual docket that establishes avoided-cost values for energy; generation, transmission and distribution capacity; losses; and risk.
- **Peak period definition.** The peak period definition is seasonal (summer and winter) and has multiple hourly windows. Transmission and distribution coincidence work is "evolving," and at the distribution level it's decidedly secondary (to energy) in terms of emphasis.
- **Load shapes.** Oregon has a long history of doing load research, but for Energy Trust's purposes it boils this research down to a single value, an efficiency load factor.

Tools, Methods and Operational Practices

- **Measure characterization.** Oregon publishes detailed technical specifications for its custom programs and screens its measures individually for cost-effectiveness.
- **Cost-effectiveness testing and evaluation.** Cost-effectiveness testing is at the measure and/or building level and is a yes/no screen. Measures with a benefit-cost ratio less than 1 must seek exceptions or separate funding.
- **Integrated resource planning.** Oregon "takes IRP seriously," and the emphasis on time-varying value is largely due to IRP requirements. The investment alternatives in the IRPs are largely limited to renewables.
- **Fuel switching.** Oregon policy discourages fuel switching measures.

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[27] Cadmus. (2022a). *Impact evaluation report for 2020 production efficiency program*, p. 51. https://www.energytrust.org/wp-content/uploads/2022/04/2020-PE-Impact-Evaluation-Report_FINALwSR.pdf

- **Anticipated changes.** Policy is dynamic on multiple fronts in Oregon with respect to carbon-based goals, low-income customers, energy justice and Oregon's approach to cost-effectiveness testing, which has not been revisited in 30 years.

Vermont

Emphasis on Demand Savings

- Efficiency Vermont programs place an explicit emphasis on achieving demand savings, and its quantifiable performance indicators include minimum requirements for both summer and winter demand savings.

Approach to TVV

- **Avoided cost.** Efficiency Vermont's avoided costs are updated every three years in collaboration with the other New England states. This effort, known as the Avoided Energy Supply Cost Study, publishes annual values for on- and off-peak energy, capacity, environmental/emissions costs, demand response induced price effect and supply induced price effect costs.
- **Peak period definition.** Efficiency Vermont's peak period is defined seasonally, with hourly windows for both energy and capacity. The hourly windows for energy follow the wholesale definition of on- and off-peak energy, while the hourly windows for capacity are based on shorter two- to four-hour windows.
- **Load shapes.** Efficiency Vermont's TRM uses a six-point load shape that aligns with the six periods defined in its peak period definition.

Tools, Methods and Operational Practices

- **Measure characterization.** Efficiency Vermont uses a TRM to standardize prescriptive measure assumptions across the state.
- **Cost-effectiveness testing and evaluation.** Efficiency Vermont uses a spreadsheet to conduct cost-effectiveness testing.
- **Integrated resource planning.**
    - Vermont utilities and its high-voltage transmission company are required to file IRPs.
    - Efficiency Vermont staff are active participants in the Vermont System Planning Committee, which produces a detailed load forecast for the entire state that explicitly includes the impact of Efficiency Vermont's programs on both energy and demand.
- **Fuel switching.** Vermont policy encourages fuel switching measures.
- **Anticipated changes.** Efficiency Vermont is not anticipating any major changes to its core enabling legislation, regulation or processes. It is, however, anticipating a role for itself in implementing Vermont's recently enacted Clean Heat Standard.

Appendix B: Time-Varying Value Analysis

Solar PV Measure

The following example uses a 10 kW DC solar array to illustrate the energy- and capacity-related TVV of a solar array in Madison, Wisconsin (see Table 7). This location was chosen because it is central and is broadly representative of how a solar array would perform throughout the state.

Table 7. Time-varying value of energy for a 10 kW DC solar array in Madison, Wisconsin

kWh AC Output of a 10 kW DC PV Array
Madison, WI

	Month											
Hour	1	2	3	4	5	6	7	8	9	10	11	12
1												
2												
3												
4												
5												
6				1	7	9	6	1				
7			5	25	32	39	38	26	16	3		
8	0	11	39	66	67	77	80	73	61	45	18	1
9	28	52	87	103	110	113	119	116	105	85	64	47
10	69	95	125	131	139	143	147	140	131	124	93	86
11	91	116	146	146	160	157	167	160	151	134	105	113
12	105	142	163	155	177	158	169	178	158	141	113	109
13	118	147	171	168	183	172	173	166	162	135	116	120
14	110	138	154	160	167	156	167	161	151	113	100	100
15	83	115	122	136	145	141	149	139	125	88	75	72
16	43	78	95	97	112	109	117	106	88	61	38	33
17	6	33	52	58	75	80	83	68	47	19	1	
18			9	20	33	39	43	30	8			
19					5	10	9	2				
20												
21												
22												
23												
24												
Total	652	927	1,167	1,266	1,411	1,402	1,469	1,367	1,205	947	722	681

