

Comparative Analysis and Trends of Energy Efficiency and Demand Management Program Budgets and Savings Impact Across the U.S.

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ABSTRACT

This paper presents results from data analysis of Energy Information Administration Form EIA-861 for electric energy efficiency and demand management programs across the United States. The results of the analysis focus on data driven trends and impacts that inform program design incentive budgets, implementation budgets, and energy savings goals. Normalized metrics are created to compare program results across utilities, states, regions, ownership types, and customer segments. Statistical analysis is presented for the costs required to impact savings, the percentage of total budget split between services and incentives, and weighted average life of program savings. In addition, demand side management program savings and total budgets are compared to utility total energy sales and revenues revealing correlations to energy efficiency planning, policy targets, and the avoided cost of energy. Annual trends over time are presented for this national assessment of energy efficiency and demand response programs. Visualization of results illustrates the empirical trends that are reflective of existing policy and program performance, which can be used to inform future program design forecast assumptions. Identified future work shows how these historical trends can inform the planning and investments needed to cost-effectively reach aggressive decarbonization goals.

Introduction

Utility demand side management (DSM) programs are the largest market adoption mechanism on the customer side of the meter. Programs provide a combination of services that deliver market-facing solutions with a positive public relations impact for the utility. These services can include management, program design, information technology systems, processes, tools, trade ally networks, education, workforce development, marketing, data analytics, outreach, operations, incentive processing, engineering, customer support, and more. Currently, utility DSM programs focus primarily on energy efficiency (EE) and demand response (DR) deployment. However, innovative utilities are starting to shift program focus toward decarbonization metrics. In addition, utility DSM programs help suppress energy costs, accelerate fossil fuel generator retirement, and create jobs, as well as provide a leading indicator for energy codes and standards. This paper discusses the results from a tool developed by TRC Companies to analyze and visualize utility DSM program data from Form EIA-861 using Tableau. The analysis tool combines data from Form EIA-861 (EIA 2021), geographical data (OpenEI 2019), and normalized metrics to provide a novel utility DSM program design

perspective that is not captured in other EIA publications. Figure 1 shows an example visualization from the tool.

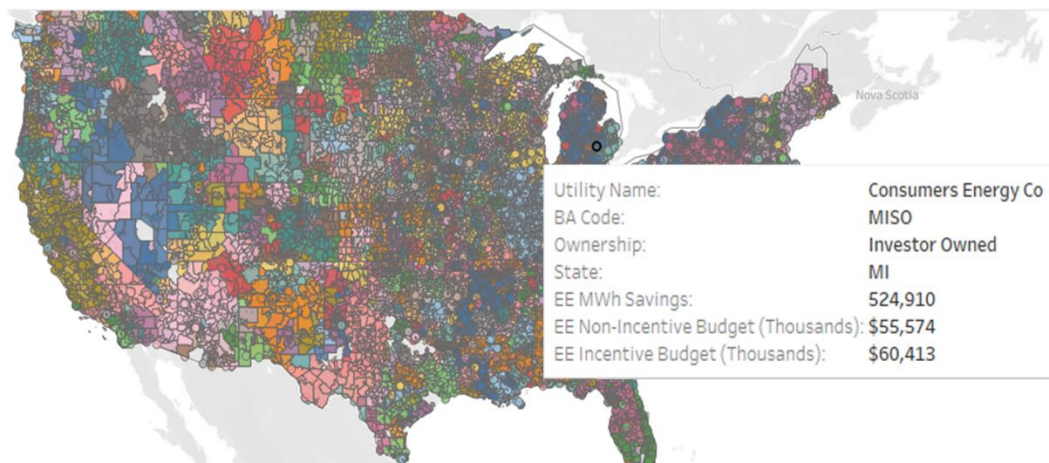


Figure 1. Map of U.S. electricity utilities with hover-over scorecard of EE program savings and budgets. *Data Source: Form EIA-861, Visualization Source: TRC Companies.*

Energy Information Administration (EIA) Form EIA-681 is a census of all United States electric utilities. It includes a breadth of information that summarizes the annual operating characteristics of the electric power industry. Detailed data files are published annually in October for the prior calendar year. Sales and operational data are available back to 1990, while data forms related to utility DSM programs were not introduced until 2001 and have changed over time. Data from these files are used in several EIA publications and reports. This paper analyzes several of the detailed data forms from 2017 to 2020 to identify recent trends in the budgets and savings impacts from EE and DR utility DSM programs. Data are typically segmented by year, utility, state, sector, balancing authority, and other variables. The specific data files that are used in the analysis for this paper include (EIA 2021):

- Sales to Ultimate Customers – utility revenue, sales (MWh), and customer count
- Operational Data – aggregate data including summer and winter peak demand
- Energy Efficiency – energy savings, peak demand savings, weighted average life cycle, and program costs
- Demand Response – number of customers enrolled, energy savings, potential and actual peak savings, and program costs
- Advanced Metering – number meters for standard, advanced metering infrastructure (AMI), and the energy served by AMI
- Dynamic Pricing – number of customers enrolled, including time-of-use, real time, variable peak, and critical peak

Background: What is a Demand Side Management Program?

Utility DSM programs primarily influence customer decisions behind the meter to reduce energy, demand, and/or emissions. Energy and demand reduction are often the least cost resources for utilities and can be a valuable investment tool for deferring capital investments for supply side generation, transmission, distribution, and other rate base assets. Utility DSM

programs typically focus on EE and DR deployment. In some cases, programs may also deploy distributed energy resources such as solar. Recent efforts to decarbonize the grid have led to innovative utility DSM programs encouraging electrification or fuel switching. Fuel switching from technologies that previously relied on fossil fuel combustion to high-efficiency electric alternatives reduces net emissions while simultaneously generating more revenue for the electric utilities.

