AEG
Applied Energy Group

KANSAS CITY POWER & LIGHT 2016 DSM POTENTIAL STUDY

VOLUME 1: EXECUTIVE SUMMARY

FINAL REPORT

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INTRODUCTION

Kansas City Power and Light Company (KCP&L) engaged the Applied Energy Group (AEG) Team to conduct this Demand Side Management (DSM) Market Potential Study. It evaluates various categories of electricity DSM resources in the residential, commercial, and industrial sectors of KCP&L's service territory in Kansas and Missouri for the years 2019-2037. The resource categories investigated are: Energy Efficiency, Demand Response, Demand-Side Rates, and Combined Heat & Power.

The key objectives of the study are to:

- Perform a comprehensive analysis that complies with the respective statutory requirements of the Missouri Public Service Commission and the Kansas Corporation Commission
- Develop annual electricity energy and peak demand potential estimates for the DSM resource categories by customer class for each KCP&L jurisdiction for the time period of 2019 to 2037
- Develop baseline projections of annual electricity use and peak demand for each KCP&L jurisdiction, accounting for future codes and standards, naturally occurring energy efficiency, opt-out customers, smart connected devices, and combined heat and power
- Identify a subset of economic and program potential that is applicable to low-income customers
- Conduct a reliable, accurate and useful residential appliance saturation survey and C&I end-use saturation survey
- Quantify potential program savings from the DSM initiatives at various levels of cost
- Support KCP&L's effort to offer programs to all customer market segments while achieving the ultimate goal of all cost-effective demand-side savings

The study assesses various tiers of potential including technical, economic, maximum achievable, and realistic achievable potential. The study developed updated baseline estimates with the latest information on federal, state, and local codes and standards for improving energy efficiency.

As part of the study, the AEG Team conducted primary market research to collect data for the KCP&L service territory, including: end-use equipment saturation data and customer demographics and firmographics. All models and assumptions include the results from these primary market research efforts.

KCP&L will use the results of this study in its DSM and IRP planning process to optimally implement programs across its four service territories: Kansas City Power & Light Missouri (KCP&L-MO), Kansas City Power & Light Kansas (KCP&L-KS), Greater Missouri Operations Missouri Public Service (GMO-MPS), and Greater Missouri Operations St. Joseph Light & Power (GMO-SJLP).

REPORT ORGANIZATION

This report is presented in five volumes:

- Volume 1, Executive Summary
- Volume 2, Market Research Report
- Volume 3, Potential Analysis
- Volume 4, Program Potential
- Volume 5, Appendices

This document is Volume 1: Executive Summary.

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ANALYSIS OVERVIEW

This analysis follows industry standard practices for DSM market potential assessments as outlined in the EPA's National Action Plan for Energy Efficiency and as illustrated in Figure 1-1 below.[1]

