THE ECONOMICS OF DEMAND FLEXIBILITY

HOW "FLEXIWATTS" CREATE QUANTIFIABLE VALUE FOR CUSTOMERS AND THE GRID

EXECUTIVE SUMMARY

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Rocky Mountain Institute (RMI)—an independent nonprofit founded in 1982—transforms global energy use to create a clean, prosperous, and secure low-carbon future. It engages businesses, communities, institutions, and entrepreneurs to accelerate the adoption of market-based solutions that cost-effectively shift from fossil fuels to efficiency and renewables. In 2014, RMI merged with Carbon War Room (CWR), whose business-led market interventions advance a low-carbon economy. The combined organization has offices in Snowmass and Boulder, Colorado; New York City; Washington, D.C.; and Beijing.

EXECUTIVE SUMMARY

Electric utilities in the United States plan to invest an estimated $1+ trillion in traditional grid infrastructure—generation, transmission, and distribution—over the next 15 years, or about $50–80 billion per year, correcting years of underinvestment. However, official forecasts project slowing electricity sales growth in the same period (less than 1% per year), coming on the heels of nearly a decade of flat or declining electricity sales nationwide. This is likely to lead to increasing retail electricity prices for customers over the same period.

Meanwhile, those customers enjoy a growing menu of increasingly cost-effective, behind-the-meter, distributed energy resource (DER) options that provide choice in how much and when to consume and even generate electricity. These dual trends and how customers might respond to them—rising prices for retail grid electricity and falling costs for DER alternatives that complement (or in extreme cases even supplant) the grid—has caused considerable electricity industry unrest. It also creates a potential for overinvestment in and duplication of resources on both sides of the meter.

Yet utility and customer investments on both sides of the meter are based on the view that demand profiles are largely inflexible; flexibility must come solely from the supply side. Now, a new kind of resource makes the demand side highly flexible too. *Demand flexibility* (DF) evolves and expands the capability behind traditional demand response programs. DF allows demand to respond continuously to changing market conditions through price signals or other mechanisms. DF is proving a grossly underused opportunity to buffer the dynamic balance between supply and demand. When implemented, DF can create quantifiable value (e.g., bill savings, deferred infrastructure upgrades) for both customers and the grid.

Here, we analyze demand flexibility's economic opportunity. In the residential sector alone, widespread implementation of demand flexibility can save 10–15% of potential grid costs, and customers can cut their electric bills 10–40% with rates and technologies that exist today. Roughly 65 million customers already have potentially appropriate opt-in rates available, so the aggregate market is large and will only grow with further rollout of granular retail pricing.

DEMAND FLEXIBILITY DEFINED

Demand flexibility uses communication and control technology to shift electricity use across hours of the day while delivering end-use services (e.g., air conditioning, domestic hot water, electric vehicle charging) at the same or better quality but lower cost. It does this by applying automatic control to reshape a customer's demand profile continuously in ways that either are invisible to or minimally affect the customer, and by leveraging more-granular rate structures that monetize demand flexibility's capability to reduce costs for both customers and the grid.

Importantly, demand flexibility need not complicate or compromise customer experience. Technologies and business models exist today to shift load seamlessly while maintaining or even improving the quality, simplicity, choice, and value of energy services to customers.

THE EMERGING VALUE OF FLEXIWATTS: THE BROADER OPPORTUNITY FOR DERs TO LOWER GRID COSTS

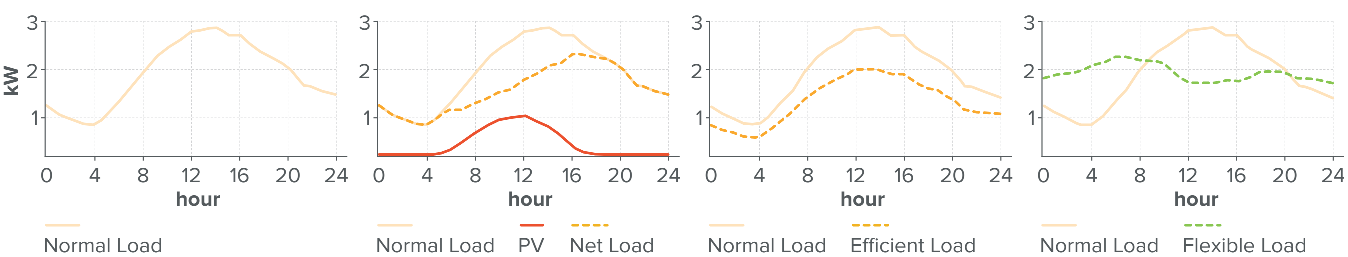
Electric loads that demand flexibility shifts in time can be called *flexiwatts*—watts of demand that can be moved across the hours of a day or night according to economic or other signals. Importantly, flexiwatts can be used to provide a variety of grid services (see Table ES1). Customers have an increasing range of choices to meet their demand for electrical services beyond simply purchasing kilowatt-hours from the grid at the moment of consumption. Now they can also choose to generate their own electricity through distributed generation, use less electricity more productively (more-efficient end-use or negawatts), or shift the timing of consumption through demand flexibility (see Figure ES1). All four of these options need to be evaluated holistically to minimize cost and maximize value for both customers and the grid.