Utility DSM Program Structures

Utility DSM programs promote the implementation of products and services (measures) that result in a cost-effective reduction in energy, demand, and emissions. There are some key differences between EE and DR utility DSM programs, that are apparent in the data reported in Form EIA-861. While exceptions do exist, EE programs generally prioritize energy reduction and incentives are provided in a one-time transaction for the permanent lifecycle reduction based on current year claimed savings and the equipment useful life. In contrast, DR programs generally prioritize demand reduction and incentives are provided in annual transactions for the current year temporary load reduction with notable differences between the actual savings and potential savings based on customers enrolled.

Utility EE programs have evolved into many different forms. However, most programs can be categorized by two main structures: prescriptive and custom. Within these two structures, a wide variety of delivery strategies are used to engage participants and other market actors. The data provided in Form EIA-861 does not provide detail on the program structures or delivery strategies, but it is important background information because it contributes to variation in the available data.

Prescriptive programs promote the implementation of projects with deemed or easily calculated savings, using fundamental energy principles and assumptions to approximate average market conditions. These pre-approved savings methodologies are published in technical reference manuals (TRMs) and technology workpapers that can be used for specific utilities, statewide, or regionally. Prescriptive programs incentivize measures based on limited data input from applicants and therefore have broad market appeal.

Custom programs promote measures that are more complex or innovative with savings that cannot be easily calculated with market-based assumptions. Custom program savings typically require more engineering, measurement and verification (M&V), technical reviews, and inspections to accurately quantify savings. To accommodate these additional requirements and justify program implementation costs, custom programs often have longer lead times prior to project approval for incentive payment, as well as minimum energy savings thresholds for eligible projects. These characteristics limit market uptake and tend to target higher energy consuming customers. Highly scalable measures often evolve from custom to prescriptive as sufficient data are gathered and calculations are replicated to reach broader market deployment.

Utilities typically offer a portfolio of utility DSM programs. Portfolios commonly include a combination of prescriptive and custom structures and a variety of delivery strategies to equitably serve and ensure access for different customer segments and market actors. For example, delivery strategies may include assessments; direct installation of measures; downstream rebates; a network of trade allies (vendors and contractors) promoting the program; point-of-sale rebates or buydowns through retailers; midstream/upstream rebates that pass-through distributors/manufacturers; and behavioral and educational campaigns such as strategic energy management, pay-for-performance with M&V services, among others.

Utility DSM portfolios can require significant management efforts. While some utilities run programs internally, most contract with a third-party through competitive solicitations. There are three main types of service providers that participate in the delivery of utility DSM programs: planners, implementers, and evaluators. Planners support the development of program budgets and forecasting program impacts (referred to as “ex-ante analysis”). Utilities use this data in integrated resource plans and to inform the goals for implementation. Implementers deliver the program and incentives to the market through a combination of services designed to achieve market adoption. Evaluators are responsible for quantifying the actual performance (referred to as “ex-post analysis”) of the program. This analysis of Form EIA-861 is intended to help service providers, as well as policy makers, utilities, and researchers, better understand the scale of utility DSM program impacts. Historical trends can also be used to inform investments needed to cost-effectively achieve future energy and emission reduction goals.

While program structures, delivery strategies, and service providers are not captured in Form EIA-861 data, a fundamental understanding is useful for interpreting trends in this report.

Value Proposition: What is Driving Investment?

Similarly, it is important to understand electric utilities’ various drivers for investment in DSM programs. Electric utilities are in the business of selling (and, in some cases, generating) electric energy and it is confusing that they encourage customers to use less of their own product. This counterintuitive industry behavior is driven by public policy. Given the tremendous complexity and variability of energy policy and electric utility regulation across the country, for the purposes of this paper, we outline three broadly applicable policy drivers in the list below:

1. Least cost planning requires suppliers of electric energy be held accountable to procure the lowest cost energy resources to meet forecasted demand for their customers. When the cost of delivering utility DSM programs is less than the cost of procuring incremental generating capacity, this results in lower costs for utilities.
2. Most states have structured cost recovery frameworks to motivate utility DSM investments in demand-side resources, enabling utilities to be “made whole” for the resulting costs, lost revenues, and/or earn a regulated rate of return (performance bonus). Further, many states have enacted laws establishing binding EE resource standards, requiring utility investments based on a percentage of revenue and/or MWh sales.
3. More broadly, many states and utilities have adopted clean energy, decarbonization, or other environmental goals, which may require or motivate investment in utility DSM programs beyond the level justified by the first and second policy drivers.

The details and applicability of these policy drivers vary by utility business model, by state, and by regional wholesale market construct, among other factors. This variability translates to utilities having different priorities and targets with respect to costs, savings, and/or emissions. Further, utility regulators’ approaches to evaluating utilities’ performance toward these targets vary considerably based on the utilities’ ownership structures, among other factors. For example, private investor-owned utilities (IOUs) report to a statewide regulatory commission while publicly owned municipal utilities and cooperatives may report to a city council or board of directors, with limited state oversight. These distinctions underscore variability among utility DSM programs including the type of investments deemed prudent (e.g., emerging technology pilots), and the transparency of publicly available information regarding these investments.

Despite all the variability and to ensure accountability, regulators across the country generally evaluate DSM programs based on a common set of criteria, including:

- Savings targets for energy, demand, emissions, or another metric
- Spending targets or caps such as a minimum threshold for spending on income-qualified customers or maximum threshold for spending on program marketing or administration
- Demonstrating public benefit, based on cost-effectiveness tests which consider perspectives of the program participant, utility, other rate payers, and broader society. Cost-effectiveness tests are key performance indicators that compare the net present value of lifecycle avoided costs and other benefits to the cost of the program. If the net present value of lifecycle benefits of the energy and demand reduction are greater than the program cost, then it is in the public's interest to invest in the utility DSM program.

