CLIMATE CABINET EDUCATION

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ELECTRIC MUNICIPAL UTILITIES AND THE TRANSITION TO A CLEAN ENERGY FUTURE

A Guide for Municipal Utility Leaders

Climate Cabinet Education combines data science with policy expertise, local partnerships and cross-state experience to support climate leadership in local governments across the US — working towards a clean energy economy that creates jobs, improves community health, and unlocks local opportunity and leadership.

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Ken Colburn retired as RAP's director of US programs in 2020. He continues to contribute to the clean energy transition part-time through his LLC, Symbiotic Strategies.

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B. Capture Demand-Side Flexibility[71]

Municipal utilities are required to provide customers with reliable energy around the clock. To do so, the utility matches energy supply with the highest expected energy demand that may be needed at a given time. The need for supply at these high demand times means that at times of low demand, typically nighttime hours, excess energy is available. It also means that there are times of high demand on the grid each day, similar to rush-hour traffic. High-traffic energy times occur predictably in the late afternoon and early evening when people start returning home and using air conditioners, cooking, watching TV and doing laundry, while commercial buildings and offices are still open and industry is operating.[72]

In addition to daily peaks of energy usage, there are also extreme events, usually due to weather, such as very hot summer days or extreme winter storms, that can stress the grid, causing customers to use more energy than usual to heat or cool their buildings. These events can lead to demand that exceeds the utility's available energy supply. Unresolved, this mismatch between energy supply and demand can lead to brownouts and blackouts.

Different options are available to utilities to fill both daily peak demand and these periodic, unexpected shortfalls of energy supply. Historically, utilities built excess generation that could be called upon during times of grid stress. Many utilities have built (or kept old) power plants known as peaker plants, which are rarely called upon but are available when the grid approaches maximum capacity. Using peaker plants is a costly option, both in terms of finances and environmental impacts; peaker plants have high fuel costs when operated, so the power they supply can be very expensive. Additionally, if they are older plants that are mothballed and kept mainly to meet periodic

71 See Budhiraja, D. (2019, January 24). *Demand response 101: Understanding how utilities balance energy supply & demand.* GridPoint. https://www.gridpoint.com/understanding-demand-response/ and Linvill et al., 2019.

72 See Budhiraja, D. (2019, January 24). *Demand response 101: Understanding how utilities balance energy supply & demand.* GridPoint. https://www.gridpoint.com/understanding-demand-response/ and Linvill et al., 2019.

energy shortfalls, they may not meet current emissions requirements but are nevertheless allowed to run in emergency situations.[73] An alternative supply option is for a utility to purchase power if it is in a regulated market.

A more efficient approach involves managing demand to more fully utilize existing grid capacity and to effectively integrate interconnected devices to create a smart two-way grid. In short, to meet these variations in supply and demand, utilities can engage customers. Customers can be encouraged to change or shift the time they use energy through time-varying pricing and demand management programs, which are discussed below. The pricing policy can also encourage customers to invest in distributed energy resources, which municipal utilities can encourage by providing net metering. Pricing and demand management programs can also shift energy use for customers' electric vehicles or space or water heaters to absorb excess renewable energy. Further, municipalities can offer energy efficiency programs — the most effective option to decrease peaks and manage demand.

Policies that are used to engage customers to capture demand-side flexibility include:

- Demand management programs.
- Time-varying pricing.
- Net energy metering and interconnection policies.

These policies are not meant to be used in isolation, and they work well together. For example, time-of-use (TOU) pricing is a rate design that may be incorporated in demand management and beneficial electrification programs.

1. Managing Demand to Realize Utility and Customer Benefits

A key to realizing system flexibility is to successfully engage customers. Because shaping energy demand previously was not technologically possible, utilities have not focused on methods to engage customers or communicate grid needs. Now, changes in technology allow the customer to save money and the utility to make the most effective use of grid assets through demand management.

Demand management[74] occurs when customers intentionally reduce or shift their electricity usage in response to a signal from the utility, usually with financial incentives to do so. Historically, the technology has not been available to store energy or shift energy

Benefits of demand management

- Reduces peak demand by an average of at least 10%.[75] This reduction:
  - Saves customers money.
  - Enables the municipal utility to avoid or defer the need to build or purchase additional generation capacity, which also leads to savings for customers.
  - Provides environmental benefits through reduced emissions, particularly if demand is able to be shifted to times when cleaner generating sources are abundant.[76]
- Helps integrate zero-emissions electric generation and end uses.
  - The flexibility of demand management enables the integration of variable energy resources like wind and solar by shifting electric vehicle charging and appliance use to times when these resources are abundant.
- Reduces greenhouse gas emissions.
  - When demand management programs reduce peak load, they also help to reduce air pollutants from existing fossil-fueled generating sources.
  - Demand management programs can provide flexibility to support growth of zero-emissions generation.[77]

73 This practice is known as "reliability must run" exceptions.

74 Demand management has been known by various terms over the decades, including demand response and demand-side management. "Demand response" is a historical term used when such programs were used to provide cost-effective energy and capacity resources to help defer the need for new sources of power, including generating facilities, power purchases and transmission and distribution capacity additions. However, due to changes that are occurring within the industry, electric utilities are also using demand management or demand-side management as a way to enhance customer service. See U.S. Energy Information Administration. (n.d.). *Electric utility demand side management.* https://www.eia.gov/electricity/data/eia861/dsm/

