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ISSUE BRIEF

The Flexible Demand Opportunity

How Smarter Electricity Use Can Support a Clean Energy Future

HIGHLIGHTS

The premise of flexible demand is simple: small adjustments in how and when we use electricity can result in major benefits for the power grid. But that potential remains largely untapped. Instead, today's grid relies on fossil fuel–fired power plants for flexibility, and it does so at significant cost—in wasted clean energy, heavier reliance on natural gas, and unnecessary grid investments. As renewable resources such as wind and solar race online, grid flexibility becomes all the more important, and the costs of overlooking demand-side flexibility increase. Stakeholders must recognize and value the potential contributions of flexible demand, remove hurdles to its mobilization, and ultimately implement equitable, secure, and forward-looking programs.

Safe, reliable power requires the constant balancing of supply and demand. As a result, flexibility plays an important role in maintaining electricity system equilibrium, from seconds to minutes to hours to days, all across the grid. Traditionally, grid operators have treated the timing of electricity use as largely fixed, leaning heavily on flexibility in electricity supply to maintain balance, building power plants and ramping them up and down to match daily and seasonal swings in need. But that approach is costly, inefficient, and increasingly incompatible with climate and public health goals—and it overlooks a cost-effective, common-sense alternative: tapping into flexibility in electricity demand.

Indeed, a number of the ways in which we use electricity are flexible, from heating and cooling homes to charging electric vehicles. "Flexible demand" takes advantage of that latent flexibility to shape and shift electricity use to better match grid needs. As the share of wind and solar on the electricity system grows, so, too, does the incentive for system flexibility to take advantage of low-cost, zero-carbon electricity whenever and wherever it is produced.

With flexible demand, consumers can directly assist in cost-effectively integrating renewables, avoiding expensive and unnecessary investments while helping slash the use of natural gas to achieve a cleaner, healthier, and lower-cost grid. The potential is significant. But to move from theory to practice, flexible demand contributions must first be recognized and valued.

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By shifting flexible electricity end uses to times that best match the needs of a high-renewables power grid, flexible demand programs can lessen reliance on natural gas, resulting in cleaner and healthier air and lower costs.

From Demand Response to Flexible Demand

The concept of modifying demand is not new to utilities. For decades, their "demand response" and "load control" programs have reduced demand during the highest-use—and thus highest-cost—times of the year. However, most of these programs have been limited in scale and one-directional, with the utility unilaterally controlling the operation of appliances or calling on major commercial and industrial customers to cut demand in response to periods of extreme energy shortage.

Flexible demand significantly expands the application and scope of demand response, leveraging the portion of electricity use, or "demand," that can be shifted within a given range of time—seconds, minutes, hours, or even days—to benefit the grid without appreciably changing the customer's experience. Today's advanced metering infrastructure allows for progressing to this fuller conception. While traditional electricity meters track the total amount of electricity consumed over a billing period (usually monthly), advanced meters now make it possible to disaggregate consumption into shorter time intervals, at least hourly but increasingly close to real-time. Recently, the deployment of that infrastructure has surged, with the number of installed "smart meters" growing from 6.7 million in 2007 to 72 million in 2016, or just under 50 percent of all meters (FERC 2018).