Budget Trends

In 2020, electric utilities across the US invested over \$5.5 billion in utility DSM incentives and non-incentive services, representing an average of 1.3% of their total electricity sales revenue (EIA 2021). Figure 2 shows the utility DSM program investment breakdown for incentives and non-incentive services. Budgets for incentives reflected a notable reduction in 2020, possibly due to COVID-19 impacts or political headwinds from policy changes.

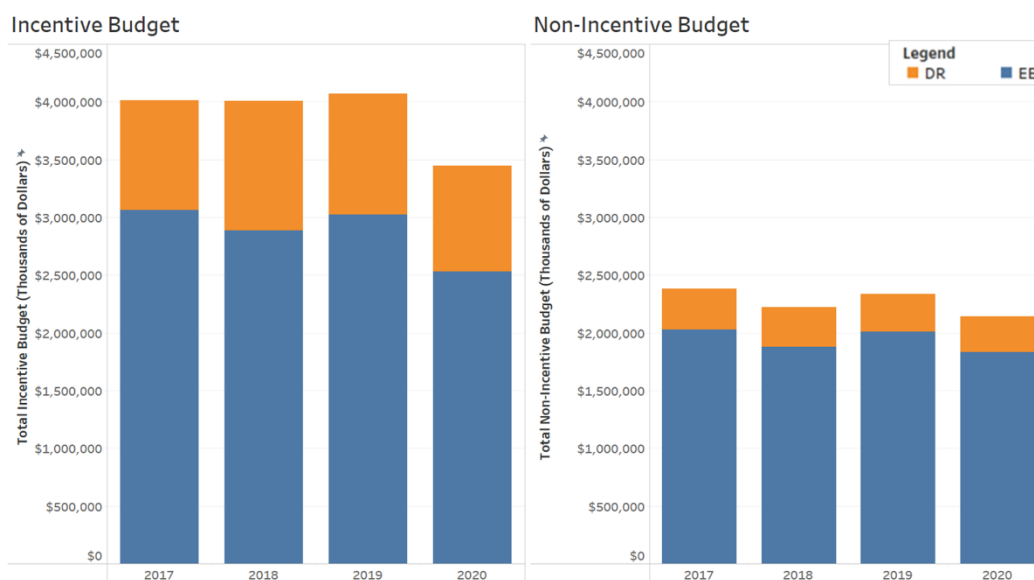


Figure 2. Incentive and Non-Incentive utility DSM budgets for EE and DR, 2017-2020. *Data Source: Form EIA-861, Visualization Source: TRC Companies.*

Figure 3 shows the total investment budget by utility ownership type and customer segment over the analysis period. The investment in utility DSM programs by IOUs is orders of magnitude higher than other ownership types which is consistent with the sales and revenue. Investments in the residential customer segment are slightly higher than commercial; and industrial segment investments are lower, possibly due to smaller market size and opt-outs.

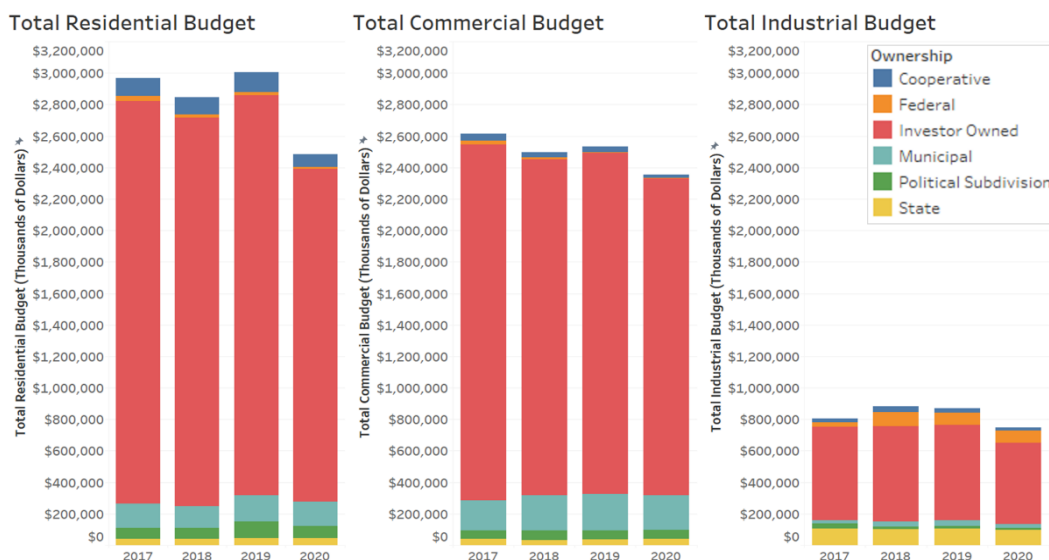


Figure 3. Total utility DSM budgets by utility ownership type, and customer segment, 2017-2020. Data Source: Form EIA-861, Visualization Source: TRC Companies.

Normalized annual averages are used to compare budgets across utility customer segments. Table 1 shows normalized average EE budgets, with higher total \$/kWh and higher percent of non-incentive services for the residential customer segment.

Table 1. EE average budget by customer segment, 2017-2020.

		Average \$/kWh		Average % of Total	
		Incentives	Non-Incentive	Incentives	Non-Incentive
Residential	2017	\$0.11	\$0.09	55%	45%
	2018	\$0.12	\$0.09	57%	43%
	2019	\$0.12	\$0.09	57%	43%
	2020	\$0.09	\$0.08	52%	48%
Commercial	2017	\$0.12	\$0.06	65%	35%
	2018	\$0.12	\$0.07	64%	36%
	2019	\$0.13	\$0.07	64%	36%
	2020	\$0.12	\$0.07	64%	36%
Industrial	2017	\$0.12	\$0.07	62%	38%
	2018	\$0.11	\$0.06	64%	36%
	2019	\$0.11	\$0.07	62%	38%
	2020	\$0.09	\$0.06	60%	40%

Number of customers enrolled is not provided on the EE data form. Data Source: Form EIA-861.