75 Nadel, 2017.

76 Hurley, D., Peterson, P., & Whited, M. (2013). *Demand response as a power system resource.* Regulatory Assistance Project. https://www.raponline.org/wp-content/uploads/2016/05/synapse-hurley-demandresponseasapowersystemresource-2013-may-31.pdf

77 National Association of Clean Air Agencies. (2014). Improve demand response policies and programs. Chapter 23 in *Implementing EPA's clean power plan: A menu of options.* https://www.4cleanair.org/wp-content/uploads/Documents/Chapter_23.pdf

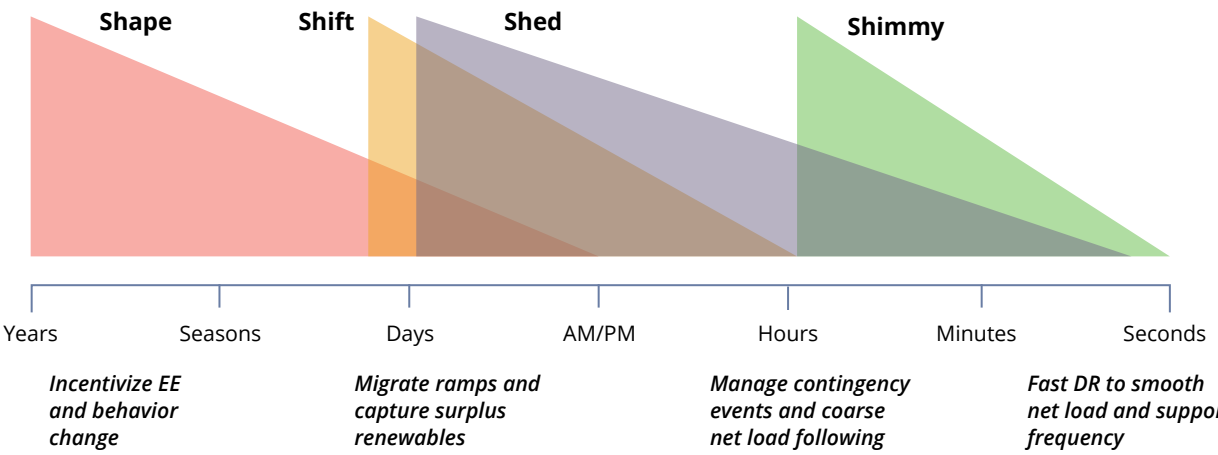
use. Consequently, management of the grid was largely a one-way option — namely, to build more power generation to meet peak load requirements. Today, rather than dispatching supply to meet uncontrolled demand, technology advances allow management of the demand side to meet available supply. Demand management is not new, but traditional demand response programs focused on simply shedding load during periods of grid stress. Today, demand management includes the ability to respond to other grid needs. Now, average residential customers are increasingly able to control their energy usage through efficiency upgrades and energy management tools and even to become grid resources themselves through behind-the-meter solar or storage. The ability for demand to play a role in balancing grid operations is a fundamental shift from the 20th-century era of large, centrally operated generating plants.

Managing the demand for electricity is now an option that can be utilized to make more efficient use of the grid, reduce customer costs and reduce environmental harm. Demand management programs are common and are fairly simple to implement. They rely on two types of mechanisms: (1) sending quantity signals to customer appliances and devices (direct load control programs); and (2) sending price signals to customers to alter their consumption habits (time-varying rates). Utilities, municipalities and electric cooperatives have used these types of programs for decades.

Demand management programs today can provide load flexibility over different time frames, as illustrated in Figure 5.[78] It is useful to think about these types of flexibility within the time frames they can operate, moving from the longest span of years and days for shaping down to time frames of minutes and even seconds for shimmying.

In practical terms, this means demand management can shape load away from expensive peaks. It can then shift load and grow load at times when renewable energy is available and energy is less expensive. It can shed load in a controlled manner during critical energy events, and it can shimmy load back and forth to meet short-term grid needs. EV charging is an example of a technology that can shimmy because it can occur all at once or can be turned on and off as the need arises.[79]

Figure 5. **Shape, shift, shed and shimmy — time frames of flexibility**



Source: Alstone, P., Potter, J., Piette, M. A., Schwartz, P., Berger, M. A., Dunn, L. N., Smith, S. J., Sohn, M. D., Aghajanzadeh, A., Stensson, S., Szinai, J., Walter, T., McKenzie, L., Lavin, L., Schneiderman, B., Mileva, A., Cutter, E., Olson, A., Bode, J., … Jain, A. (2017). *2025 California Demand Response Potential Study — Charting California's Demand Response Future: Final Report on Phase 2 Results*

78 Alstone, P., Potter, J., Piette, M. A., Schwartz, P., Berger, M. A., Dunn, L. N., Smith, S. J., Sohn, M. D., Aghajanzadeh, A., Stensson, S., Szinai, J., Walter, T., McKenzie, L., Lavin, L., Schneiderman, B., Mileva, A., Cutter, E., Olson, A., Bode, J., … Jain, A. (2017). 2025 *California demand response potential study — Charting California's demand response future: Final report on Phase 2 results* (LBNL-2001113), Figure 19. Lawrence Berkeley National Laboratory. https://eta.lbl.gov/publications/2025-california-demand-response

79 Linvill et al., 2019.

a. Methods to Obtain Flexibility

Encourage customers to shift load through time-based rates.

Methods of engaging customers in demand management efforts include offering **time-based rates**. Customers are able to see the cost savings they can achieve if they reduce air-conditioning load, turn off lights or program their dishwasher or washing machine to less expensive, off-peak times of day. Examples of demand management in response to price signals include dynamic pricing programs, peak-time rebates, smart EV charging and smart thermostat programs. (For more detail, see Section B-1-b-ii, "Time-varying pricing.")