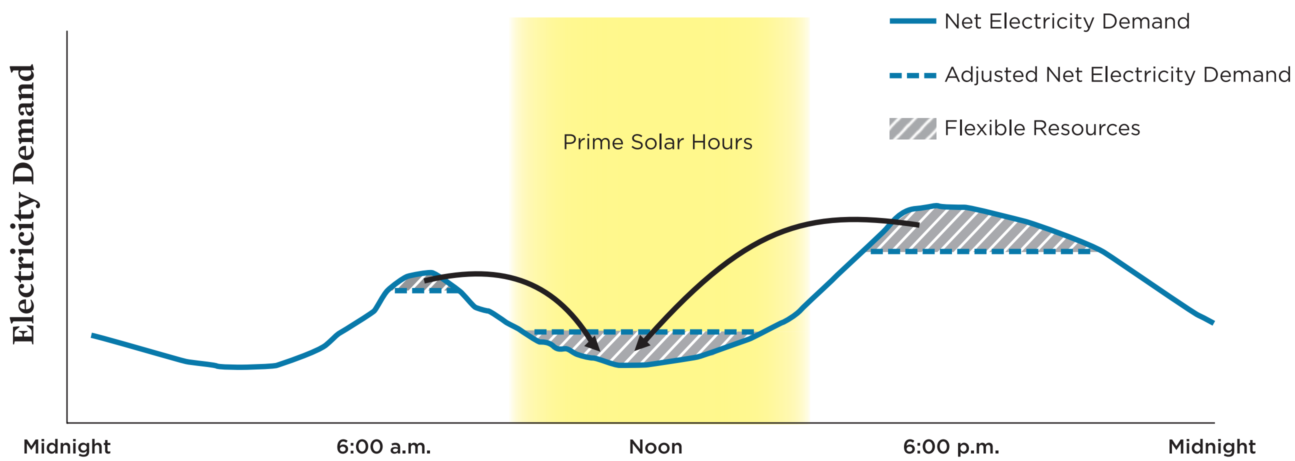
Utility programs leveraging this information have grown in turn, primarily by deploying price-reflective, time-varying rates to encourage customers to shift their electricity use from higher- to lower-cost times of the day (McNamara, Wisland, and Jacobs 2017). Still, the growth of demand-side utility programs has been sluggish compared with the scale of the opportunity, and most utilities continue to exclusively focus on the historical application of reducing use during peak periods (FERC 2018).

Flexible demand looks beyond historical applications to new ways of modifying demand to lower costs and reduce pollution as the needs of the power grid—and resources on it—evolve. The exact mix of those needs will vary by utility, but three primary applications for flexible demand stand out: maximizing alignment of demand with renewables production, precluding natural gas generation and avoiding infrastructure upgrades, and replacing historical fossil fuel resource responsibilities.

- **Maximizing alignment with renewables production.** By shifting loads across different times of the day (see figure), flexible demand can directly address one challenge of running a system with a high level of variable renewable resources: periods when demand and renewable energy production are out of step. Flexible electricity use can be shifted and shaped to maximize alignment with periods of renewable energy abundance.

  California provides an emerging example. As solar produces an increasing share of the state's electricity mix, supply is starting to outpace demand in the middle of the day, particularly during the spring and fall when

Maximizing Alignment of Flexible Loads with Renewable Resource Production



Some flexible loads can shift the timing of their consumption across hours to match periods of renewables production and avoid periods of renewables scarcity. In places such as California, where midday sunshine is abundant, shifting electricity use to the middle of the day can optimize low-cost, clean energy consumption.

Note: Net demand curves (demand minus variable renewable resources), renewable resource profiles, and flexible resources vary across seasons and geographies; these representations are illustrative only.

> ***Flexible demand looks beyond historical applications to new ways of modifying demand to lower costs and reduce pollution as the needs of the power grid—and resources on it—evolve.***

demand for space heating and cooling drops, resulting in lower electricity loads. During those periods, wholesale electricity prices plummet, and "extra" renewable electricity must be spilled (known as "curtailment"), moved elsewhere, or stored for later at a cost. However, electricity end uses that can be flexible in the timing of their consumption can take advantage of the differential, maximizing use of cheaper, solar-laden hours while avoiding times of more expensive, fossil fuel–heavy generation (Load Shift Working Group 2019).

- **Precluding natural gas and avoiding infrastructure upgrades.** Traditional demand-response programs aim to lower overall system costs by targeting the highest-cost, peak-period times of the year. Flexible demand applications expand upon that approach by targeting a wider range of high-cost issues, including system ramps, local grid constraints, and transmission system constraints. A fast "ramp" refers to a period of rapidly increasing or decreasing need for electricity, which can pose challenges for the grid. Ramps have typically been demand-driven, reflecting broad behavioral patterns—turning on appliances after returning home from work, for example—but patterns in the timing of renewable resource production are also increasingly relevant.