Table 2 shows the normalized average DR budgets. The industrial segment has the lowest non-incentive services \$/kW and highest \$/Customer, which is illustrative of larger customers. The commercial customer segment has the highest \$/kW incentives.

Table 2. DR average budget by customer segment, 2017-2020.

		Average \$/kW Potential		Average \$/Customer	
		Incentives	Non-Incentive	Incentives	Non-Incentive
Residential	2017	\$33.38	\$27.73	\$36.81	\$30.59
	2018	\$37.68	\$27.90	\$37.15	\$27.51
	2019	\$35.65	\$26.58	\$30.05	\$21.52
	2020	\$32.88	\$25.09	\$24.94	\$19.03
Commercial	2017	\$53.51	\$11.52	\$287.09	\$61.82
	2018	\$53.11	\$9.93	\$347.55	\$64.97
	2019	\$50.00	\$7.31	\$741.49	\$110.19
	2020	\$51.55	\$10.85	\$864.38	\$181.96
Industrial	2017	\$24.07	\$3.80	\$5,588.27	\$882.55
	2018	\$34.71	\$4.28	\$7,928.80	\$977.34
	2019	\$33.02	\$5.10	\$8,528.18	\$1,366.82
	2020	\$27.93	\$3.83	\$10,022.21	\$1,375.28

Potential represents the total demand response resource enrolled. *Data Source:* Form EIA-861.

Figure 4 shows box and whisker plots that represent the statistical ranges for the total EE and DR budgets. The data shows an upward trend in total EE budgets and significant variability which may be indicative of program structures and delivery strategies not differentiated in data.

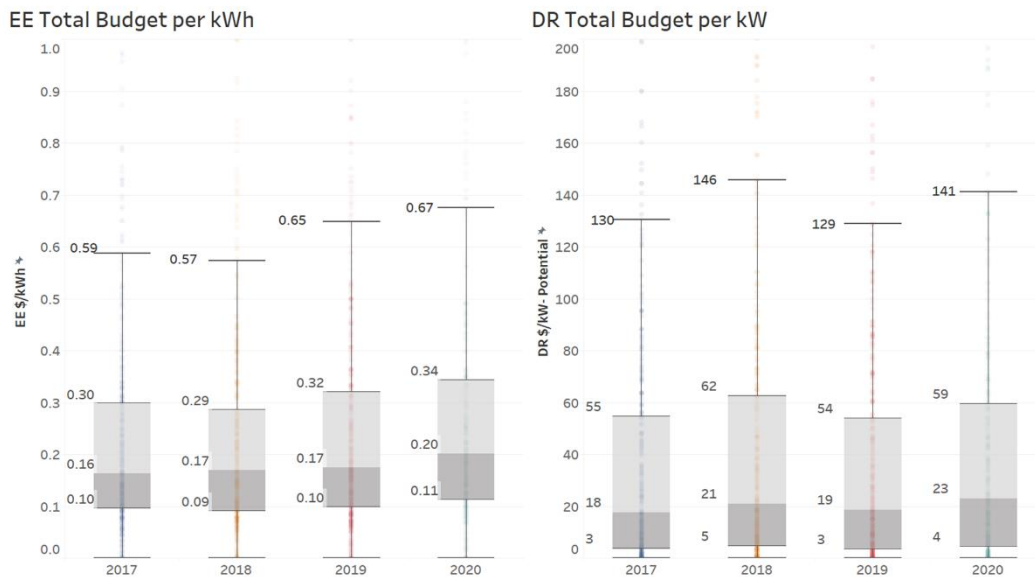


Figure 4. Box and whisker plots of total EE \$/kWh and total DR \$/kW, 2017-2020. *Data Source:* Form EIA-861, *Visualization Source:* TRC Companies.

Table 3 shows EE total budgets as a percent of total revenue. The commercial customer segment has the highest investment relative to revenue.

Table 3. EE total budget % of revenue by customer segment, 2017-2020.

	2017	2018	2019	2020	Average
Residential	2.132%	1.936%	2.144%	1.678%	1.970%
Commercial	2.739%	2.562%	2.710%	2.706%	2.678%
Industrial	1.098%	0.959%	1.038%	0.972%	1.018%

Total revenue for only utilities with EE programs. *Data Source:* Form EIA-861.

Table 4 shows the DR total budgets as a percent of total revenue. The industrial customer segment has higher investment relative to revenue which contrasts with the EE trend.

Table 4. DR total budget % of revenue by customer segment, 2017-2020.

	2017	2018	2019	2020	Average
Residential	0.495%	0.473%	0.463%	0.399%	0.458%
Commercial	0.506%	0.540%	0.489%	0.384%	0.480%
Industrial	1.307%	1.623%	1.592%	1.423%	1.486%

Total revenue for only utilities with DR programs. *Data Source:* Form EIA-861.

Impact Trends

In 2020, utility DSM programs achieved annual savings of 25,642 GWh/yr and 14.3 GW/yr with a weighted average useful life of approximately 13 years (EIA 2021). Figure 5 shows the utility DSM program total energy and demand savings impact breakdown for EE and DR over the period of analysis. Slight downward trend is observed over the analysis period.