TABLE ES1
FUNDAMENTAL VALUE DRIVERS OF DEMAND FLEXIBILITY

CATEGORY	DEMAND FLEXIBILITY CAPABILITY	GRID VALUE	CUSTOMER VALUE
Capacity	Can reduce the grid's peak load and flatten the aggregate demand profile of customers	Avoided generation, transmission, and distribution investment; grid losses; and equipment degradation	Under rates that price peak demand (e.g., demand charges), lowers customer bills
Energy	Can shift load from high-price to low-price times	Avoided production from high-marginal-cost resources	Under rates that provide time-varying pricing (e.g., time-of-use or real-time pricing), lowers customer bills
Renewable energy integration	Can reshape load profiles to match renewable energy production profiles better (e.g., rooftop solar PV)	Mitigated renewable integration challenges (e.g., ramping, minimum load)	Under rates that incentivize onsite consumption (e.g., reduced PV export compensation), lowers customer bills

FIGURE ES1
GRID PURCHASES, DISTRIBUTED GENERATION, ENERGY EFFICIENCY, AND DEMAND FLEXIBILITY COMPARED

Grid Purchases	Distributed Generation	Energy Efficiency	Demand Flexibility
Buy kWh from the grid as and when needed.	Generate electricity, changing the profile of net grid demand while reducing total grid demand.	Reduce demand whenever load is operated, thus lowering the daily load curve.	Shift eligible loads across the hours of a day to lower-cost times, reshaping the daily load curve.



FINDINGS

Residential demand flexibility can avoid $9 billion per year of forecast U.S. grid investment costs—more than 10% of total national forecast needs—and avoid another $4 billion per year in annual energy production and ancillary service costs.

While our analysis focuses primarily on demand flexibility's customer-facing value, the potential grid-level cost savings from widespread demand flexibility deployment should not be ignored. Examining just two residential appliances—air conditioning and domestic water heating—shows that ~8% of U.S. peak demand could be reduced while maintaining comfort and service quality. Using industry-standard estimates of avoided costs, these peak demand savings can avoid $9 billion per year in traditional investments, including generation, transmission, and distribution. Additional costs of up to $3 billion per year can be avoided by controlling the timing of a small fraction of these appliances' energy demands to optimize for hourly energy prices, and $1 billion per year from providing ancillary services to the grid. The total of $13 billion per year (see Figure ES2) is a conservative estimate of the economic potential of demand flexibility, because we analyze a narrow subset of flexible loads only in the residential sector, and we do not count several other benefit categories from flexibility that may add to the total value.[1]

Demand flexibility offers substantial net bill savings of 10–40% annually for customers.

Using current rates across the four scenarios analyzed, demand flexibility could offer customers net bill savings of 10–40%. Across all eligible customers in each analyzed utility service territory, the aggregate market size (net bill savings) for each scenario is $110–250 million per year (see Figure ES3). Just a handful of basic demand flexibility options—including air conditioning, domestic hot water heater timing, and electric vehicle charging—show significant capability to shift loads to lower-cost times (see Figure ES4), reduce peak demand (see Figure ES5), and increase solar PV on-site consumption (see Figure ES6). In Hawaii, electric dryer timing and battery energy storage also play a role in demand flexibility.