Encourage customers to control load through smart devices that can respond to smart rates.

Controllable load, often electrified load, means that virtually all major household electricity uses can be at least partly shifted away from peak periods using smart, responsive technologies. Smart thermostats make it possible for heating and cooling uses to participate in programs like Google Nest's Rush Hour Rewards, which provide incentives to customers that let their thermostat automatically be turned down by a very small amount during peak times.[80] Electric vehicles are a controllable load and can be set to charge at certain times or price points. Grid-integrated water heaters can respond to signals from the utility or demand-side aggregator, and major appliances, such as the refrigerator, dishwasher, washer and dryer, can be grid interactive or scheduled.[81] Smart customer systems such as in-home displays or home area networks can make it easier for customers to change behavior and reduce peak period consumption. These programs also have the potential to help the utility save money through reductions in peak demand, which in turn enables the utility to defer construction of new power plants.[82] The load avoided for a single home may be small, but when many customers participate, it creates a large reduction in energy demand for the utility.[83]

Advanced metering infrastructure (smart meters) expands the types of time-based rate programs that can be offered to customers. The ability to institute various types of time-varying pricing is somewhat dependent on the types of meters used. Retail electricity meters are now available in a spectrum of complexity and capability. Simple conventional meters measure only kWh consumption and are read at intervals, such as monthly, to note the customer's consumption since the last reading. These meters are not able to provide time-of-use price signals. Somewhat more complex meters are capable of not only recording kWh consumption but also of dividing that usage between two or a few preset time periods (a TOU meter), recording the peak load since the previous reading (a demand meter) or both.

At the other end of the metering spectrum, advances in communications and digital technology are bringing down the costs of advanced metering infrastructure and smart meters for the mass market. These innovations are increasing opportunities to send not only long-term average price signals (already possible using conventional meters) but also price signals that reflect weekly, daily, hourly or even real-time variability in system costs and conditions and to record customer usage over time intervals as short as five minutes. Today, just over half of the public power meters installed in the United States are smart meters.[84] Installation of smart meters is just the start, as merely installing smart meters does not alone facilitate advanced pricing; meter data management systems investments, billing engine modifications and rate studies are needed to develop advanced pricing.

Manage customer load for them through utility direct load control.

Demand management also includes **direct load control programs** that allow the utility or private aggregators to directly alter a customer's energy consumption during periods of peak demand in exchange for a financial incentive and lower electric bills for the customer.[85] Radio or internet-controlled switches on residential air conditioners or electric water heaters are but one of many methods used.[86]

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80 Linvill et al., 2019.

81 Linvill et al., 2019.

82 U.S. Department of Energy, Office of Electricity. (n.d.-a). *Demand response.* https://www.energy.gov/oe/activities/technology-development/grid-modernization-and-smart-grid/demand-response

83 Budhiraja, D. (2019, January 24). Demand response 101: *Understanding how utilities balance energy supply & demand.* GridPoint. https://www.gridpoint.com/understanding-demand-response/

84 Zummo, P. (n.d.). *Moving public power forward.* American Public Power Association. https://www.publicpower.org/system/files/documents/Moving-Public-Power-Forward-Community-Driven-Solutions-for-Industry-Transformation_0.pdf

85 U.S. Department of Energy, Office of Electricity, n.d.-a.

86 U.S. Department of Energy, Office of Electricity. (n.d.-b). *Demand response — Policy.* https://www.energy.gov/oe/services/electricity-policy-coordination-and-implementation/state-and-regional-policy-assistanc-4

Direct load control programs represent some of the initial approaches to demand management that existed prior to much of the technology that is available today. These programs result in overall savings for the municipal utility and an incentive payment for participating customers.[87] The majority of direct load control programs are for residential central air-conditioning switches, but some offer a credit for each controlled electric appliance the customer registers with the utility. Electric water heaters and pool pumps are also commonly incentivized with fixed bill credits and cycled by the utility in a similar manner. With air-conditioning, when the utility expects a high peak load day due to very warm weather forecasts, it will notify the customer in advance. When energy demand peaks, the utility will send a signal to a customer's air conditioner (or other appliance) that causes it to operate for a shorter period of time.

A common feature among direct load control programs is that customers have a choice between the level of service interruption they will accept and the amount of an incentive they receive. Typically, these are directly variable: The more interruption a customer will tolerate, the higher the incentive. Residential direct load control programs with cycling options and fixed monthly bill credits offer a simple and understandable method for customers to reduce their addition to peak load without tying the benefit to abstract concepts like kW demand charges or kWh shifting. Until recently, utility direct load control programs have been enabled by a control switch installed on an individual appliance, but with advances in technology, utilities are now able to use programmable communicating thermostats to control household energy use.

Obtain flexibility through regional markets.

Planning and market processes are another tool for adding flexibility to the power system. In regions with a regulated market, more innovative uses of demand management are able to bid into the market to maintain reliability by providing capacity or energy reductions or to reduce wholesale electricity prices and provide economic benefits.[88] Municipal utilities may also be able to work with demand management aggregators to bid demand management programs into a regulated market and provide further economic benefit to municipal customers.[89]

b. Important Elements of Successful Demand Management Programs[90]

Experience reveals several key elements to successful demand management program design and implementation, which include the following.