Average Energy Prices ($/MWH, 2021, WPS.Forward_LD)

	Month												
Hour	1	2	3	4	5	6	7	8	9	10	11	12	Ave.
1	$21	$48	$19	$22	$20	$24	$28	$31	$39	$43	$43	$34	$31
2	$20	$43	$19	$21	$19	$22	$26	$29	$37	$41	$41	$30	$29
3	$20	$41	$19	$21	$19	$21	$24	$28	$35	$41	$40	$28	$28
4	$20	$42	$19	$21	$19	$21	$24	$27	$35	$41	$41	$28	$28
5	$20	$43	$20	$23	$20	$21	$24	$28	$36	$44	$43	$28	$29
6	$21	$46	$23	$27	$22	$23	$25	$30	$42	$53	$50	$30	$33
7	$24	$65	$28	$31	$24	$25	$27	$30	$44	$59	$58	$37	$38
8	$28	$88	$29	$32	$27	$28	$30	$32	$45	$59	$66	$45	$42
9	$28	$90	$29	$31	$28	$30	$33	$36	$47	$58	$61	$43	$42
10	$27	$87	$28	$31	$29	$33	$36	$40	$49	$62	$61	$41	$43
11	$26	$80	$27	$30	$30	$36	$40	$45	$51	$62	$60	$41	$44
12	$25	$72	$26	$30	$30	$39	$42	$49	$53	$61	$58	$40	$44
13	$24	$64	$24	$29	$31	$42	$46	$53	$56	$62	$55	$39	$44
14	$23	$60	$24	$28	$31	$46	$49	$57	$58	$62	$53	$37	$44
15	$22	$54	$23	$27	$31	$49	$52	$60	$61	$62	$51	$36	$44
16	$22	$50	$22	$27	$32	$54	$58	$67	$65	$64	$51	$36	$46
17	$23	$50	$23	$28	$33	$58	$61	$68	$65	$67	$55	$39	$47
18	$27	$59	$24	$28	$32	$54	$58	$61	$62	$70	$67	$50	$49
19	$29	$75	$26	$29	$31	$47	$51	$55	$61	$73	$68	$48	$49
20	$26	$80	$29	$33	$31	$42	$46	$49	$57	$62	$60	$44	$46
21	$25	$69	$25	$32	$31	$39	$42	$46	$51	$57	$56	$42	$43
22	$24	$63	$23	$27	$26	$33	$37	$40	$45	$52	$52	$40	$38
23	$23	$53	$21	$24	$23	$29	$33	$35	$43	$49	$48	$37	$35
24	$21	$48	$20	$23	$21	$26	$30	$33	$40	$45	$45	$34	$32
Ave	$24	$61	$24	$27	$27	$35	$38	$43	$49	$56	$54	$38	$39

Total Energy Value [(kWh * $/MWH) / 1,000 = $]

	Month												
Hour	1	2	3	4	5	6	7	8	9	10	11	12	Total
1	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
3	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
4	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
5	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
6	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$1
7	$0	$0	$0	$1	$1	$1	$1	$1	$1	$0	$0	$0	$5
8	$0	$1	$1	$2	$2	$2	$2	$2	$3	$3	$1	$0	$19
9	$1	$5	$2	$3	$3	$3	$4	$4	$5	$5	$4	$2	$41
10	$2	$8	$4	$4	$4	$5	$5	$6	$6	$8	$6	$4	$61
11	$2	$9	$4	$4	$5	$6	$7	$7	$8	$8	$6	$5	$71
12	$3	$10	$4	$5	$5	$6	$7	$9	$8	$9	$7	$4	$77
13	$3	$9	$4	$5	$6	$7	$8	$9	$9	$8	$6	$5	$79
14	$3	$8	$4	$4	$5	$7	$8	$9	$9	$7	$5	$4	$73
15	$2	$6	$3	$4	$5	$7	$8	$8	$8	$5	$4	$3	$62
16	$1	$4	$2	$3	$4	$6	$7	$7	$6	$4	$2	$1	$46
17	$0	$2	$1	$2	$2	$5	$5	$5	$3	$1	$0	$0	$26
18	$0	$0	$0	$1	$1	$2	$3	$2	$0	$0	$0	$0	$9
19	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$1
20	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
21	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
22	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
23	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
24	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total	$16	$63	$30	$37	$43	$58	$66	$69	$66	$58	$41	$27	$572