METHODOLOGY AND ASSUMPTIONS

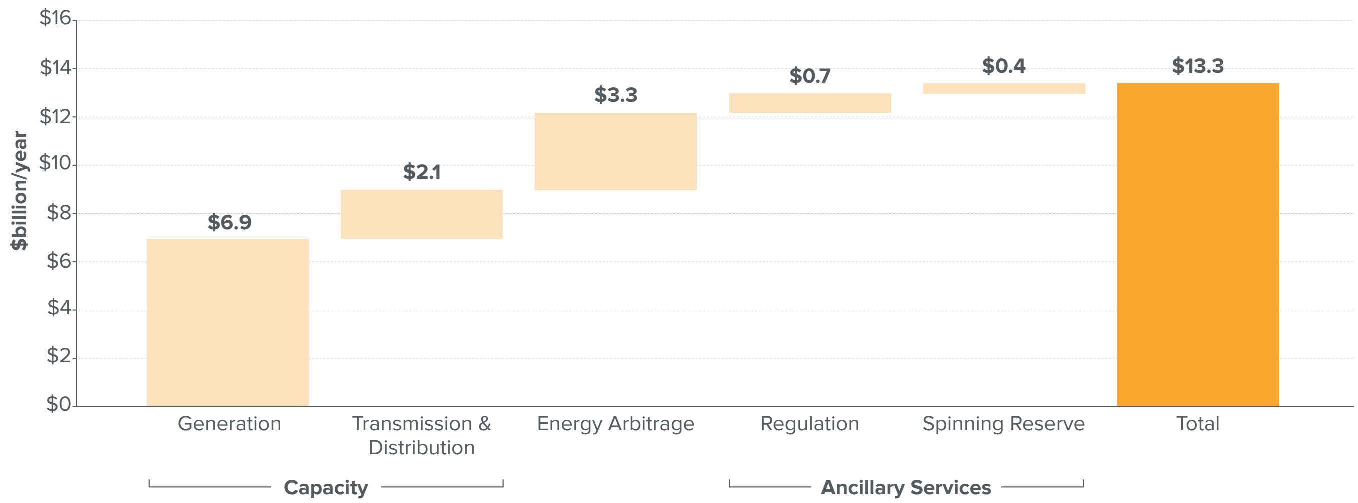
We analyze the economics of demand flexibility for residential customers in two use cases across four total scenarios under specific, illustrative, real-world utility rate structures:

1. Provide bill savings by shifting energy use under granular utility rates
   a. Residential real-time pricing (Commonwealth Edison, Illinois (ComEd))
   b. Residential demand charges (Salt River Project, Arizona (SRP))
2. Improve the value of customer-focused distributed energy resource deployment
   a. Non-export option for rooftop PV (Hawaiian Electric Company (HECO)) *Proposed*
   b. Reduced compensation for exported PV (Alabama Power Company (APC))

We use detailed data on consumption patterns to calibrate models for demand shifting in different climates, seasons, and rate structures; and perform an economic analysis of five major demand-flexible residential loads:

- Air conditioning (AC)
- Domestic hot water (DHW)
- Electric vehicle (EV) charging
- Electric dryer cycle timing
- Battery energy storage

FIGURE ES2
ESTIMATED AVOIDED U.S. GRID COSTS FROM RESIDENTIAL DEMAND FLEXIBILITY



Individual components do not add to total because of rounding

FIGURE ES3
DEMAND FLEXIBILITY ANNUAL POTENTIAL BY SCENARIO
DF GENERATES SIGNIFICANT PER-CUSTOMER BILL SAVINGS (%) WITH LARGE AGGREGATE MARKET SIZES ($ FOR EACH ANALYZED UTILITY TERRITORY)