- **Customer education.** Not only does education through effective marketing enable meaningful demand reduction, it also leads to improved customer satisfaction in both the program and the utility. Customer education is key toward ensuring that demand response mechanisms are properly used by customers to optimize the results. Utilities should prepare a budget specifically for customer education.
- **Incentives and tools.** The utility must provide customers with incentives to participate and the tools needed to achieve savings. Customers are more likely to participate when:
  - They earn a reward, so it is important to show them their measurable savings.
  - The utility provides physical hardware such as thermostats and switches, as well as reliable communication of peak events and tips on how and when to conserve energy.
  - The utility provides immediate feedback on how much customers saved following a peak event.
  - The utility shows customers their savings on their monthly bill.
    - For direct load control programs, a set monthly bill credit (i.e., $4 during summer months) rather than a varying rate discount gives the customer confidence in future savings.
    - For TOU rates, the utility should use historical customer data to calculate the potential impact.
  - Multiple demand management programs are marketed together (i.e., a direct load control switch and TOU rate) rather than in separate marketing campaigns, which can reduce program costs.
  - Third-party demand management program administrators participate, which provides greater

87 Customers respond to utility signals, often with very limited notice, and most often using preheated or cooled water.

88 National Association of Clean Air Agencies, 2014.

89 National Association of Clean Air Agencies, 2014.

90 State of Michigan. (n.d.). *Common demand response practices and program designs.* https://www.michigan.gov/documents/energy/Common_Practices_Feb22_522983_7.pdf

variety in program design and limits the utility's exposure to program-related risks, such as marketing, hardware and software updating costs.
- TOU rates are the default rate for eligible customers (i.e., smart-metered customers); this leads to very high participation.

There are some important considerations beyond reflecting costs when designing demand management programs and TOU rates. Usually, demand management programs decrease emissions. However, demand management based on price signals can shift usage from one time period that has generation with lower emissions to another time period when generation has higher emissions. Utilities can design the program to avoid this result by considering not only peak periods but also to send price signals to shift demand to times when generation is cleaner, such as when wind or solar resources are plentiful. Awareness of the generation resources available during certain periods of the day and night and providing demand management signals to customers to shift load to beneficial times will yield both economic and environmental benefits.

Demand management programs can provide an excellent opportunity to reduce peak demand and cut costs by avoiding the need for expensive peaking capacity. Mansfield Municipal Electric Department in Massachusetts offers monthly rewards for customers that purchase or own certain smart devices, including batteries, EV chargers, electric water heaters, mini split controller and Wi-Fi thermostats, through its HELPS Connected Homes Program. The program helps the utility and the city to reduce their carbon footprint, stabilize the electric load and keep electric rates low.[91] An additional benefit of such programs is added reliability; the Mansfield Municipal Electric Department was nationally recognized for exceptional reliability in 2021 by the American Public Power Association.[92]

Program administration: The third-party option

Third-party administrators can be a valuable resource for municipal utilities that do not have the specific expertise or staff resources to take on new projects. The third party can be a contractor hired by the municipality to administer energy efficiency or demand management programs, or it can be an independent company that is authorized to perform the services. Payment can be made by the municipality's including this cost in its budget, or payment can be made based on the administrator keeping a percentage of the savings or some combination thereof, such as payment of the cost for the service with the profit or return coming from a percentage of the savings. For a third-party administrator under contract and paid directly, the municipality can add requirements such as using a local workforce to implement the program. Where it is an independent company that provides the services, it will be important for the municipal utility to work with the company to provide it with the data it needs. The municipal utility will need to develop protocols for addressing customer privacy; many utilities have done this already. In fact, the U.S. Department of Energy launched in 2012 its Smart Grid Data Privacy Voluntary Code of Conduct, which provides guidance on balancing data needs and customer privacy.

Useful Resources on Customer Data

Navigant Consulting. (2015). *Value of Customer Data Access: Market Trends, Challenges, and Opportunities.* National Association of Regulatory Utility Commissioners. https://pubs.naruc.org/pub/536E2D7C-2354-D714-5129-435231D889E0

U.S. Department of Energy & Office of Electricity. (n.d.). *DataGuard Energy Data Privacy Program.* https://www.energy.gov/oe/activities/technology-development/grid-modernization-and-smart-grid/dataguard-energy-data-privacy

91 Mansfield Municipal Electric Department. (n.d.). *3 reasons to enroll in the HELPS Connected Homes Program*. https://www.mansfieldelectric.com/sites/g/files/vyhlif836/f/uploads/mansfield_connected_homes_2.pdf

92 Mansfield Municipal Electric Department. (2021, May 4). *Mansfield Electric nationally recognized for exceptional reliability.* https://www.mansfieldelectric.com/home/news/mansfield-electric-nationally-recognized-exceptional-reliability

Useful Resources on Demand Management

Alstone, P. Potter, J., Piette, M. A., Schwartz, P., Berger, M. A., Dunn, L. N., Smith, S. J., Sohn, M. D., Aghajanzadeh, A., Stensson, S., & Szinai, J. (2016). 2015 *California Demand Response Potential Study – Charting California's Demand Response Future: Interim Report on Phase 1 Results.* Lawrence Berkeley National Laboratory (LBNL-2001115). https://eta.lbl.gov/publications/2015-california-demand-response

Hurley, D., Peterson, P., & Whited, M. (2013). *Demand Response as a Power System Resource.* Regulatory Assistance Project. https://www.raponline.org/wp-content/uploads/2016/05/synapse-hurley-demandresponseasapowersystemresource-2013-may-31.pdf