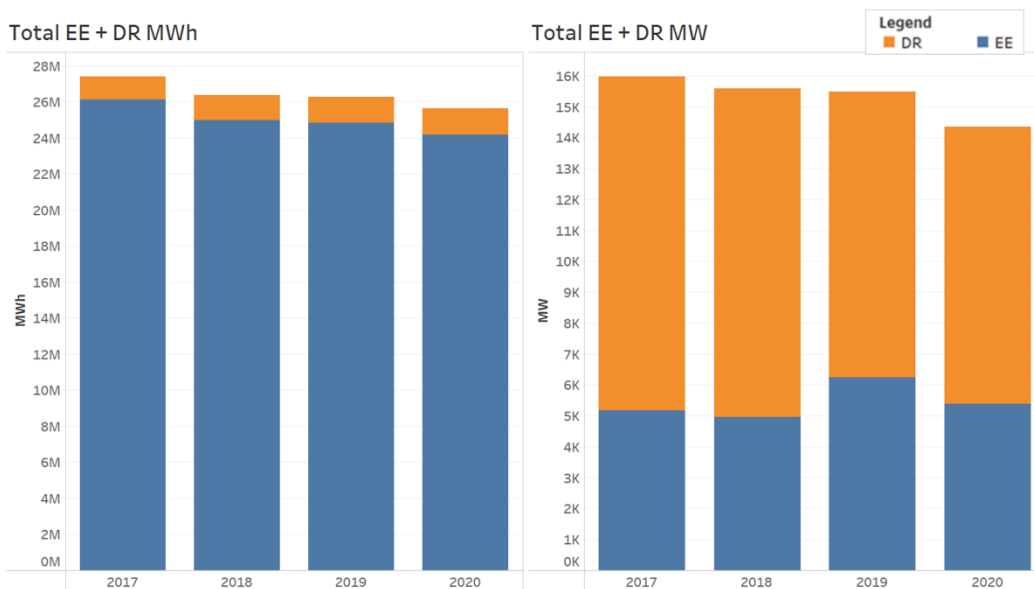


Figure 5. EE and DR total savings impact, 2017-2020. *Data Source:* Form EIA-861, *Visualization Source:* TRC Companies.

Figure 6 shows the EE savings by utility ownership type and customer segment. The commercial customer segment is the sole source of declining EE energy savings.



Figure 6. EE savings impacts by utility ownership type and customer segment, 2017-2020. *Data Source: Form EIA-861, Visualization Source: TRC Companies.*

Figure 7 shows the DR customers enrolled and savings impact by utility ownership type and customer segment. Residential customer segment enrollments are growing, while commercial and industrial customer segments enrollments are declining. DR demand savings impacts are declining.

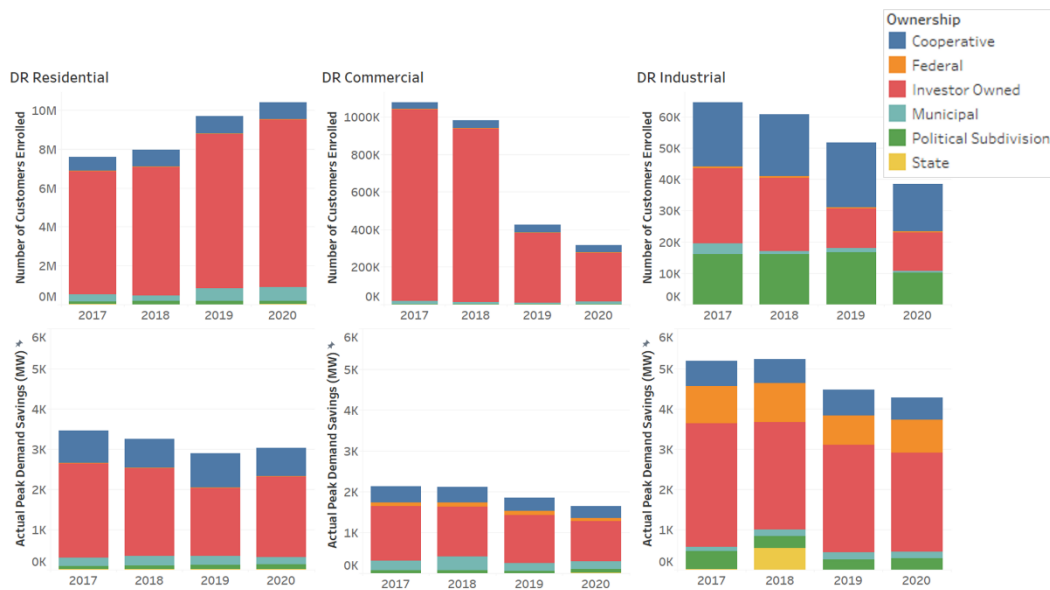


Figure 7. DR customers enrolled and savings impacts utility ownership type and customer segment, 2017-2020. *Data Source: Form EIA-861, Visualization Source: TRC Companies.*

EE programs report both the first-year savings and the lifecycle savings for impacts. This is especially important for cost-effectiveness where the net present value of lifecycle benefits is compared to the program costs. Table 5 shows the weighted average life, in years, for EE program impacts over the study period. Commercial customer segment EE programs had the longest weighted average life, followed by industrial and residential.

Table 5. EE weighted average life (years) of energy savings impacts, 2017-2020.

	2017	2018	2019	2020	Average
Residential	9.9	10.0	9.7	10.6	10.0
Commercial	14.5	14.7	14.8	15.5	14.8
Industrial	12.5	13.0	12.8	12.6	12.7

Lifecycle data only available for EE. *Data Source:* Form EIA-861.

For permanent load reduction within EE utility DSM programs, the relationship to peak savings can be somewhat complex with weather dependency and a large variety end use load shapes. To simplify this relationship for planning, peak coincident demand factors (PCDF) can be used for forecasting. PCDFs represent the fraction of savings expected to be coincident with the peak period, based on the ratio of the peak savings to annual energy savings. Table 6 shows the calculated average PCDFs by customer segment over the analysis period. Residential energy savings have consistently high peak coincidence possibly due to the coincidence of morning and evening loads driven by traditional work schedules. In addition, commercial and industrial customer segments are observed to have more variability of peak coincidence savings which could be due to process driven loads or the dynamic nature of peak events.