  Traditional ramp-covering resources—natural gas plants—are expensive and polluting, and they can displace renewable resources. Energy storage, predominantly in the form of batteries, offers an increasingly viable alternative. Still, the magnitude of a given ramp drives the amount of resource required, and the more that demand flexibility can limit a ramp's size, the better able and less expensive it is for energy storage to cover it. Demand can be optimized to tackle both ends of a ramp, filling the valley and clipping the peak.

  Flexible demand can also ease operational constraints at both the distribution and transmission levels, presenting an efficient "non-wires alternative" to costly infrastructure upgrades (Chew et al. 2018). For example, recent research in California studied the potential impact of a widescale deployment of electric vehicles in the presence or absence of managed, or grid-informed, charging. The study projected that managed charging would preclude the need for most otherwise-required upgrades to the distribution system, yielding significant grid savings (Coignard et al. 2019).

- **Replacing the responsibilities of fossil fuel resources.** Grid reliability requires constant fine-tuning of the system, with adjustments often referred to as "ancillary services." Traditionally, fossil fuel–fired generators have provided these adjustments; one hurdle in displacing today's fossil plants with renewables has been developing mechanisms for identifying, quantifying, and valuing grid needs in ways that recognize and compensate new resources for their ability to provide those ancillary services instead. Demand-side solutions are well able to contribute. For example, adding smart controls to electric water heaters in PJM, a regional electricity market, has enabled a low-cost source for frequency regulation, a type of ancillary service that manages rapid changes in grid stability (Mosaic Power, n.d.).

Demand-side solutions will not meet all future grid flexibility needs, but they can make a significant contribution. And the more renewable resources on the grid, the greater the need for—and value of—flexibility. A recent national-level assessment estimated that cost-effective demand response can potentially more than triple by 2030, with a value of more than $14 billion annually (Hledik et al. 2019). A separate modeling effort focused on a high-renewables future in Texas found that mobilizing demand flexibility could reduce renewables curtailment by 40 percent and lower the average magnitude of ramps by more than half (Goldenberg, Dyson, and Masters 2018).

Identifying Flexible End Uses

A key enabling feature underpins flexible demand: a subset of electricity-consuming products and processes can be flexible in when they consume energy without significantly affecting the eventual level of service. Still, there are important differences among flexible loads regarding the timing, duration, and magnitude at which they can contribute and at what cost. These differences—and opportunities—are critically important to understand as a growing number of states, cities, and other entities push to transition buildings and transportation to all-electric end uses, which could lead to significant added flexible load.

- **Space heating and cooling.** Space heating and cooling accounts for about half of all residential energy consumption (EIA 2018a). Flexibility in this area comes in three forms for electricity-based loads: using the thermal inertia of a structure as a form of battery to enable preheating or precooling a home; using thermal batteries directly (for example, preheating ceramic bricks for space warming or preforming ice for space cooling); and coordinating slight modifications in heating or cooling operations across many locations to limit aggregate peaks in use.
- **Water heating.** As a form of storing thermal energy, electric tank water heaters present a significant opportunity for load shifting and ancillary services (Hledik, Chang, and Lueken 2016). Retrofitting an electric water heater with a simple, low-cost controller yields significant flexibility. New electric water heaters can allow further flexibility via added system controls.
- **Electric vehicle charging.** As electric vehicle use grows, charging them will increase electricity consumption and potentially increase peak power demand (Mai et al. 2018). However, many users can be flexible in when they charge their electric vehicles, creating an enormous opportunity for adding beneficial, flexible load to the grid. Local grid conditions, including the timing of renewable generation and the specific characteristics of the distribution system, will inform optimal charging patterns.

As a growing number of states, cities, and other entities push to transition to all-electric end uses, there is an opportunity for significant added flexible load.