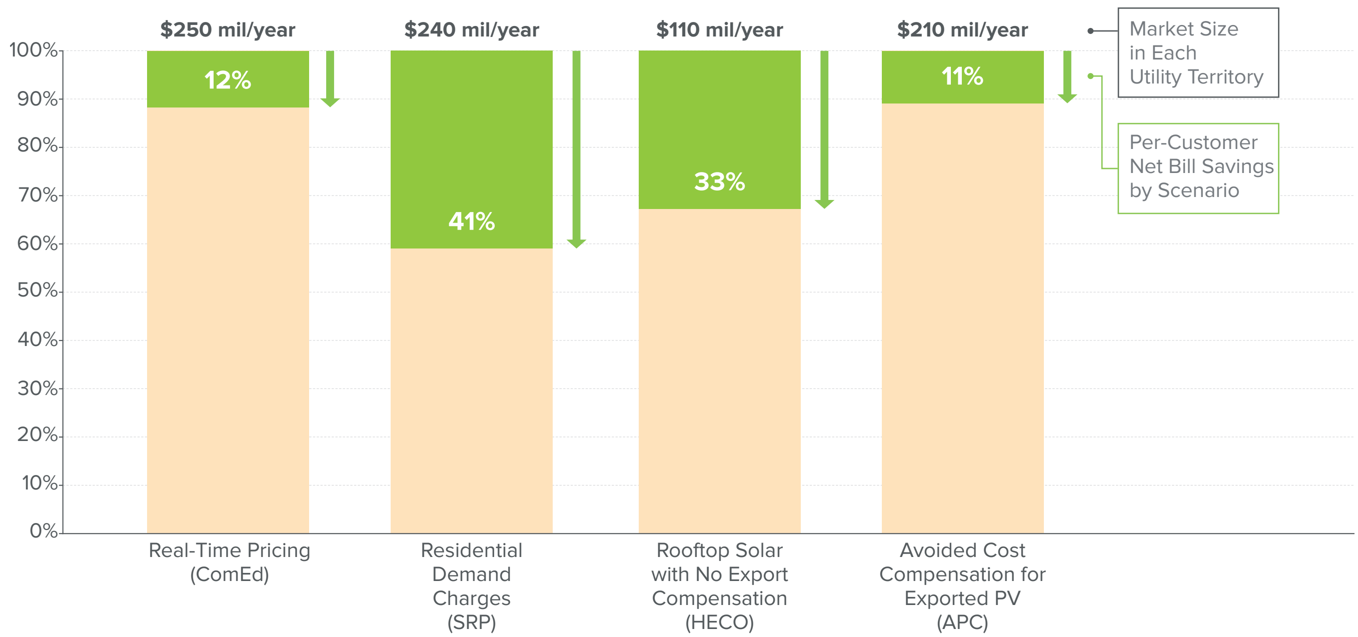


FIGURE ES4

SHIFTING LOADS TO LOWER-COST TIMES THROUGH DEMAND FLEXIBILITY (ComEd)

DF SHIFTS LOAD FROM HIGH-COST TO LOW-COST HOURS

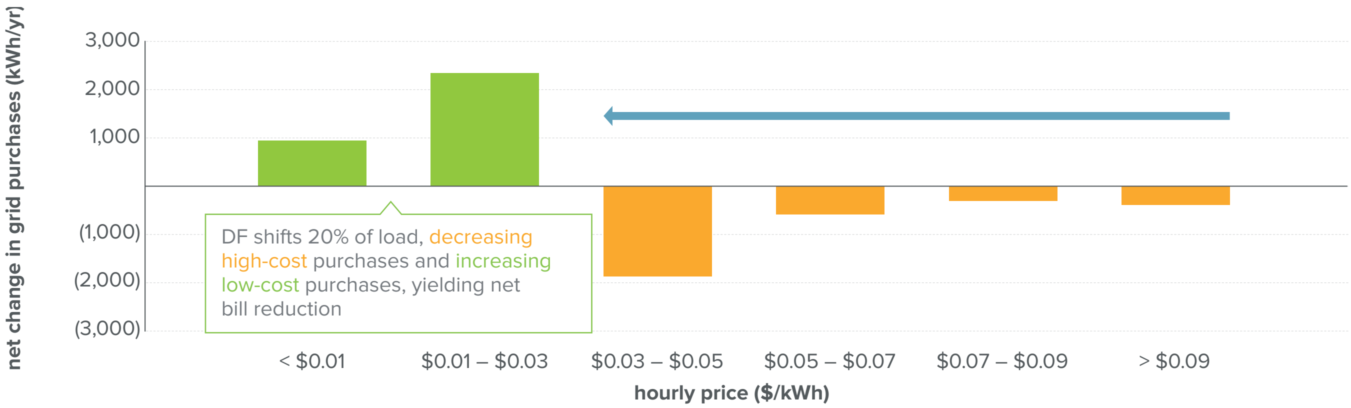


FIGURE ES5

REDUCING PEAK DEMAND THROUGH DEMAND FLEXIBILITY (SRP)