Table 6. EE peak coincident demand factors (kW/kWh), 2017-2020.

	2017	2018	2019	2020	Average
Residential	0.000207	0.000216	0.000256	0.000227	0.000227
Commercial	0.000186	0.000184	0.000243	0.000229	0.000210
Industrial	0.000220	0.000182	0.000264	0.000162	0.000206

PCDF data only relevant for EE. *Data Source:* Form EIA-861.

DR programs enroll customers with flexible demand resources that can temporarily shape, shift, shed, and shimmy loads to reduce peak demand in forecasted peak demand events. Table 7 shows average potential kW per customer and the actual kW per customer saved. There are many reasons that the total potential kW is not achieved. For example, savings may only be needed in specific regions, some participants may opt out of events, some equipment may not be eligible to participate during a specific event, or others. Table 7 also shows the calculated resource effectiveness ratio, which is the actual kW divided by the potential kW and indicates on average how much actual savings can be reasonably expected from a DR resource.

Table 7. DR average savings by customer segment, 2017-2020.

		Potential kW/Customer	Actual kW/Customer	Resource Effectiveness Ratio (Actual/Potential)
Residential	2017	1.1	0.5	41%
	2018	1.0	0.4	41%
	2019	0.8	0.3	35%
	2020	0.8	0.3	38%
Commercial	2017	5.4	2.0	37%
	2018	6.5	2.2	33%
	2019	14.8	4.4	29%
	2020	16.8	5.2	31%
Industrial	2017	232.1	80.4	35%
	2018	228.4	86.4	38%
	2019	258.3	86.5	33%
	2020	358.8	111.6	31%

Potential peak reduction represents the total DR resource enrolled. Actual peak reduction is the actual achieved savings. *Data Source:* Form EIA-861.

Figure 8 shows the adoption of DR grid-connected water heaters by utility ownership type over the analysis period. There is a growth trend for the adoption of grid-connected water heaters, with a drop-off shown in 2020 possibly due to COVID-19 impacts or policy changes. Cooperative and municipal utilities have the highest adoption in grid connected water heaters, which is counter to the order of magnitude of customers, budgets, and impacts compared to IOUs. This could be a result of public utilities having more rural geographies with higher likelihood of electric water heating, or the more flexible regulatory structure of those ownership types which allow them to be early adopters of emerging technology pilots.

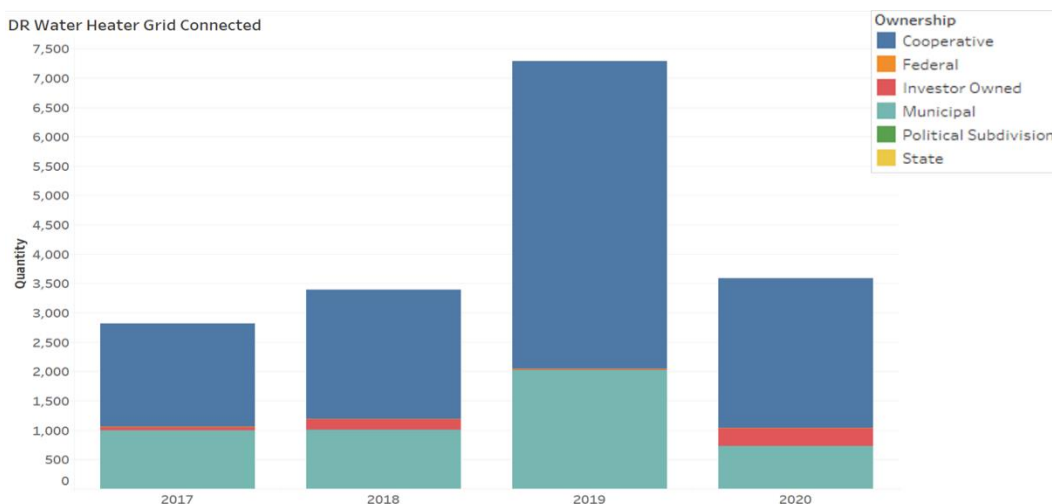


Figure 8. DR grid connected water heaters adoption by utility ownership type, 2017-2020. *Data Source:* Form EIA-861, *Visualization Source:* TRC Companies.

Presently, DR programs encourage targeted modifications to customers' flexible loads, primarily to achieve demand reduction during peak hours. However, it is possible that these flexible loads could be called on to provide resiliency and reliability when needed. Figure 9 shows the potential kW available through DR utility DSM programs by North American Reliability Corporation (NERC) regions. NERC is a regulatory authority that helps assure the reliability and security of the grid (NERC 2022).

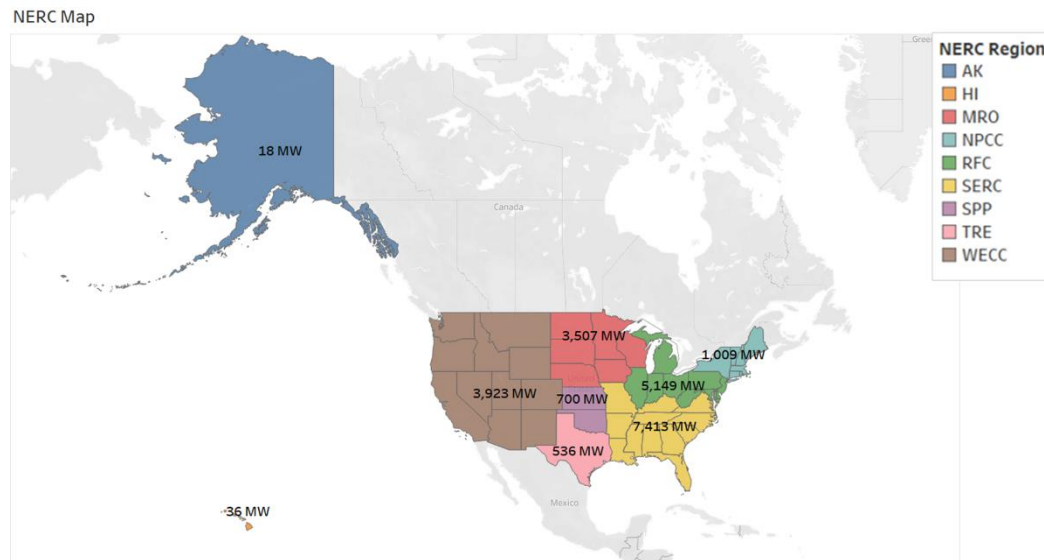


Figure 9. DR potential kW by NERC region, 2017-2020. *Data Source:* Form EIA-861, *Visualization Source:* TRC Companies.