Data sources: National Renewable Energy Laboratory. (n.d.). *PVWatts Calculator*; Midcontinent Independent System Operator. (n.d.). *Market Reports: Historical LMP*

Using the default assumptions from the National Renewable Energy Laboratory,[28] the first table on the left in Table 7 shows the energy output of the array by hour and by month. This is the volume input to the (P * V = $) equation, and the values simply follow the length of the day and angle of the sun throughout the year.

The middle table shows the actual wholesale energy prices from 2021 at the WPS.Forward LD node,[29] which is a Wisconsin-based MISO pricing point that was used as a proxy for the value of energy in this analysis. This is the price input to the (P * V = $) equation, and the values differ based on actual market conditions in MISO.

Avoided-cost estimates are forward-looking and do not capture this variability, but it is important to note its size. For example, the coefficient of variation (the standard deviation divided by the average) is about 39%, which is typical for wholesale electricity markets. Time-varying value is an inherent feature of wholesale energy markets, and it is substantial.

Finally, the third table on the far right shows the product of the first two tables, and the darker blue shading highlights where the value was greatest in 2021. The total energy-related value was $572 in 2021, and this is highlighted in dark blue in the lower right-hand corner of the table.

Table 8 on the next page illustrates the TVV of generation, transmission and distribution capacity using the avoided-cost values from the 2021 evaluation report[30] ($194/kW-year). In this depiction, the average hourly output of the PV array is displayed in the left-hand table. These are the approximate contributions that the array will make to avoiding capacity-related resource adequacy requirements.

The range of the peak months and hours, highlighted by the bold box in the table, is June through September during hours 15 through 18.

[28] National Renewable Energy Laboratory. (n.d.). *PVWatts calculator*. https://pvwatts.nrel.gov

[29] Midcontinent Independent System Operator. (n.d.). *Market reports: Historical LMP*. https://www.misoenergy.org/markets-and-operations/real-time--market-data/market-reports/#nt=/MarketReportType:Historical%20LMP

[30] Cadmus. (2022b). *Focus on Energy. Calendar year 2021 evaluation report* (Vol. 1), Table 19, p. 35. https://assets.focusonenergy.com/production/inline-files/Eval-Rep-CY-2021-Vol-01.pdf. Calculations use the low end of the range of electric capacity value and transmission and distribution avoided costs.

Table 8. TVV of generation, transmission and distribution capacity for a 10 kW DC solar array in Madison, Wisconsin

Average kW AC Output of a 10 kW DC PV Array

	Month											
Hour	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1												
2												
3												
4												
5												
6					0.2	0.3	0.2					
7			0.2	0.8	1.0	1.3	1.2	0.8	0.5	0.1		
8	0.0	0.4	1.3	2.2	2.1	2.6	2.6	2.3	2.0	1.4	0.6	0.0
9	0.9	1.8	2.8	3.4	3.5	3.8	3.8	3.8	3.5	2.7	2.1	1.5
10	2.2	3.4	4.0	4.4	4.5	4.8	4.8	4.5	4.4	4.0	3.1	2.8
11	2.9	4.2	4.7	4.9	5.2	5.2	5.4	5.1	5.0	4.3	3.5	3.6
12	3.4	5.1	5.2	5.2	5.7	5.3	5.5	5.8	5.3	4.6	3.8	3.5
13	3.8	5.2	5.5	5.6	5.9	5.7	5.6	5.4	5.4	4.4	3.9	3.9
14	3.5	4.9	5.0	5.3	5.4	5.2	5.4	5.2	5.0	3.7	3.3	3.2
15	2.7	4.1	3.9	4.5	4.7	4.7	4.8	4.5	4.2	2.8	2.5	2.3
16	1.4	2.8	3.1	3.2	3.6	3.6	3.8	3.4	2.9	2.0	1.3	1.1
17	0.2	1.2	1.7	1.9	2.4	2.7	2.7	2.2	1.6	0.6		
18		0.0	0.3	0.7	1.1	1.3	1.4	1.0	0.3			
19					0.2	0.3	0.3	0.1				
20												
21												
22												
23												
24												
Ave	**2.1**	**3.0**	**3.1**	**3.5**	**3.3**	**3.3**	**3.4**	**3.4**	**3.3**	**2.8**	**2.7**	**2.4**