Linvill, C., Lazar, J., Littell, D., Shipley, J., & Farnsworth, D. (2019). *Flexibility for the 21st Century Power System.* Regulatory Assistance Project. https://www.raponline.org/knowledge-center/flexibility-for-the-21st-century-power-system/

Michigan New Energy Policy. (n.d.). *Common Demand Response Practices and Program Designs.* https://www.michigan.gov/documents/energy/Common_Practices_Feb22_522983_7.pdf

National Association of Clean Air Agencies. (2014). Improve Demand Response Policies and Programs. Chapter 23 in *Implementing EPA's Clean Power Plan: A Menu of Options.* https://www.4cleanair.org/wp-content/uploads/Documents/Chapter_23.pdf

Examples of municipal demand management programs

- City Utilities. *City Utilities Demand Response Program.* https://www.publicpower.org/system/files/documents/SAMPLE%20-%20EEMCP%20Business%20Plan.pdf
- Northern Municipal Power Agency. *Demand Response Program.* https://www.nmpagency.com/demand-response
- Massachusetts Municipal Association. *MunEnergy.* https://www.mma.org/about-mma/services/munenergy/

2. Time-Varying Pricing

Rate design refers to the elements of electricity prices that form the basis of the retail customer bills. For most retail and small commercial customers, the designed rate typically appears on a monthly utility bill as a fixed monthly customer charge and a usage component, which is generally a per-kWh charge.[93] Most residential customer rates are still flat rates, meaning that the amount customers pay does not vary across the day, and customers pay the same price per kWh no matter how much electricity they use during peak times. A flat rate does not accurately reflect the changes in cost that the utility faces to serve customers over the course of the day.

Time-of-use electricity pricing, one of many types of time-varying pricing options, provides better price signals to customers by more accurately aligning rates to utility costs. It gives customers the opportunity to take control of their energy use and electricity bills. TOU pricing enables people to choose when they power up appliances or electric vehicles based on electricity prices and to make decisions that can both save them money and reduce harmful pollution. In contrast to rates that do not change with the time of day, TOU rates give customers a view of varying electricity costs so they can plan ahead to avoid expensive time periods. By paying more attention to the timing of energy use, or programming charging devices to do so, customers could have a new means of lowering energy bills and reducing the strain on the electric grid, while the municipality gains flexibility in supply options to serve customers.

The municipal utility in Fort Collins, Colorado, adopted a residential rate that is well designed because it allows customers to achieve bill savings through shifting their load. The utility moved all residential customers to TOU rates that have a very low off-peak rate and a peak rate that is three times as high as the off-peak rate. This incentivizes energy usage in off-peak hours. It also has a tier charge that applies to all usage over 700 kWh per month, which also provides an energy conservation incentive (see Table 2).[94]

93 Lazar, J. (2013). *Rate design where advanced metering infrastructure has not been fully deployed.* Regulatory Assistance Project. https://www.raponline.org/knowledge-center/rate-design-where-advanced-metering-infrastructure-has-not-been-fully-deployed/

94 City of Fort Collins. (n.d.). *Residential electric rates.* https://www.fcgov.com/utilities/residential/rates/electric/. The Fort Collins rate is beneficial for several reasons. First, by moving all customers onto the TOU rate as a default, the utility maximizes the benefits but still allows those who want to opt out the ability to do so. The rate is useful because, first, the low customer charge increases the amount that a customer can change the bill. Second, the very low off-peak rate creates noticeable bill savings for switching usage to that period. Third, setting the peak rate at three times the off-peak rate signals the extra costs to the utility during peak hours. See Linvill et al., 2019.

Table 2. **Fort Collins, Colorado, residential time-of-use rate**

Customer charge	$6.78	
	Summer	**Winter**
Off-peak	$0.069	$0.067
On-peak	$0.241	$0.216
Tier charge (0ver 700 kWh)	+0.0194/kWh	

Source: City of Fort Collins. (n.d.). *Residential Electric Rates*

a. Customers and TOU

What does TOU pricing mean for the customer? When Sacramento Municipal Utility District implemented TOU pricing, people reported greater satisfaction with this plan compared to existing electricity rates, noting that TOU provides "fairer pricing" and "more opportunities to save money."[95] However, some customers are unable to shift demand as much as other customers to realize lower rates, particularly the elderly, those with disabilities and low-income households. Low-income customers still saved money under TOU rates but less than average customers. TOU rates have the potential to achieve big system benefits and many customer benefits, but for those living in leaky homes with old, inefficient appliances, those benefits are far harder to realize. Utilities build into their rates the risk of recovering their costs for procuring power during periods of high peak usage. TOU rates help mitigate that risk and can reduce the price customers pay.

With strong supporting policies, TOU rates can be implemented and ensure that all communities can participate in the benefits. These supporting implementation procedures include the following.[96]

Prioritize vulnerable customers for energy efficiency, electrification and appliance upgrade programs. Vulnerable populations, such as low-income customers, elderly people and people with disabilities, may find TOU rates to be more expensive because of leaky, inefficient homes and old appliances. Municipalities should specifically reach out to these customers with weatherization and appliance upgrade programs and prioritize these customers for energy efficiency and electrification programs. Note also that upgraded appliances may include timers, which allow customers to set an appliance, such as a washing machine or dishwasher, to operate after they have gone to bed. This is especially useful for disabled people and older adults.