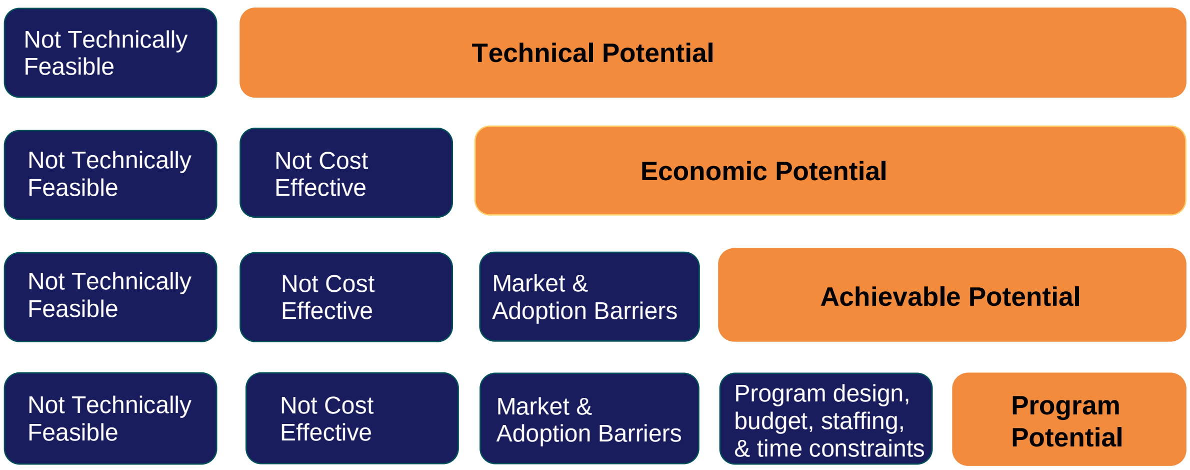

Figure 1-1 Definitions of DSM Potential

The analysis occurs in stages that yield multiple levels of potential. Technical Potential is the theoretical upper limit of energy efficiency potential, assuming that customers adopt all feasible measures regardless of cost or customer preference. Economic Potential is also a theoretical construct which includes the subset of technical potential that is cost-effective. Achievable Potential then carves out another subset by accounting for limitations in customer awareness and adoption. We refer to potentials at these first three levels as being at the measure-level before program bundling, cost, and delivery assumptions are applied. Finally, the fourth level of potential is defined at the program-level, which is Program Potential, or the portion of the Achievable Potential that might be reasonably achieved given the realities of implementation and the constraints of program resources. See Volumes 3 and 4 for more detail on these definitions and their application.

More specifically for this analysis, the framework is adapted to include parallel analyses of three DSM resource categories: energy efficiency, demand response and demand-side rates, and combined heat and power. DR and DSR are included in the same analysis section because they are primarily capacity-focused resources and use similar modeling techniques. The three parallel analyses stem from the same foundation of study objectives, market research, market characterization, and baseline definition. Ultimately, they are all integrated again in the final step of developing Program Potential. A flowchart of these analysis steps is presented in Figure 1-2.

[1] Per Missouri requirements, two levels of achievable potential are estimated: maximum and realistic. Size of Boxes not necessarily indicative of size of associated resources.

Source: National Action Plan for Energy Efficiency, "Guide to Resource Planning with Energy Efficiency." Figure 2-1. https://www.epa.gov/sites/production/files/2015-08/documents/resource_planning.pdf