Average Coincidence Factor (%) Ave kW During Peak / Max kW

	Month			
Hour	**6**	**7**	**8**	**9**
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15	80%	81%	76%	71%
16	62%	64%	58%	50%
17	46%	46%	37%	27%
18	22%	24%	16%	5%
19				
20				
21				
22				
23				
24				
Ave	**52%**	**54%**	**47%**	**38%**

Total GT&D Capacity Value Using $194/kW-year

	Month			
Hour	**6**	**7**	**8**	**9**
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15	**$910**	**$930**	**$871**	**$808**
16	**$703**	**$734**	**$663**	**$571**
17	**$520**	**$521**	**$426**	**$306**
18	**$253**	**$272**	**$188**	**$52**
19				
20				
21				
22				
23				
24				
Ave	**$597**	**$614**	**$537**	**$434**

The middle table in Table 8 shows the coincidence factor of the array during the peak months and hours. The values range from a high of 80% coincidence to a low of 5%. Without being paired with storage, this range is typical, and it highlights the potential inaccuracy of using an average value. The averages at the bottom of the middle table range between a high of only 54% and a low of 38%. Finally, the third table at the far right shows the product of the first table and the avoided cost of generation, transmission and distribution capacity ($194/kW-year). The capacity-related values range widely because of the wide range of coincidence factors.

Like the coincidence factors themselves, the wide range of avoided costs illustrate two issues: First, using averages during measure characterization can be inaccurate. Second, the direction of the inaccuracy is known, at least in the short term. As more solar is installed, the peak coincidence will continue to decline, and once the peak occurs after dark, its capacity value may drop to zero. This may change as more storage is installed.

Table 9 on the next page summarizes the energy- and capacity-related avoided costs and shows the same ratio of total value to the energy-related value that LBNL's method does. For a measure like a solar array, it is important to note the difference between its performance over the peak period window. This illustrates how the time value changes as the coincident peak hour shifts later into the afternoon hours. Specifically, the ratio drops by 50% between hour 15 and hour 18.

Table 9. Ratio of total value to energy-related value for a 10 kW DC solar array

Value item	Hour 15	Hour 16	Hour 17	Hour 18
Energy-related value	$572	$572	$572	$572
Capacity-related value	$880	$668	$443	$191
Total value	**$1,452**	**$1,240**	**$1,015**	**$763**
Total/energy-related	2.5	2.2	1.8	1.3

The implication for Focus' solar program is that the capacity-related value can be larger than the energy-related value. However, this value is highly dependent on the measure's coincidence with the summer peak, which is likely to continue moving into the late afternoon hours. As a result, it will be important for Focus to monitor the timing of the summer peak and update the measure's coincidence factor promptly as it shifts.