- **Behind-the-meter batteries.** Batteries are rapidly appearing on the distribution system. When situated at homes or businesses, they can act as a timing buffer between calling on the grid and final energy use. This buffering can further boost the flexibility and responsiveness of a residential, commercial, or industrial entity's overall electricity consumption.
- **Industrial/commercial applications.** In addition to the shared flexibility of major residential loads, commercial

Dennis Schroeder/NREL

Electric vehicle users can often be flexible in the exact timing of vehicle charging, allowing for optimized charging programs, such as through this demonstration system being installed, which allows coordination of charging needs across users to lower costs and limit strain on grid infrastructure.

Customer-Based Programs to Improve Grid Flexibility

	Behavioral	Price-Exposed	Subscription-Enrolled
Purpose	Reduce electricity use during highest-cost hours of the year	Guide electricity loads to grid-optimal periods each day	Guide electricity loads to grid-optimal periods each day, individually or in aggregate
Frequency	A few times a year	Year-round	Year-round
Communication	Often day-ahead call, text, or email about upcoming alert hours	Advanced meter or other device capable of conveying prices to end users	Connected energy control device, managed by the utility or a third party
Compensation	Varies from no monetary compensation to small benefit on bills	Lowered bills by taking advantage of low-cost hours	Compensation for participation, including up-front, fixed credit, or pay for performance

Multiple pathways exist for leveraging the flexibility of customer electricity end uses. These programs types have tradeoffs, and what may work for one utility or one grid need may not work for another.

and industrial applications tend to include a range of large additional electricity end uses, such as for lighting, pumping, or production processes. Some of these loads can be highly price-responsive; the specifics vary on a case-by-case basis.

- **Other devices and appliances.** Other devices plugged into outlets can add up, accounting for about half of the average US home's electricity use (EIA 2018b). Some, like pumps for swimming pools, can contribute a great deal of flexibility but are much less common. The cost of enabling technology and the relevant granularity of electricity prices are likely to drive the degree to which various plug loads can be expected to participate in broader flexible demand programs.

Within a given end-use category, only a subset of loads will be good candidates to participate in flexible demand programs, and cost-effective applications will not apply universally. Furthermore, a utility may only be interested in a subset of possible flexible end uses, driven by cost and magnitude of need.

Mobilizing the Customer

Demand-side contributions to grid flexibility exist within a broad matrix of enabling technologies and market access models. Understanding the different pathways for mobilizing resources is critical to advancing deployment. In general, utilities can implement three types of program. The first is simple but limited in effect; the others, while more complex, are capable of yielding fuller value (see table).

- **Behavioral.** The most basic form of demand mobilization is behavioral. A person can be motivated to respond to special events like a heat wave, or even to change broad daily patterns of electricity use, simply based on information about how their actions can help or hurt the grid, and thereby shift to broadly beneficial consumption patterns in response. A drawback of these low-cost interventions comes from the uncertainty of participation, limiting the ability of utilities to depend on such a response for reliability purposes or to target more dynamic day-by-day grid needs.

- **Price-exposed.** Customers can be exposed to more dynamic and granular electricity pricing, specific to time and even location.* Price variations reflect the needs of the system, from the availability of clean energy resources to the status of the local grid's infrastructure. Electricity users can respond to such prices manually or, increasingly, they can direct their appliances and other electricity end uses to adjust operations automatically.

* *Time-of-use rates, which set rates for peak and off-peak hours by season, share some traits of behavioral and price-exposed approaches. Such rates are intended to broadly guide consumption patterns beyond peak events; however, they cannot respond to more dynamic day-by-day grid needs as is characteristic of the price-exposed category here.*

Consumers can take such steps individually or at the direction of a third party.

- **Subscription-enrolled.** Customers can enroll in a demand-management program for all or some portion of their flexible electricity end uses. In exchange for compensation, the customer allows a utility or third party to directly adjust electricity end uses according to grid needs. This reduces the complexity of communicating sufficiently informative prices to the end user, and it more easily supports capturing value streams only possible through targeted customer aggregation.

For each type of program, customers can set bounds, such as specifying that an electric vehicle must be fully charged in time for the morning commute or that a home's temperature must be at a certain point when someone returns from work. Participation can occur at the appliance level, such as through an electric vehicle charger or a smart thermostat, or for a whole home—optionally assisted by a home energy management system—with various end uses contributing behind the customer's meter. Notably, distributed energy resources such as rooftop solar are increasingly likely to factor into the consumption calculus.