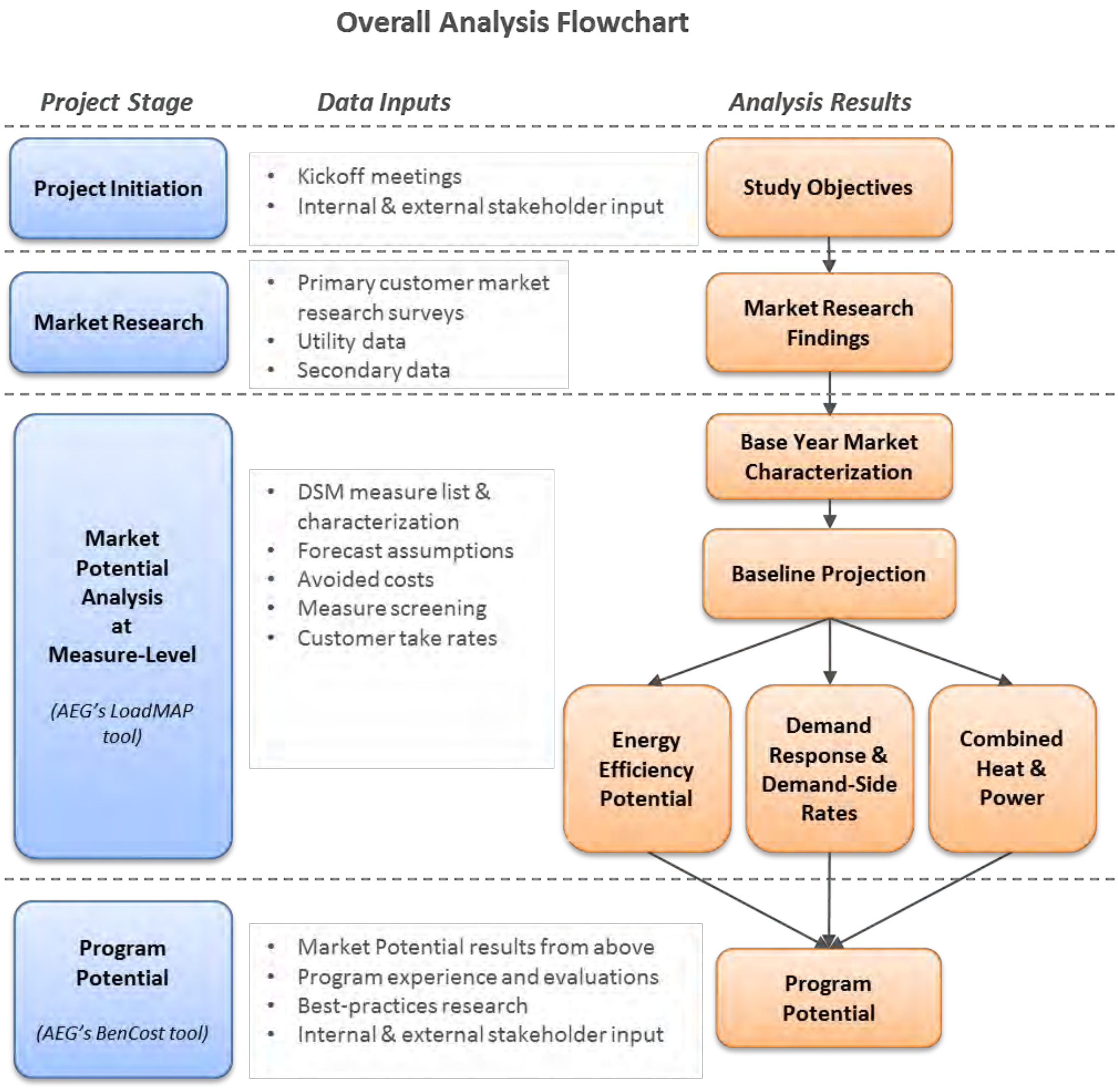

Figure 1-2 Overall Analysis Flowchart

Overall Summary of Energy Savings Potential

It is not appropriate to sum the impacts from the various resource categories because these analyses are conducted in parallel to this point. There are interactions and stacking effects that are not considered until the integrated step of developing the Program Potential.

Table 1-1 summarizes the achievable energy savings potential at the measure level for the three major DSM resource categories in key years of interest throughout the study's time horizon. The savings are represented as cumulative gigawatt-hours (GWh), representing the actual impact of the resource at the given time. This accounts for functioning measures that have been installed in prior years and also nets out any expired or retired measures.

We develop and examine two levels of Achievable Potential: Maximum and Realistic. Maximum Achievable Potential (MAP) assumes the maximum expected participation and customer awareness level, while Realistic Achievable Potential (RAP) assumes a more moderate set of participation and awareness assumptions that corresponds to past levels of DSM activity at KCP&L and peer utilities. This two-level construct provides a range of values rather than a point estimate, which can be helpful for planning purposes where many contingencies and uncertainties cannot be explicitly controlled.

By the third year of the study in 2021, achievable energy efficiency savings reach levels of 431 GWh and 624 GWh for RAP and MAP respectively. By the end of the study in 2037, the resource is 2,245 GWh for RAP and 3,101 GWh for MAP, which is 9% and 12% respectively of projected 2037 baseline sales.

Demand response interventions & demand-side rates do not generally pursue energy savings, and as such the table shows no values here in this analysis.[2] Achievable energy savings for combined heat and power measures are also quite small compared with traditional energy efficiency programs. Because of low retail energy rates and relatively high equipment and operational costs of CHP equipment, very few systems and applications are cost-effective. 14 to 20 GWh of CHP energy potential are achievable by the final year of the study, comprising around 0.1% of projected 2037 baseline system sales.

It is not appropriate to sum the impacts from the various resource categories because these analyses are conducted in parallel to this point. There are interactions and stacking effects that are not considered until the integrated step of developing the Program Potential.

Table 1-1 KCP&L Measure-Level Achievable Potential by Resource Category (Annual GWh)

All KCP&L Service Territories	2019	2020	2021	2030	2037
RAP Cumulative Net Savings (GWh)					
Energy Efficiency	203	318	431	1,440	2,245
Demand Response & Demand-Side Rates	-	-	-	-	-
Combined Heat & Power	1	1	2	8	14
MAP Cumulative Net Savings (GWh)					
Energy Efficiency	283	455	624	2,032	3,101
Demand Response & Demand-Side Rates	-	-	-	-	-
Combined Heat & Power	1	2	3	12	20

Summary of Summer Peak Demand Savings Potential

Similar to the results above, this section presents summer peak demand savings. Table 1-2 summarizes the achievable peak demand savings potential at the measure level for the three major DSM resource categories in the key study years of interest. The savings are represented as cumulative megawatts (MW), representing the actual impact of the resource at the given time, accounting for functioning measures and initiatives that have been installed in prior years and also netting out expired or retired impacts. (Winter peak analysis and results are presented in Volume 3.)