Heat Pump Water Heater Measure

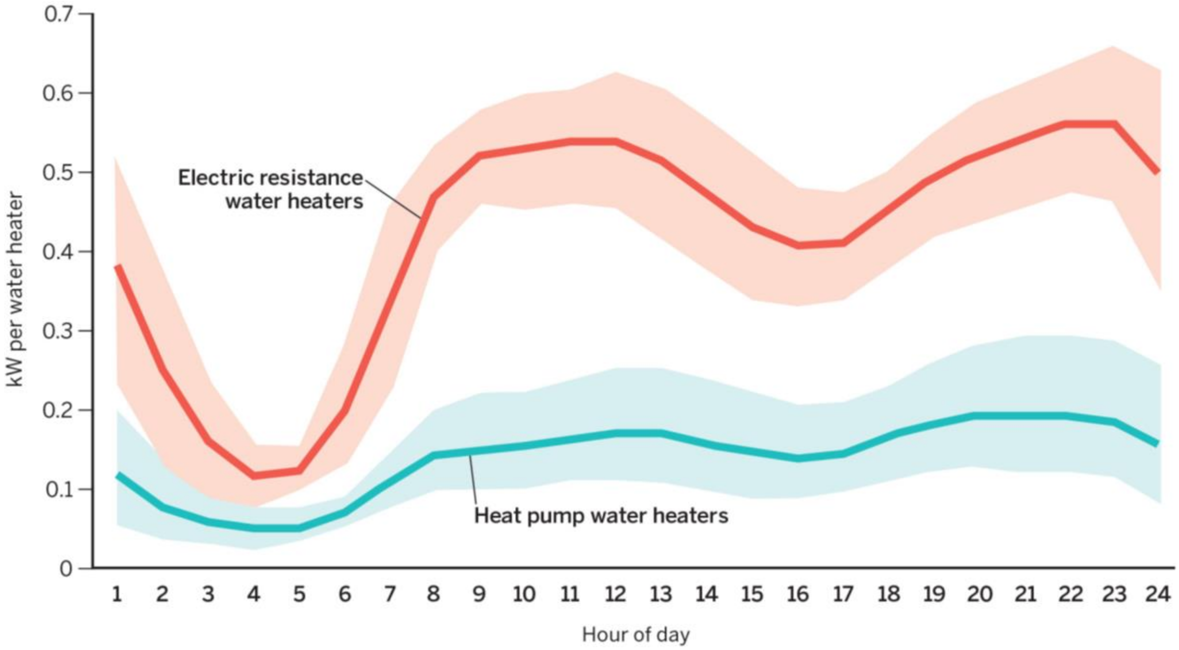
This measure was chosen for the TVV analysis for several reasons. First, hot water was one of the end uses with the highest potential in the 2021 Wisconsin energy efficiency potential study. Second, heat pump water heaters represent a potential source of electrification because they can replace fossil-fueled alternatives. Finally, the *MISO Electrification Insights* report called out water heaters as a potential source of flexible load.

Figure 6 on the next page shows the baseline load shapes of two types of water heaters in Wisconsin's stock of single-family homes.[31] The electric resistance water heater's load shape does not assume any demand response, and as a result, it has a pronounced 6-to-1 ratio between its minimum and its maximum, which simply results from the demand for hot water throughout the day.

The heat pump water heater has a markedly different load shape. The energy usage is smaller, and the shape is noticeably flatter. This is due to the nature of the technology. The compressor in a typical heat pump water heater must operate for two hours to reheat the water, while an electric resistance element in a traditional water heater can reheat the water in about half the time.

[31] ResStock. (2022, October). *EUSS ResStock national TMY3 2022.1 release* [Dataset]. National Renewable Energy Laboratory. https://resstock.nrel.gov/datasets

Figure 6. Electric resistance and heat pump water heater load shapes

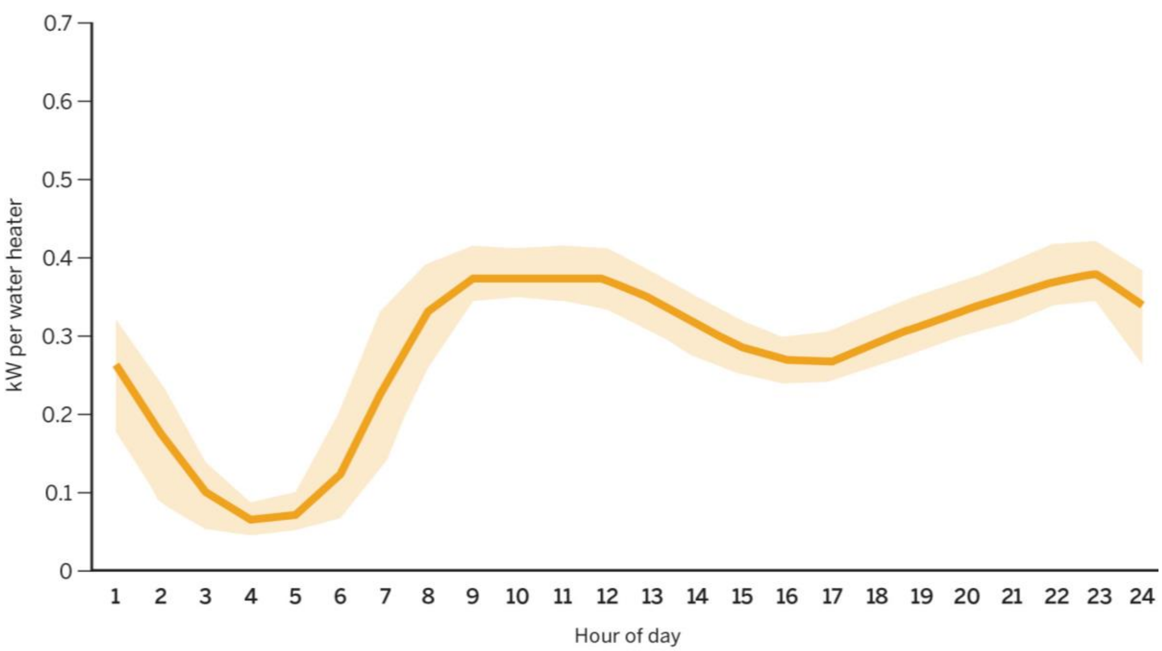


Tinted areas show the range between minimum and maximum.