DF REDUCES PEAK CUSTOMER DEMAND BY COORDINATING LOAD TIMING TO MINIMIZE PEAKS

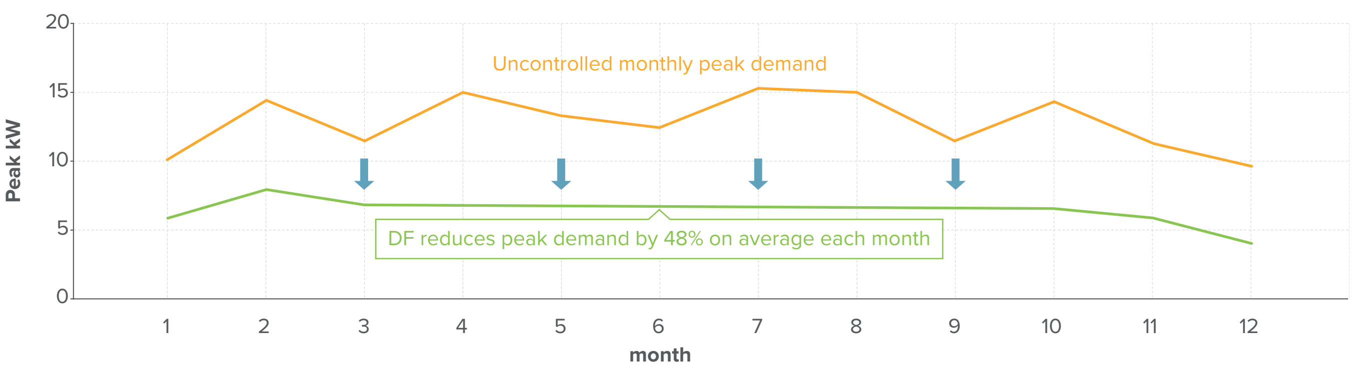
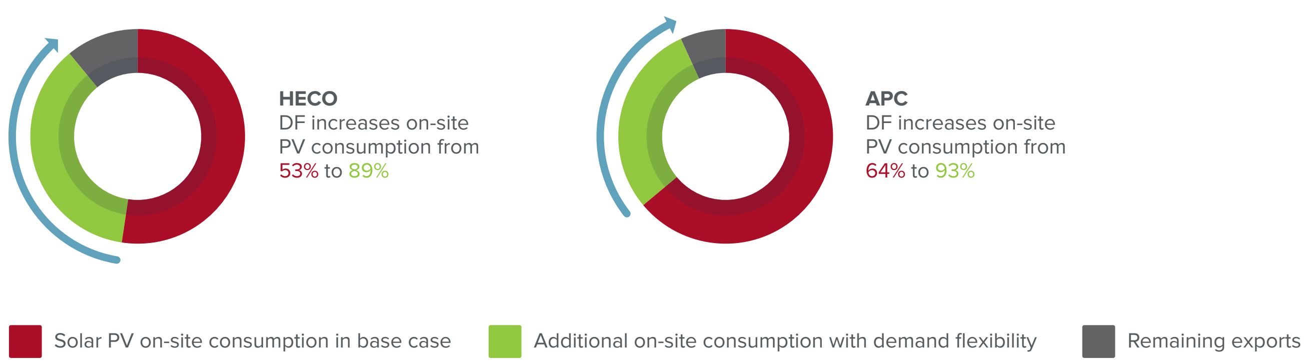


FIGURE ES6

INCREASING SOLAR PV ON-SITE CONSUMPTION THROUGH DEMAND FLEXIBILITY (HECO & APC)

DF SHIFTS LOAD TO COINCIDE WITH ROOFTOP PV PRODUCTION, INCREASING ON-SITE CONSUMPTION AND REDUCING EXPORTS



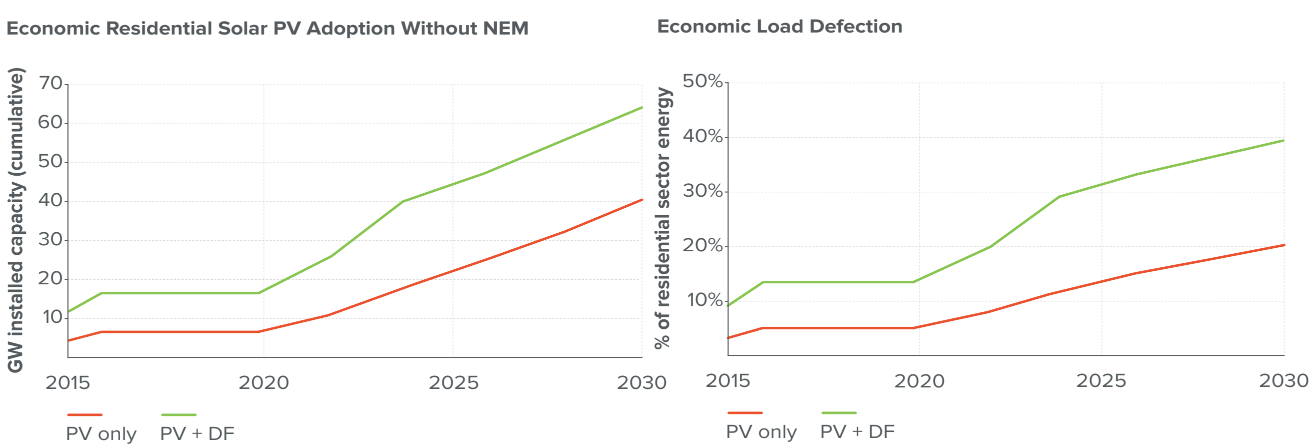
Utilities should see demand flexibility as a resource for grid cost reduction, but under retail rates unfavorable to rooftop PV, demand flexibility can instead hasten load defection by accelerating rooftop PV's economics in the absence of net energy metering (NEM).