Table 1-2 KCP&L Measure-Level Achievable Potential by Resource Category (Summer Peak MW)

All KCP&L Service Territories	2019	2020	2021	2030	2037
RAP Cumulative Net Savings (Summer Peak MW)					
Energy Efficiency	37	57	77	263	407
Demand Response & Demand-Side Rates	199	291	420	637	676
Combined Heat & Power	0.1	0.1	0.2	0.9	1.5
MAP Cumulative Net Savings (Summer Peak MW)					
Energy Efficiency	48	78	108	366	558
Demand Response & Demand-Side Rates	416	509	595	772	818
Combined Heat & Power	0.1	0.2	0.3	1.4	2.3

[2] There are two caveats to this worth mentioning: First is that Smart Thermostats are present and cost-effective in both the EE and DR analyses, and the energy savings from the former and demand savings from the latter are combined in the integrated Program Potential step. Second is that Inclining Block Rate designs do produce energy savings, but because the analysis prioritized capacity savings, other demand-side rates take precedence in the analysis hierarchy and resulting IBR participation and therefore energy savings are insignificant.

By the end of the study in 2037, achievable peak demand savings from energy efficiency programs reach levels of 407 MW and 558 MW for RAP and MAP respectively. This is 7% and 10% of the projected 2037 baseline peak.

Demand response interventions & demand-side rates provide a larger capacity resource than the energy efficiency program, but on the same order of magnitude. Their projected savings potential in 2037 is 676 MW and 818 MW for RAP and MAP respectively. This is 11% and 13% of the projected 2037 baseline peak.

Again, savings for combined heat and power measures are considerably lower than other resources. 1.5 to 2.3 MW of CHP energy potential are achievable by the final year of the study.

As previously mentioned in the context of measure-level energy savings, it is not appropriate to sum the impacts from the various resource categories because these analyses are conducted in parallel to this point. For this, see the Program Potential discussion in the next section.

Overall Summary of Program Potential

Table 1-3 summarizes the Program Potential after all applicable resource categories and measures have been bundled and outfit with delivery mechanisms and appropriate cost structures. The portfolios here are built from the corresponding measure-level analyses in the RAP and MAP scenarios described in Table 1-1, but they are not a simple summation of the piece parts. The rationale and process for developing Program Potential is discussed in more detail in Volume 4.

The energy savings of the Program Potential scenarios come primarily from energy efficiency programs. Program potential generally provides 80% to 90% of the energy savings of the measure-level achievable EE potential, depending on the year or scenario. By the end of the study in 2037, the resource is 1,886 GWh for RAP and 2,579 GWh for MAP, which is 7.3% and 10.0% respectively of projected 2037 baseline sales.

With respect to summer peak demand, the Program Potential portfolios produce a large capacity resource primarily from EE and DR initiatives, reducing 2037 load by 780 MW in the RAP scenario and 1,001 MW in MAP. This comprises 12.7% and 16.3%, respectively, of projected 2037 baseline peak demand. Corresponding annual budgets range between $36 million and $71 million in the first three year cycle, rising as high as $119 million for Program MAP in the final year.

Table 1-3 KCP&L Program Potential Results Summary

All KCP&L Service Territories	2019	2020	2021	2030	2037
Total Budget (000s)					
Program RAP	$36,323	$39,844	$44,427	$49,637	$67,541
Program MAP	$59,724	$64,642	$71,256	$86,368	$118,746
Net Cumulative Energy Savings (MWh)					
Program RAP	177,284	287,497	401,301	1,312,666	1,886,204
Program MAP	233,418	378,027	527,741	1,744,232	2,578,995
Net Cumulative Summer Peak Demand Savings (MW)					
Program RAP	198	274	354	688	780
Program MAP	215	336	436	867	1,001
Energy Savings as % of Baseline					
Program RAP	0.8%	1.2%	1.7%	5.4%	7.3%
Program MAP	1.0%	1.6%	2.3%	7.2%	10.0%
Summer Peak Demand Savings as % of Baseline					
Program RAP	3.6%	4.9%	6.3%	11.7%	12.7%
Program MAP	3.9%	6.0%	7.8%	14.8%	16.3%

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Market Research

As part of the study, the AEG Team conducted primary market research to collect data for the KCP&L service territory, including: end-use equipment saturation data and customer demographics and firmographics. The goal of the primary market research was to develop information that could be used to drive estimates of DSM potential. The results of this research are the primary basis for the sector market profiles and equipment and measure baselines in the subsequent potential analysis when integrated with other data from KCP&L, AEG, and third-party sources.

Survey recruitment was performed according to a sample design described in Volume 2 that provides for statistically representative results in each of the desired, downstream analysis segments. The research design for residential households involved using mailed survey packages to solicit the completion of questionnaires by a representative sample of customers. Respondents had a choice of whether to complete the questionnaire by mail or online. Businesses were surveyed by telephone, or in the case of select key accounts via onsite survey. The allocation of completed surveys is shown in Table 2-1. A total of 3,961 surveys were fielded and processed across all KCP&L customers.