Data source: ResStock. (2022, October). *EUSS ResStock National TMY3 2022.1 Release* [Dataset]

Figure 7 shows the "savings shape," which is the result of subtracting the hourly values of the heat pump water heater from the hourly values of the electric resistance water heater. This shape is used as the basis for the TVV analysis.

Figure 7. Heat pump water heater savings shape



Tinted areas show the range between minimum and maximum.

Table 10 shows the energy-related TVV using the same method and price inputs that were used for the solar array. The only difference is that the heat pump water heater savings shape was used in the first table on the left instead of a solar generation shape. The third table on the far right shows the distribution of the time value; it is far more evenly distributed across all hours than the value of the solar array. Because the energy savings (in kWh) of the heat pump water heater are smaller than the generation of the solar array, the energy-related value is smaller too. Total energy-related value is $99.

Table 10. Time-varying value of energy savings for a heat pump water heater

HPWH Savings Shape (ERWH - HPWH) * Days/Month
HPWH Total Energy Savings by Month and by Hour (kWh)
Source: REStock, Wisconsin Single-Family Detached Homes

	Month											
Hour	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1	9.6	8.9	9.5	8.1	6.9	7.3	6.8	6.6	5.3	6.4	9.6	9.9
2	7.0	6.6	6.6	4.9	3.9	4.5	4.0	3.8	2.8	3.7	6.9	7.2
3	4.0	3.8	4.1	2.9	2.3	2.5	2.2	2.1	1.6	2.0	4.1	4.2
4	2.2	2.1	2.6	2.0	2.0	1.7	1.5	1.4	1.5	1.5	2.4	2.3
5	1.8	1.5	2.4	2.4	2.9	2.1	2.0	1.9	2.4	2.4	1.7	1.6
6	2.5	2.2	3.6	4.4	6.0	3.7	3.8	3.7	5.1	4.8	2.3	2.1
7	5.3	4.6	6.7	8.5	10.3	7.6	7.8	7.7	8.7	8.9	4.3	4.1
8	9.4	8.2	10.2	11.4	12.1	10.6	10.7	10.6	10.4	11.2	8.2	8.1
9	11.4	10.0	11.9	12.4	12.4	11.4	11.4	11.2	10.7	11.4	11.0	10.7
10	11.6	10.5	12.2	12.3	12.3	11.3	11.1	10.8	10.5	11.2	11.6	11.4
11	11.4	10.3	12.4	12.3	12.4	11.3	11.0	10.8	10.6	11.3	11.4	11.2
12	11.6	10.4	12.2	12.3	11.9	11.3	10.8	10.7	10.1	10.9	11.3	11.2
13	11.0	9.9	11.6	11.4	10.9	10.4	10.0	9.9	9.3	10.0	11.1	11.0
14	10.1	9.3	10.7	10.3	9.6	9.4	9.0	8.8	8.2	8.8	10.2	10.2
15	9.1	8.5	9.8	9.4	8.8	8.5	8.1	7.8	7.6	8.0	9.2	9.1
16	8.3	7.7	9.2	8.9	8.7	8.0	7.7	7.5	7.4	7.7	8.3	8.4
17	8.0	7.4	8.9	9.1	9.1	8.1	7.8	7.5	7.8	7.9	7.8	7.9
18	8.2	7.6	9.3	9.8	10.0	8.7	8.6	8.2	8.6	8.8	8.1	8.0
19	8.8	8.1	10.1	10.5	10.7	9.6	9.5	9.1	9.2	9.5	8.7	8.6
20	9.5	8.6	10.7	11.1	11.3	10.2	10.0	9.6	9.8	10.1	9.5	9.3
21	9.9	8.9	11.3	11.6	12.0	10.8	10.5	10.2	10.5	10.9	9.9	9.8
22	10.7	9.6	12.1	12.4	12.7	11.5	11.3	10.8	11.0	11.5	10.6	10.4
23	11.5	10.4	12.6	12.6	12.3	11.7	11.5	11.1	10.4	11.3	11.3	11.3
24	11.5	10.4	11.9	11.0	10.0	10.2	9.7	9.6	8.1	9.4	11.3	11.4
Total	**204**	**186**	**223**	**222**	**221**	**202**	**197**	**192**	**187**	**200**	**201**	**199**