Dennis Schroeder/NREL

With the right systems in place, flexible demand programs can boost renewables integration at the home, neighborhood, and grid level by optimizing the timing of flexible electricity end uses.

Mobilizing the Utility

Viable program design is only part of the mobilization equation; the potential for beneficial demand-side contributions has long outpaced actual deployment by utilities. In the absence of targeted interventions, the broader range of flexible demand opportunities will likely face similar hurdles, too.

- **Recognize value.** Regulators must require utilities to consider the full spectrum of demand-side potential, particularly as the penetration of renewable resources grows and drives the value of such flexibility higher. A natural place for such a prompt is the integrated resource planning process. Many states require utilities to periodically develop integrated resource plans. Such processes can serve as useful opportunities to require utilities to consider new resources and how those might contribute to existing and future resource portfolios (see Northern States Power Company 2019). As distribution system planning becomes more prevalent, supporting analyses should consider flexible demand contributions as well, including as possible alternatives to expensive investment proposals for power lines and supporting grid infrastructure.
- **Align utility incentives.** Many utility business models run counter to demand-side interventions (Migden-Ostrander 2018). By precluding the buildout of large infrastructure upgrades or generation investments, cost-effective demand flexibility programs directly undercut utility returns on investment accruing to capital expenditures. The decoupling of utility revenues from retail sales, often advanced as a way to support energy efficiency initiatives, can be similarly useful here. Transitioning to performance-based ratemaking, including through the use of performance-incentive mechanisms, can help to overcome conflicting interests by compensating utilities for investing in demand flexibility and meeting established metrics, such as for system efficiency (Littell et al. 2017). Even more transformative measures, like restructuring, divestment, and retail competition, are also potential responses to market inefficiencies. Any effort to support utility action should align with utility regulatory paradigms that protect consumers by maximizing affordability and reliability while minimizing costs and risks.
- **Remove obstacles to participation.** Today's wholesale electricity markets present hurdles to flexible demand program participation. While demand response has carved a path for limited participation in wholesale markets, clear market opportunities do not yet exist for all the mechanisms by which flexible demand can contribute. Limits on the direct participation of third-party aggregators in wholesale markets threaten to further constrain the magnitude of the available potential. The

design of flexible demand programs must include standards and requirements that enable the complete capture of demand-side benefits, including—as is being advanced for energy storage—allowing participation at both the distribution and wholesale levels.

Fully evaluating the potential of demand-side solutions will require changes to modeling approaches and shifts in a number of utilities' core assumptions. Mobilizing new programs will require more changes still, with a need for proactive and enduring education of, and outreach to, consumers. Throughout, public-benefitting solutions will require sustained support as they face off against entrenched interests profiting from the existing framework.

Considerations for Program Design

Demand-side solutions enable consumers to play an important role in the transition to a cleaner grid. This empowerment is to be celebrated; it also requires care. Issues of equity, ratepayer protections, data management, structural durability, and openness to emerging opportunities all require careful consideration in program design and deployment.

- **Equity and accessibility.** Demand-side initiatives must proactively ensure equity in developing and deploying programs. Disparities can arise in the opportunity and ability to participate in initiatives and in the distribution of accrued grid-wide benefits. For example, if residential programs begin by targeting customers with the largest load potential and the most grid-responsive appliances, they would limit qualifying customers to large energy users and those who can afford to upgrade appliances—resulting in an inherent bias toward higher-income households. However, if intentionally considered, those disparities can be overcome, such as through dedicated carveouts, enrollment requirements, and joint efforts with energy efficiency and weatherization programs to ensure that new investments are primed for demand-side participation (NEEP 2018). At the same time, ratepayer protections should ensure that programs do not expose participants to excessive pricing risks or harm consumers unable to participate, and that all customers share in the benefits of a lower-cost grid.