Provide bill protection for up to one year. Municipalities may want to implement bill protection, whereby customers will not face bill increases under a TOU rate for a period of time, preferably up to a year. This allows customers to benefit from TOU savings if they are able but will not harm those who find themselves unable to adequately shift consumption during peak hours. This lead time enables customers to see if they are able to shift their usage. If they are not, they have time to opt out of the program. A variant on this approach is shadow billing, where the customer remains in the non-TOU program but receives a shadow bill showing what they would have paid using TOU rates. The municipality could allow customers to opt in to the program sooner, and then make the program mandatory after a period of time.

Start with opt-in TOU policies with customer education. Most TOU policies are voluntary and apply only to customers who opt in. Customer education about TOU policies and the effect of the policies is incredibly important to help customers understand their current bill and the effect of TOU rates. Shadow billing, discussed above, is an effective tool to help customers see the effect on them of TOU rates. Education on behavioral changes to receive more benefits under TOU rates is also important.

Allow TOU policies to be opt-out. As noted above, most TOU programs are opt-in. However, few customers do, particularly where customer education on the benefits of TOU is poor. Thus, education about how the program works is the most critical step to encouraging more customer participation and ensuring that customers understand how to use the program to their advantage. Putting customers on TOU without them understanding how it works can have adverse consequences when customers start getting bills that are higher because they did not properly use the TOU rate. Allowing customers to opt out provides an important option to ensure equitable outcomes from more advanced electricity pricing, particularly for low-

95 Environmental Defense Fund. (n.d.). *Time-of-use electricity pricing: Savings when they matter* [Factsheet] https://www.edf.org/sites/default/files/ca_tou_fact_sheet_091514.pdf

96 For more information on the suggestions referenced here, see Spiller, B. (2020, March 9). *How we can make time of use pricing work for everyone.* Environmental Defense Fund. http://blogs.edf.org/markets/2020/03/09/how-we-can-make-time-of-use-pricing-work-for-everyone/

income renters. Opt-out provisions are preferable from a system benefits and cost-savings perspective because they drive cost-effective behavior, and customers tend to change their behavior rather than opt out.

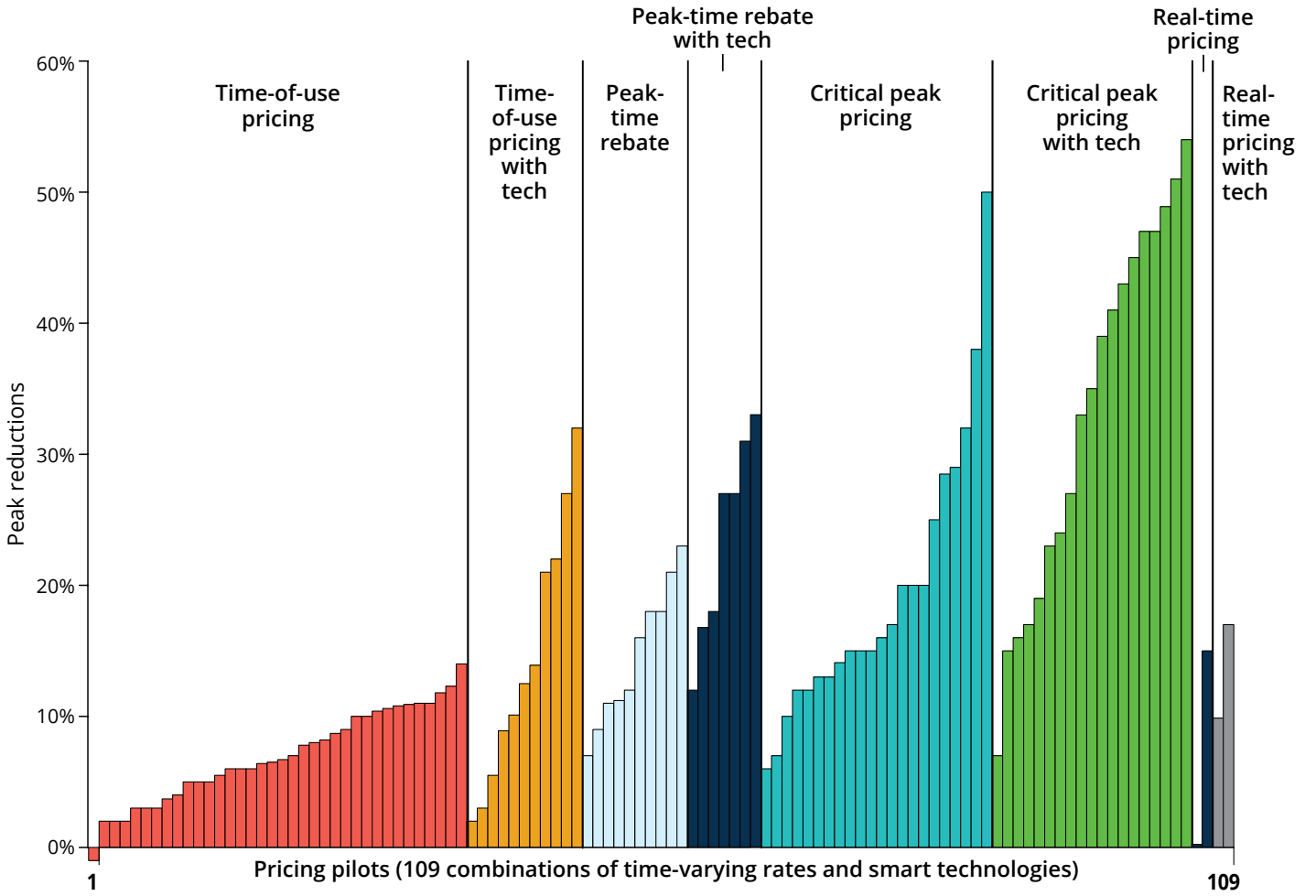
Ensure TOU rates are actionable. For TOU rates to be most effective at reducing consumption during peak hours, the price difference of peak to off-peak needs to be significant and the length of the peak hours manageable.[97] For example, peak hours cannot be so long that customers find it difficult to comply, and customers must see real financial benefit to switching to off-peak hours. TOU time blocks should provide ample space for customers to shift away from peak times and benefit from a greater number of low-cost hours.