Table 8 shows the total EE MWh savings as a percent of total MWh sales. This normalized metric is reflective of the policy driving investment in utility DSM programs. It also represents reasonable expectations of savings goals for new programs. The commercial customer segment has the highest goals relative to sales, followed by the residential customer segment. The industrial segment has significantly lower goals relative to sales.

Table 8. EE kWh savings % of total sales by customer segment, 2017-2020.

	2017	2018	2019	2020	Average
Residential	1.342%	1.231%	1.341%	1.260%	1.293%
Commercial	1.592%	1.492%	1.431%	1.499%	1.504%
Industrial	0.397%	0.396%	0.386%	0.417%	0.399%

Total sales for only utilities with EE programs. *Data Source:* Form EIA-861.

Table 9 shows the DR total potential kW as a percent of total summer peak. The trend for DR is opposite compared to EE, with the industrial customer segment showing significantly higher savings relative to summer peak. The commercial and residential customer segments have lower savings relative to summer peak.

Table 9. DR kW savings % of summer peak by customer segment, 2017-2020.

	2017	2018	2019	2020	Average
Residential	1.559%	1.448%	1.525%	1.501%	1.508%
Commercial	1.078%	1.181%	1.175%	1.010%	1.112%
Industrial	2.794%	2.554%	2.492%	2.622%	2.615%

Total sales for only utilities with DR programs. *Data Source:* Form EIA-861.

AMI deployment and dynamic pricing adoption trends were observed to increase steadily over the analysis period. Figure 10 shows the total AMI meters deployed and customers enrolled in dynamic pricing by utility ownership type. AMI meters currently represent approximately 65% of the total meters in 2020 (EIA 2021). However, dynamic pricing adoption is significantly less. This is possibly due to public relations related to complex rate structures, increased level of effort for utility billing, or other hurdles related to dynamic pricing models.

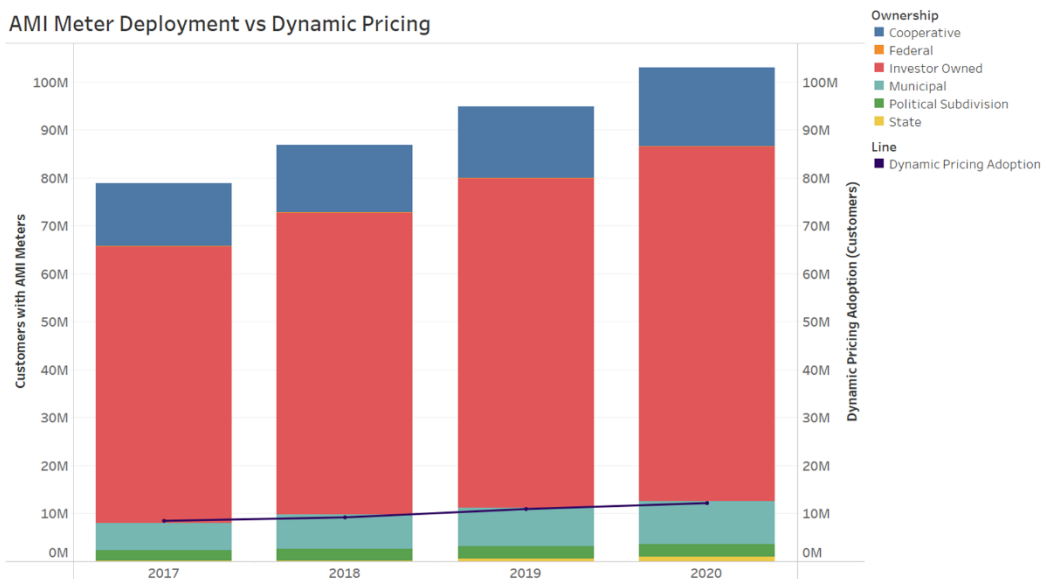


Figure 10. AMI meter deployment versus dynamic pricing adoption, 2017-2020. *Data Source:* Form EIA-861, *Visualization Source:* TRC Companies.

The impacts analysis provides a benchmark but does not show granularity between program structures or the various delivery strategies which may have significant differences.

Summary

Utility DSM programs are the largest market adoption mechanism for EE, DR, and decarbonization deployment on the customer side of the meter. In 2020, utilities invested over \$5.5 billion in incentive and non-incentive services and achieved savings of 25,642 GWh/yr, 14.3 GW/yr, and approximately 18 million metric tons of CO₂. Form EIA-861 is an invaluable resource for historical budget and impact trends that can help inform future policy and program design. Utility DSM program investments are in the range of 0.5%-2.5% of revenue. Impacts of COVID-19 are visible in 2020 incentive budgets, but non-incentive services remained stable. The residential segment has a higher percent of non-incentive services due to the level of effort

for smaller project sizes. Declining EE savings and increasing \$/kWh are observed in the commercial segment, possibly due to the saturation of LEDs. Declining DR savings are observed in all customer segments despite increased enrollment in the residential customer segment.