- **Data security, privacy, and access.** Because demand-side interventions trade on detailed information at the individual level, issues of data security and privacy must be a high priority from the outset. A breach of user trust can permanently derail a program. Alongside such concerns comes a parallel need to ensure that users have meaningful control over, and access to, their own data, as well as the ability to easily share it with third-party service providers if they so desire.

- **Durability vs. elasticity.** Demand-side programs must constantly balance the need for durability against the need to respond to rapid change. To drive consumer choices and developer investments, programs must signal clearly where value exists and what opportunities can be exploited. At the same time, because demand-side programs are intended to add flexibility to a rapidly changing grid, they must be fluid enough to respond as technologies advance and grid needs evolve. Adaptive program design can strike such a balance, coupling near-term certainty with interim checkpoints to ensure continued effectiveness.

- **Planning for electrification.** In the drive toward economy-wide decarbonization, a consensus is emerging around the importance of electrifying other fossil fuel–fired end uses, including motor vehicles and space and water heaters. Such uses could significantly increase electricity consumption, yet they also hold significant potential for flexibility in their consumption patterns. These dueling trajectories—exacerbated inflexible demand curves versus increased demand-side flexibility contributions—make clear the importance of proactive planning that incorporates flexibility in electrification initiatives from the start. Leveraging flexible demand programs to inform energy efficiency investments can drive further savings at the times and locations of greatest value for the grid.

From Theory to Practice

In some parts of the United States, renewables are already facing challenges from the inherent inflexibility of an electricity system designed around fossil fuels. And we pay for that—in wasted clean energy, in heavier reliance on natural gas, in higher grid-transition costs. But the challenges are surmountable. Indeed, the growing pains of today's grid reinforce the enormous opportunities afforded by thoughtfully transitioning to a system optimized around clean energy.

A fundamental part of this transition is recognizing and mobilizing the latent flexibility within daily electricity use, in turn directly supporting the integration of a high level of renewables onto the grid. Simply facilitating the process of using electricity smartly—of shaping and shifting electricity use to match the needs of a clean energy grid—will make possible a far more cost-effective system and aid in the rapid displacement of fossil fuel-fired resources along the way.

Moving from theory to practice will take dedicated work. Stakeholders, including utilities, regulators, policymakers, and energy analysts, all share responsibility in ensuring that this cost-effective, common-sense solution is not overlooked and is advanced to the benefit of all consumers and the environment.

***Julie McNamara** is a senior energy analyst in the UCS Climate and Energy Program.*

ACKNOWLEDGMENTS

This issue brief was made possible through support from the John D. and Catherine T. MacArthur Foundation, the Heising-Simons Foundation, and UCS members.

Thank you to our external reviewers Cara Goldenberg, a senior associate at the Rocky Mountain Institute, and John Shenot, a senior advisor at the Regulatory Assistance Project, for providing a rigorous review and helpful recommendations. Finally, thank you to UCS colleagues for offering valuable feedback; our editor, Marc S. Miller, for making the report more readable and effective; and Cynthia DeRocco and Heather Tuttle for ably overseeing the brief's production.

The opinions expressed herein do not necessarily reflect those of the organizations that funded the work or the individuals who reviewed it. The Union of Concerned Scientists bears sole responsibility for the brief's content.

REFERENCES

Chew, B., E.H. Myers, T. Adolf, and E. Thomas. 2018. *Non-wires alternatives: Case studies from leading U.S. projects*. E4TheFuture, PLMA, and Smart Electric Power Alliance. https://e4thefuture.org/wp-content/uploads/2018/11/2018-Non-Wires-Alternatives-Report_FINAL.pdf.

Coignard, J., P. MacDougall, F. Stadtmueller, and E. Vrettos. 2019. Will electric vehicles drive distribution grid upgrades?: The case of California. *IEEE Electrification Magazine* 7(2):46–66. https://doi.org/10.1109/MELE.2019.2908794.

Federal Energy Regulatory Commission (FERC). 2018. *2018 assessment of demand response and advanced metering*. Washington, DC. www.ferc.gov/legal/staff-reports/2018/DR-AM-Report2018.pdf.