Average Energy Prices ($/MWH, 2021, WPS.Forward_LD)

	Month												
Hour	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Ave.**
1	$21	$48	$19	$22	$20	$24	$28	$31	$39	$43	$43	$34	$31
2	$20	$43	$19	$21	$19	$22	$26	$29	$37	$41	$41	$30	$29
3	$20	$41	$19	$21	$19	$21	$24	$28	$35	$41	$40	$28	$28
4	$20	$42	$19	$21	$19	$21	$24	$27	$35	$41	$41	$28	$28
5	$20	$43	$20	$23	$20	$21	$24	$28	$36	$44	$43	$28	$29
6	$21	$46	$23	$27	$22	$23	$25	$30	$42	$53	$50	$30	$33
7	$24	$65	$28	$31	$24	$25	$27	$30	$44	$59	$58	$37	$38
8	$28	$88	$29	$32	$27	$28	$30	$32	$45	$59	$66	$45	$42
9	$28	$90	$29	$31	$28	$30	$33	$36	$47	$58	$61	$43	$42
10	$27	$87	$28	$31	$29	$33	$36	$40	$49	$62	$61	$41	$43
11	$26	$80	$27	$30	$30	$36	$40	$45	$51	$62	$60	$41	$44
12	$25	$72	$26	$30	$30	$39	$42	$49	$53	$61	$58	$40	$44
13	$24	$64	$24	$29	$31	$42	$46	$53	$56	$62	$55	$39	$44
14	$23	$60	$24	$28	$31	$46	$49	$57	$58	$62	$53	$37	$44
15	$22	$54	$23	$27	$31	$49	$52	$60	$61	$62	$51	$36	$44
16	$22	$50	$22	$27	$32	$54	$58	$67	$65	$64	$51	$36	$46
17	$23	$50	$23	$28	$33	$58	$61	$68	$65	$67	$55	$39	$47
18	$27	$59	$24	$28	$32	$54	$58	$61	$62	$70	$67	$50	$49
19	$29	$75	$26	$29	$31	$47	$51	$55	$61	$73	$68	$48	$49
20	$26	$80	$29	$33	$31	$42	$46	$49	$57	$62	$60	$44	$46
21	$25	$69	$25	$32	$31	$39	$42	$46	$51	$57	$56	$42	$43
22	$24	$63	$23	$27	$26	$33	$37	$40	$45	$52	$52	$40	$38
23	$23	$53	$21	$24	$23	$29	$33	$35	$43	$49	$48	$37	$35
24	$21	$48	$20	$23	$21	$26	$30	$33	$40	$45	$45	$34	$32
Ave	**$24**	**$61**	**$24**	**$27**	**$27**	**$35**	**$38**	**$43**	**$49**	**$56**	**$54**	**$38**	**$39**

Total Energy Value [(kWh * $/MWH) / 1,000 = $]

	Month												
Hour	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Total**
1	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$3
2	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$2
3	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$1
4	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$1
5	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$1
6	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$1
7	$0	$0	$0	$0	$0	$0	$0	$0	$0	$1	$0	$0	$3
8	$0	$1	$0	$0	$0	$0	$0	$0	$0	$1	$1	$0	$5
9	$0	$1	$0	$0	$0	$0	$0	$0	$0	$1	$1	$0	$6
10	$0	$1	$0	$0	$0	$0	$0	$0	$1	$1	$1	$0	$6
11	$0	$1	$0	$0	$0	$0	$0	$0	$1	$1	$1	$0	$6
12	$0	$1	$0	$0	$0	$0	$0	$1	$1	$1	$1	$0	$6
13	$0	$1	$0	$0	$0	$0	$0	$1	$1	$1	$1	$0	$5
14	$0	$1	$0	$0	$0	$0	$0	$0	$0	$1	$1	$0	$5
15	$0	$0	$0	$0	$0	$0	$0	$0	$0	$1	$0	$0	$4
16	$0	$0	$0	$0	$0	$0	$0	$1	$0	$0	$0	$0	$4
17	$0	$0	$0	$0	$0	$0	$0	$1	$1	$1	$0	$0	$5
18	$0	$0	$0	$0	$0	$0	$0	$0	$1	$1	$1	$0	$5
19	$0	$1	$0	$0	$0	$0	$0	$0	$1	$1	$1	$0	$5
20	$0	$1	$0	$0	$0	$0	$0	$0	$1	$1	$1	$0	$5
21	$0	$1	$0	$0	$0	$0	$0	$0	$1	$1	$1	$0	$5
22	$0	$1	$0	$0	$0	$0	$0	$0	$0	$1	$1	$0	$5
23	$0	$1	$0	$0	$0	$0	$0	$0	$0	$1	$1	$0	$5
24	$0	$1	$0	$0	$0	$0	$0	$0	$0	$0	$1	$0	$4
Total	**$5**	**$12**	**$5**	**$6**	**$6**	**$7**	**$8**	**$9**	**$10**	**$12**	**$11**	**$8**	**$99**