Conclusion

Services related to utility DSM programs provide a proven mechanisms for large scale market adoption on the customer side of the meter. These services include planning management, program design, information technology systems, processes, tools, trade ally networks, education, workforce development, marketing, data analytics, outreach, operations, incentive processing, engineering, customer support, evaluation and more. Programs use a combination of services to deploy large-scale solutions that are technology and metric neutral.

Historical trends are a good benchmark for forecasting and can inform reasonable assumptions for future program designs and policy metrics. However, baselines are constantly changing for energy reducing technologies and innovation will always be necessary to capture above-code savings. As utility DSM programs evolve, there are many anticipated disruptions that could change the trajectory of budget and impact trends. For example, LED lighting has been a major contributor to utility DSM program savings and yet the market is nearing saturation. With lighting starting to play a lesser role, total program savings may trend downward, and average program cost per kWh saved is expected to increase. Reduced lighting savings may also make it more difficult to meet cost-effectiveness criteria, which may cause utility DSM program designs to focus more on lifecycle savings and possibly use a minimum floor on equipment useful life for products and services (measures). While future technology-specific disruptions may alter budget and impact trends, normalized metrics relative to revenues and sales will likely remain stable.

Another possible disruption is the rapid adoption of high-efficiency heat pump technology. As heat pumps electrify heating loads across the country, it is anticipated that an increasing number of utilities will see winter peak demand exceeding summer peak demand. Currently, approximately 30% of utilities in the U.S. have winter peaks and 70% have summer peaks (EIA 2021). As peaks shift, so will the peak demand savings and cost-effectiveness for all weather dependent technologies, prompting changes to program design and delivery strategies.

As AMI deployment increases, increased adoption of dynamic pricing is expected to result in the new price signals reaching end use customers that influence their behind-the-meter behavior and technology adoption. However, historical trends for dynamic pricing adoption have had a significant lag relative to AMI deployment. Future policy may drive increased adoption, but other market adoption hurdles should be considered. For example, the public relations of more complex pricing structures could result in customer dissatisfaction, increased complaint calls, and increased level of effort for utility billing. Similarly, AMI deployment will continue to enable real-time M&V and savings based on normalized meter energy consumption analysis. These new M&V capabilities are enabling increased investment in flexible load technologies, in addition to more accurate energy savings evaluation. However, the added evaluation costs and delayed incentive payments to utility customers hinder program participation. Customer preferences may temper the expected scale and timeline of these projected impacts. In this example and many others, technical potential does not always make something feasible or appropriate. Utility DSM programs successfully influence market adoption by designing around customer preferences and solving for other market barriers rather than technical accuracy alone.

Future Work

Form EIA-861 records the utility DSM investments of electric utilities but does not include DSM efforts pursued by gas utilities. While gas utilities do report utility DSM program activities, there is no central repository for data like Form EIA-861. Future work is needed to centralize data for gas utilities and analyze historical trends and normalized metrics.

An increasingly decarbonized grid will continue to spawn electrification programs that target fuel switching from high emission fossil fuel combustion end use technologies to high efficiency electric end use technologies. The decarbonization of the electric grid and fuel switching electrification programs may challenge gas utility business models in the future. Currently, the low cost of natural gas is major obstacle for fuel switching decarbonization strategies. There have been many studies that document how electrification may save emissions, but early adopters will have a higher cost burden until the rate base increases enough to lower costs for all customers (ASHRAE 2020). A nationally standardized value for the social cost of carbon (IWG 2021) can help all utility DSM programs monetize the GHG savings from program impacts in cost-effectiveness tests. As previously mentioned, policy drives investment. Future collaboration is needed between utilities, regulators, and utility DSM service providers to inform and align utility DSM program goals with national, state, local, and utility decarbonization initiatives. Organizations like the National Association of Regulatory Utility Commissioners (NARUC 2022) can help coordinate future work.

Similarly, standardization is needed for methodologies to quantify the benefits of resiliency and reliability in cost-effectiveness calculations. If utility DSM programs can monetize the benefits of resiliency and reliability, it could result in the deployment of a new category of products and services (measures). Alternatively, different funding streams may leverage the existing market adoption services provided by utility DSM programs to deploy products and services (measures) related to resiliency and reliability.

EIA reporting and regulatory criteria will need to evolve as innovative utility DSM program designs continue to target metrics related to decarbonization. For example, the California Public Utility Commission (CPUC) has set energy efficiency goals based on Total System Benefits (TSB) and, starting in 2024, will transition away from goals based on savings of kWh, kW, and therms. The new TSB metric will maximize long duration GHG reductions and grid benefits and is an expression, in dollar value, of the lifecycle energy, capacity, and GHG benefits of a utility's energy efficiency program portfolio. The metric encourages programs to target high value load reduction and longer-duration energy savings while being fuel neutral (CPUC 2021). The CPUC currently provides one of the most advanced avoided cost models for utility DSM programs with hourly levelized values for cap-and-trade, GHG adder, GHG rebalancing, energy, generation capacity, transmission capacity, distribution capacity, ancillary services, losses, and methane leakage. Aligning goals with TSB is a regulatory innovation that will allow utility DSM programs to optimize program structures and delivery strategies to meet the aggressive decarbonization goals but does not fit within current EIA reporting structure.

Increased collaboration between emerging technology researchers and utility DSM service providers is needed to develop a framework for deploying market-ready technologies at scale. Utility DSM programs can provide access to large infrastructures of existing services that achieve market adoption of advanced energy technologies. However, emerging technology pilots represent risk for utilities and service providers who are striving to achieve goals within budget and cost-effectiveness criteria. There is a direct correlation between simplicity and scale.

Aligning research with existing utility DSM program prescriptive and custom structures to help graduate measures from high risk and high M&V levels of effort to low risk and low M&V levels of effort (emerging technology > custom > prescriptive > codes and standards) will help accelerate deployment.

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