Goldenberg, C., M. Dyson, and H. Masters. 2018. *Demand flexibility: The key to enabling a low-cost, low-carbon grid*. Boulder, CO: Rocky Mountain Institute. http://rmi.org/wp-content/uploads/2018/02/Insight_Brief_Demand_Flexibility_2018.pdf.

Hledik, R., A. Faruqui, T. Lee, and J. Higham. 2019. *The national potential for load flexibility*. Cambridge, MA: The Brattle Group. https://brattlefiles.blob.core.windows.net/files/16639_national_potential_for_load_flexibility_-_final.pdf.

Hledik, R., J. Chang, and R. Lueken. 2016. *The hidden battery: Opportunities in electric water heating*. Cambridge, MA: The Brattle Group. https://brattlefiles.blob.core.windows.net/files/7167_the_hidden_battery_-_opportunities_in_electric_water_heating.pdf.

Littell, D., C. Kadoch, P. Baker, R. Bharvirkar, M. Dupuy, B. Hausauer, C. Linvill, J. Migden-Ostrander, J. Rosenow, W., Xuan, O. Zinaman, and J. Logan. 2017. *Next-generation performance-based regulation: Emphasizing utility performance to unleash power sector innovation*. Montpelier, VT, and Golden, CO: Regulatory Assistance Project and National Renewable Energy Laboratory. www.raponline.org/knowledge-center/next-generation-performance-based-regulation-emphasizing-utility-performance-unleash-power-sector-innovation.

Load Shift Working Group. 2019. *Final report of the California Public Utilities Commission's Working Group on Load Shift*. Prepared by Gridworks. https://gridworks.org/wp-content/uploads/2019/02/LoadShiftWorkingGroup_report.pdf.

Mai, T., P. Jadun, J. Logan, C. McMillan, M. Muratori, D. Steinberg, L. Vimmerstedt, R. Jones, B. Haley, and B. Nelson. 2018. *Electrification futures study: Scenarios of electric technology adoption and power consumption for the United States*. Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A20-71500. www.nrel.gov/docs/fy18osti/71500.pdf.

McNamara, J., M. Jacobs, and L. Wisland. 2017. *Flipping the switch for a cleaner grid: Using time-varying rates to boost renewables and save money*. Cambridge, MA: Union of Concerned Scientists. www.ucsusa.org/resources/flipping-switch-cleaner-grid.

Migden-Ostrander, J. 2018. Power sector transformation in state utility regulation: To boldly go where no regulator has gone before. *Electricity Journal* 32(7):106626. https://doi.org/10.1016/j.tej.2019.106626.

Mosaic Power. n.d. About frequency regulation. https://mosaicpower.com/the-frequency-regulation-market.

Northeast Energy Efficiency Partnerships (NEEP). 2018. *Action plan to accelerate strategic electrification in the Northeast*. Lexington, MA. https://neep.org/reports/strategic-electrification-action-plan.

Northern States Power Company. 2019. 2020–2034 *Upper Midwest resource plan*. Xcel Energy. Docket No. E002/RP-19-368. www.xcelenergy.com/staticfiles/xe-responsive/Company/Rates%20&%20Regulations/The-Resource-Plan-No-Appendices.pdf.

US Energy Information Administration (EIA). 2018a. *2015 residential energy consumption survey*. www.eia.gov/consumption/residential/data/2015/index.php.

US Energy Information Administration (EIA). 2018b. *EIA's residential energy survey now includes estimates for more than 20 new end uses*. Washington, DC. www.eia.gov/todayinenergy/detail.php?id=36412.

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NATIONAL HEADQUARTERS
Two Brattle Square
Cambridge, MA 02138-3780
Phone: (617) 547-5552
Fax: (617) 864-9405

WASHINGTON, DC, OFFICE
1825 K St. NW, Suite 800
Washington, DC 20006-1232
Phone: (202) 223-6133
Fax: (202) 223-6162

WEST COAST OFFICE
500 12th St., Suite 340
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Phone: (510) 843-1872
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Phone: (312) 578-1750
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