Some utilities and trade groups are considering or advocating for changes to traditional net energy metering arrangements that would compensate exported solar PV at a rate lower than the retail rate of purchased utility energy (similar to the avoided cost compensation case discussed above). We build on the analysis presented in RMI's *The Economics of Load Defection* and show that, if export compensation for solar PV were eliminated or reduced to avoided cost compensation on a regional scale in the Northeast United States, DF could improve the economics of non-exporting solar PV, thus dramatically hastening load defection—the loss of utility sales and revenue to customer-sited rooftop PV (see Figure ES7).

FIGURE ES7

NORTHEAST U.S. RESIDENTIAL SOLAR PV MARKET POTENTIAL WITH AND WITHOUT DEMAND FLEXIBILITY

ASSUMING ROOFTOP PV RECEIVES EXPORT COMPENSATION AT AVOIDED COST, DF ACCELERATES THE PV MARKET AND LOAD DEFECTION



IMPLICATIONS

Demand flexibility represents a large, cost-effective, and largely untapped opportunity to reduce customer bills and grid costs. It can also give customers significant ability to protect the value proposition of rooftop PV and adapt to changing rate designs. Business models that are based on leveraging flexiwatts can be applied to as many as 65 million customers today that have access to existing opt-in granular rates, with no new regulation, technology, or policy required. Given the benefits, broad applicability, and cost-effectiveness, the widespread adoption of DF technology and business models should be a near-term priority for stakeholders across the electricity sector.

Third-party innovators: pursue opportunities now to hone customer value proposition

Many different kinds of companies can capture the value of flexiwatts, including home energy management system providers, solar PV developers, demand response companies, and appliance manufacturers, among others. These innovators can take the following actions to capitalize on the demand flexibility opportunity:

1. Take advantage of opportunities that exist today to empower customers and offer products and services to complement or compete with traditional, bundled utility energy sales.
2. Offer the customer more than bill savings; recognize that customers will want flexibility technologies for reasons other than cost alone.
3. Pursue standardized and secure technology, integrated at the factory, in order to reduce costs and scale demand flexibility faster.
4. Partner with utilities to monetize demand flexibility in front of the meter, through the provision of additional services that reduce grid costs further.

Utilities: leverage well-designed rates to reduce grid costs

Utilities of all types—vertically integrated, wires-only, retail providers, etc.—can capture demand flexibility's grid value by taking the following steps:

1. Introduce and promote rates that reflect marginal costs, in order to ensure that customer bill reduction (and thus, utility revenue reduction) can also lead to meaningful grid cost decreases.
2. Consider flexiwatts as a resource for grid cost reduction, and not solely as a threat to revenues.
3. Harness enabling technology and third-party innovation by coupling rate offerings with technology and new customer-facing business models that promote bill savings and grid cost reduction.

Regulators: promote flexiwatts as a least-cost solution to grid challenges

State regulators have a role to play in requiring utilities to consider and fully value demand flexibility as a low-cost resource that can reduce grid-level system costs and customer bills. Regulators should consider the following:

1. Recognize the cost advantage of demand flexibility, and require utilities to consider flexiwatts as a potentially lower-cost alternative to a subset of traditional grid infrastructure investment needs.
2. Encourage utilities to offer a variety of rates to promote customer choice, balancing the potential complexity of highly granular rates against the large value proposition for customers and the grid.
3. Encourage utilities to seek partnerships that couple rate design with technology and third-party innovators to provide customers with a simple, lower cost experience.