b. Forms of Time-Based Rate Programs

The options for electricity pricing based on time of use include the following.[98]

- **Time-of-use pricing.** This pricing typically applies to usage over broad blocks of hours (e.g., on-peak equals six hours for summer weekday afternoon; off-peak equals all other hours in the summer months) where the price for each period is predetermined and constant. Rough time-varying blocks can be accomplished with traditional meters.
- **Real-time pricing.** These rates fluctuate hourly based on the hourly price of electricity.
- **Variable peak pricing.** This pricing is a hybrid of time-of-use and real-time where the different periods for pricing are defined in advance (e.g., on-peak equals six hours for summer weekday afternoon; off-peak equals all other hours in the summer months), but the price established for the on-peak period varies.
- **Critical peak pricing.** These substantially increased prices occur during periods when municipalities

Figure 6. **Average peak reduction under time-varying rate pilot programs**



Source: Faruqui, A., Hledik, R., & Palmer, J. (2012). *Time-Varying and Dynamic Rate Design*

97 Spiller, 2020.

98 Smart Grid. (n.d.). *Recovery act: Time based rate programs.* https://www.smartgrid.gov/recovery_act/time_based_rate_programs.html

observe or anticipate power system emergency conditions or a specific critical time period (e.g., 3 p.m. to 6 p.m. on a hot summer weekday). Two variants of this type of rate design exist: one where the time and duration of the price increase are predetermined when events are called and another where the time and duration of the price increase may vary based on the electric grid's need to have loads reduced.

- **Critical peak rebates (also known as peak-time rebates).** These refunds are made to the customer at a single, predetermined value for any reduction in consumption during a utility-declared critical event, relative to what the utility deemed the customer was expected to consume. The price for electricity during these time periods remains the same.

Figure 6 shows the average peak reduction from various pricing models in pilot programs.[99]

Among variable rate pricing options, TOU pricing is the most common and the easiest to implement. Studies have found that TOU rates can lead to demand reductions of 16% and average reductions in consumption of 2.1%, which can also provide customer savings.[100]

Useful Resources on Time-Varying Pricing

American Public Power Association. (n.d.). *Moving Ahead with Time of Use Rates.* https://www.publicpower.org/system/files/documents/Moving-Ahead-Time-of-Use-Rates.pdf

Colgan, J., Delattre, A., Fanshaw, B., Gilliam, R., Hawiger, M., Howat, J., Jester, D., LeBel, M., & Zuckerman, E. (2017). *Guidance for Utilities Commissions on Time of Use Rates.* https://votesolar.org/wp-content/uploads/2020/12/TOU-Paper-7.17.17.pdf

Huber, L. (n.d.). *TOU Pilot Strategies and Lessons.* Strategen Consulting. https://e21initiative.org/wp-content/uploads/2018/01/e21_Forum_TOUPilotBestPractices_5.05.17.pdf

Lazar, J., & Gonzales, W. (2015) *Smart Rate Design for a Smart Future.* Regulatory Assistance Project. https://www.raponline.org/knowledge-center/smart-rate-design-for-a-smart-future/

U.S. Department of Energy. (2016, November 16). *Final Report on Customer Acceptance, Retention and Response to Time-Based Rates from the Consumer Behavior Studies.* https://www.smartgrid.gov/document/CBS_Results_Time_Based_Rate_Studies.html

3. Net Metering

Net metering is a policy that allows electricity customers with their own on-site generation capacity (e.g., rooftop solar) to be financially compensated by their utility or municipality for the energy they produce. Net metering, also called net energy metering, is widely regarded as having an important role in deployment of distributed generation, especially solar energy. Depending upon state law, local governments may have the authority to establish net-metering policies. Net metering has been very successful at increasing the amount of distributed resources, but as it has increased and as utilities develop more and more of their own renewable resources, it has also posed challenges for some municipal utilities. Planning processes will help the utility to prepare for the increase in customer generation (whether through residential solar rooftops or through larger distributed generation facilities) and to determine the amount and location of additional distributed generation resources that could be useful to the distribution grid.

Net metering allows utility customers with on-site generation sources, such as solar PV, to offset the electricity they draw from the grid. The utility customer pays for the net energy consumed from the utility grid. If the amount of electricity the customer's system produces is more than the amount of electricity that customer can use, the excess amount is exported to the utility's electric grid. If the net-metering customer uses more electricity than the distributed generation system produces, the customer Imports electricity from the grid and pays the full retail rate for that electricity, just like a traditional utility customer.[102]

Net metering requires either a single bidirectional meter (with an optional export validation meter, if

99 Faruqui, A., Hledik, R., & Palmer, J. (2012). *Time-varying and dynamic rate design.* Regulatory Assistance Project. https://www.raponline.org/knowledge-center/time-varying-and-dynamic-rate-design/

100 Baatz, B. (2017, March). *Rate design matters: The intersection of residential rate design and energy efficiency.* American Council for an Energy-Efficient Economy. https://www.aceee.org/sites/default/files/publications/researchreports/u1703.pdf