Table 11 on the next page illustrates the TVV of generation, transmission and distribution capacity using the avoided-cost values from the 2021 evaluation report ($194/kW-year).[32] The average hourly savings from the heat pump water heater are displayed in the left-hand table. These are

32 Cadmus, 2022b.

the approximate contributions that the measure will make toward avoiding capacity-related resource adequacy requirements. The range of the peak months and hours, highlighted by the bold box, is June through September during hours 15 through 18.

Table 11. TVV of generation, transmission and distribution capacity for a heat pump water heater

HPWH Average Energy Savings by Month and by Hour (kW)
Source: REStock, Wisconsin Single-Family Detached Homes

	Month											
Hour	1	2	3	4	5	6	7	8	9	10	11	12
1	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3
2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2
3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
4	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.2	0.2	0.1	0.1
7	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.2	0.3	0.3	0.1	0.1
8	0.3	0.3	0.3	0.4	0.4	0.4	0.3	0.3	0.3	0.4	0.3	0.3
9	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3
10	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.4	0.4	0.4	0.4
11	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.4	0.4	0.4	0.4
12	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.4	0.4	0.4
13	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.4	0.4
14	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
15	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
16	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.3	0.3
17	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.3	0.3	0.3	0.3
18	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
19	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
20	0.3	0.3	0.3	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3
21	0.3	0.3	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.4	0.3	0.3
22	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.3	0.4	0.4	0.4	0.3
23	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.4	0.4	0.4
24	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4
Ave	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3

Average Coincidence Factor (%)
Ave kW During Peak / Max kW

	Month			
Hour	6	7	8	9
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15	69%	63%	61%	61%
16	64%	60%	58%	60%
17	65%	61%	59%	63%
18	70%	67%	64%	69%
19				
20				
21				
22				
23				
24				
Ave	67%	63%	61%	63%

Total GT&D Capacity Value
Using $194/kW-year

	Month			
Hour	6	7	8	9
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15	$57	$52	$51	$51
16	$53	$50	$48	$50
17	$54	$50	$48	$52
18	$58	$56	$53	$57
19				
20				
21				
22				
23				
24				
Ave	$56	$52	$50	$52

Unlike for the solar array, the peak coincidence factors in the middle table do not vary greatly, and as a result, the averages at the bottom of the table are representative of the measure's peak coincidence. Similarly, the TVV of capacity varies little in the far-right table, whose averages are clustered in the low- to mid-$50 range.

Table 12 shows the avoided costs, as well as the ratio of total value to energy-related value. Unlike for the solar array, the ratio does not change significantly across the hours in the peak window. The capacity-related TVV is less variable as a result.

Table 12. Ratio of total value to energy-related value for a heat pump water heater

Value Item	Hour 15	Hour 16	Hour 17	Hour 18
Energy-related value	$99	$99	$99	$99
Capacity-related value	$53	$50	$51	$56
Total value	**$151**	**$149**	**$150**	**$155**
Total/energy-related	1.5	1.5	1.5	1.6

The implication for Focus' heat pump water heater program is that the capacity-related value is about half of the energy-related value, and it is a fairly certain number. The system peak can fall anywhere within the peak window, and the heat pump water heater savings are likely to be the same. This does not mean that additional capacity-related value cannot be achieved from this measure. The heat pump water heater load could be controlled by a demand response program, which would product additional capacity-related value.

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