101 Congressional Research Service. (2019, November 14). *Net metering: In brief.* https://sgp.fas.org/crs/misc/R46010.pdf

102 National Renewable Energy Laboratory. (n.d.). *Net metering.* https://www.nrel.gov/state-local-tribal/basics-net-metering.html

Net metering benefits and challenges

Utilities in the United States first began offering net-metering tariffs in the early 1980s. In those early days, digital smart meters were not available. Limitations in metering capabilities, paired with billing system challenges and the desire to keep tariffs simple enough for customers to easily understand, led to the design of what we will call traditional net-metering tariffs. Many U.S. utilities still offer traditional tariffs today. However, smart meters are now widely available that are capable of monitoring net exports and net imports of energy in small time intervals for use in a variety of distributed generation tariff designs, including those relying on time-varying rates. A growing number of utilities (and the public utility commissions and legislatures that regulate them) are considering alternatives to traditional net metering. Net metering has successfully encouraged more customers to install distributed generation. Net-metering experience in states with high distributed energy adoption indicates that adding large amounts of these resources will cause system demand to shift, which can in turn shift peak periods and periods with significant ramping. Time-of-use rates and the redefinition of the peak period have proven to be important tools to fully utilize the higher solar production. A number of higher-adoption states, such as California, are implementing these tools. Other strategies can create more manageable load profiles, such as the robust demand management programs discussed above.[103]

gross generation measurements are desired) or two unidirectional meters. Today, net metering is the most commonly used tariff design for customers who have solar PV or any other customer-owned generation resources.[104]

Net-metering policies commonly vary with regard to the following elements:

- **Eligible technologies.** Specified renewable energy technologies may include solar PV, wind, geothermal electric, biomass and fuel cells.
- **System size caps.** A system size cap is the maximum individual system size that can be net metered. Caps can be capacity (e.g., kW) or percentage based (e.g., 120% of maximum daily load).
- **Program size caps.** These caps are the total amount of net-metering systems installed in a region or utility service territory. Net-metering program caps can be calculated in many ways, including percent of peak demand or load and capacity. Some states have no program caps, and some states have trigger mechanisms that require net-metering policies to be reevaluated when certain thresholds are met.
- **Customer type.** Eligible customer classes for net metering include residential and commercial.
- **Net excess generation**. Customers are credited for net excess generation. This varies by:
  - The rate (e.g., full retail, less than retail, no compensation) paid for excess generation to the customer. Rates should reflect the value to the utility of distributed generation.
  - The term for using credits for excess generation in a particular billing cycle and whether the credits expire. It is common for them to expire after a finite number of billing cycles (e.g., 12 months) or at the end of a calendar year, after which they are either forfeited or credited at a predetermined net excess generation rate, usually between zero and the full retail electricity rate.

Interconnection policies, the process through which customers with distributed generation connect to the grid, have an impact on the number of distributed generation customers there are in a utility district. Typical barriers to interconnection are the costs and the lack of specified timelines in the utility approval process, which can cause excessive delays. If the policies are cumbersome and difficult to figure out, customers with distributed generation may not interconnect to the grid. In some cases, customers may even disconnect or defect from the grid. The decreased cost of residential distributed generation resources and improved technology of storage systems makes defection more possible. What was a theoretical risk for utilities may

103 For more on net metering evolution, see LeBel, M., Shipley, J., Linvill, C., & Kadoch, C. (2021). *Smart rate design for distributed energy resources.* Regulatory Assistance Project. https://www.raponline.org/knowledge-center/smart-rate-design-distributed-energy-resources-2/

104 Zinaman, O., Aznar, A., Linvill, C., Darghouth, N., Dubbeling, T., & Bianco, E. (n.d.). *Grid-connected distributed generation: Compensation mechanism basics.* National Renewable Energy Laboratory. https://www.nrel.gov/docs/fy18osti/68469.pdf

105 National Renewable Energy Laboratory, n.d.

become an issue that municipal utilities need to address as defection deprives the utility of the distributed resource and the revenues it would have collected from that customer. If the utility instead considers how distributed generation resources can serve both the customer and the utility and streamlines interconnection policies to encourage resource development in that vein, more distributed generation options, such as solar PV or customer-owned or -sited storage, will contribute as system resources.

Useful Resources on Net Metering

Lawson, A. (2019). *Net Metering: In Brief. Congressional Research Service.* https://sgp.fas.org/crs/misc/R46010.pdf

LeBel, M., Shipley, J., Linvill, C., & Kadoch, C. (2021). *Smart Rate Design for Distributed Energy Resources.* Regulatory Assistance Project. https://www.raponline.org/knowledge-center/smart-rate-design-distributed-energy-resources-2/

Institute for Local Self-Reliance. (n.d.). *Municipal Financing for Renewables and Efficiency.* https://ilsr.org/rule/municipal-financing-for-renewables-and-efficiency/

Institute for Local Self-Reliance. (n.d.). *Net Metering*. https://ilsr.org/rule/net-metering/

National Renewable Energy Laboratory. (n.d.). *Interconnection Standards.* https://www.nrel.gov/state-local-tribal/basics-interconnection-standards.html

National Renewable Energy Laboratory. (n.d.). *Net Metering.* https://www.nrel.gov/state-local-tribal/basics-net-metering.html

Office of the New York State Comptroller. (2008, April). *Green Best Practices: How Local Governments Can Reduce Energy Cost and Minimize Impact on Global Climate Change.* https://www.osc.state.ny.us/files/local-government/publications/pdf/researchbrief_green.pdf

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