Table 2-1 Summary of Primary Market Research Activities

Survey Strategy	Survey Strategy	Number of Surveys Processed
Residential	Mix of Mail and Internet surveys	3,209
Business		752
Subtotal: Key Accounts	Onsite surveys	40
Subtotal: Other Business	Telephone surveys	712
Total		**3,961**

Residential Market Research Highlights

As shown in Figure 2-1, the survey results indicate that a total of 79% of households are single-family properties (71% detached and 8% attached), while 12% are multi-family households in buildings with 2-4 units, and 6% are multi-family households in buildings with five or more units. Consistent with these proportions, just under three-quarters of households (72%) say they own their own properties.

On average homes are older, with a median age of 40 years (just 26% have been constructed since 1990) with, most commonly, three bedrooms and an average size of just under 1,800 square feet.

More than half of all households (57%) have a member that has graduated from a four-year college. The median income for the population as a whole is just under $52,000, with 30% earning $75,000 or more.

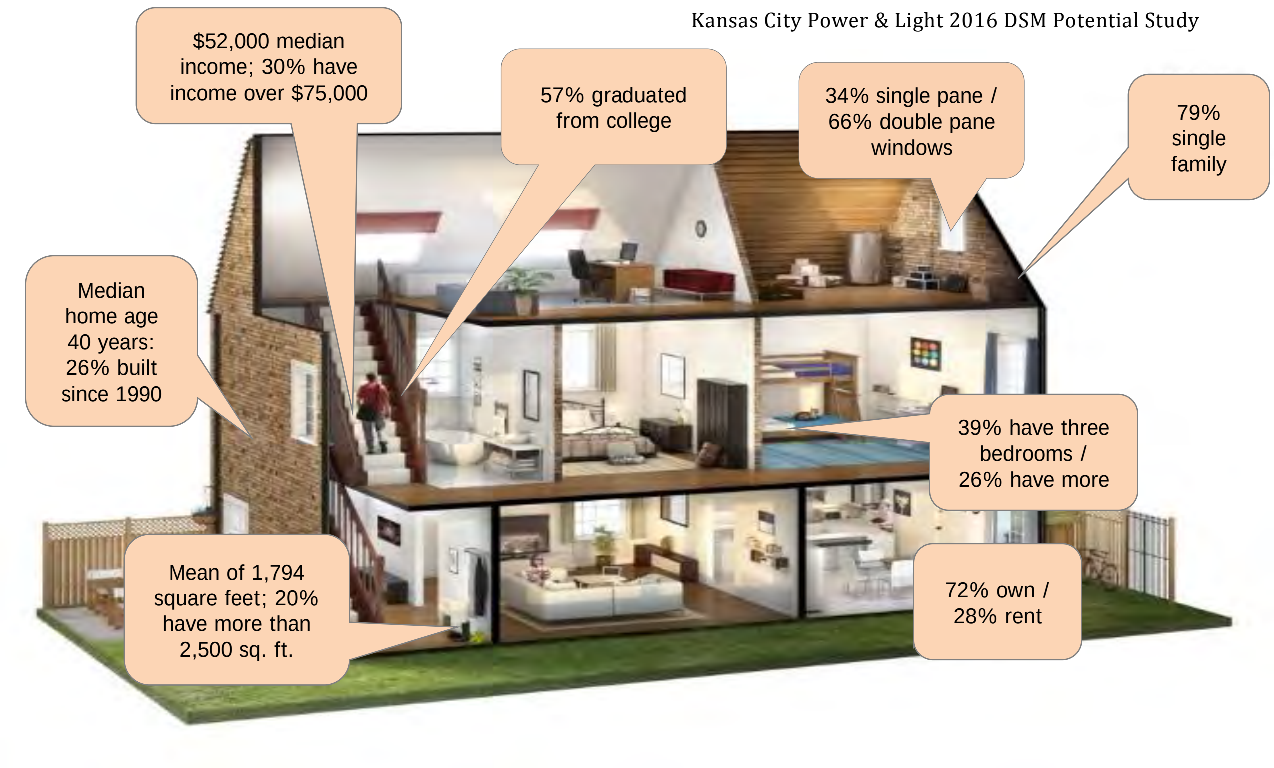


Figure 2-1 Summary of Demographic and Household Characteristics (N=3,209 All Respondents)

Business Market Research Highlights

The survey results indicate that just over three-quarters of establishments (79%) have no more than 19 full-time employees present at any one time. As would be expected, the mean reported facility size (in square footage) is much higher - at just over 50,000 sq. ft. - than the median size (at almost 4,900 sq. ft.). See Figure 2-2 for more information.

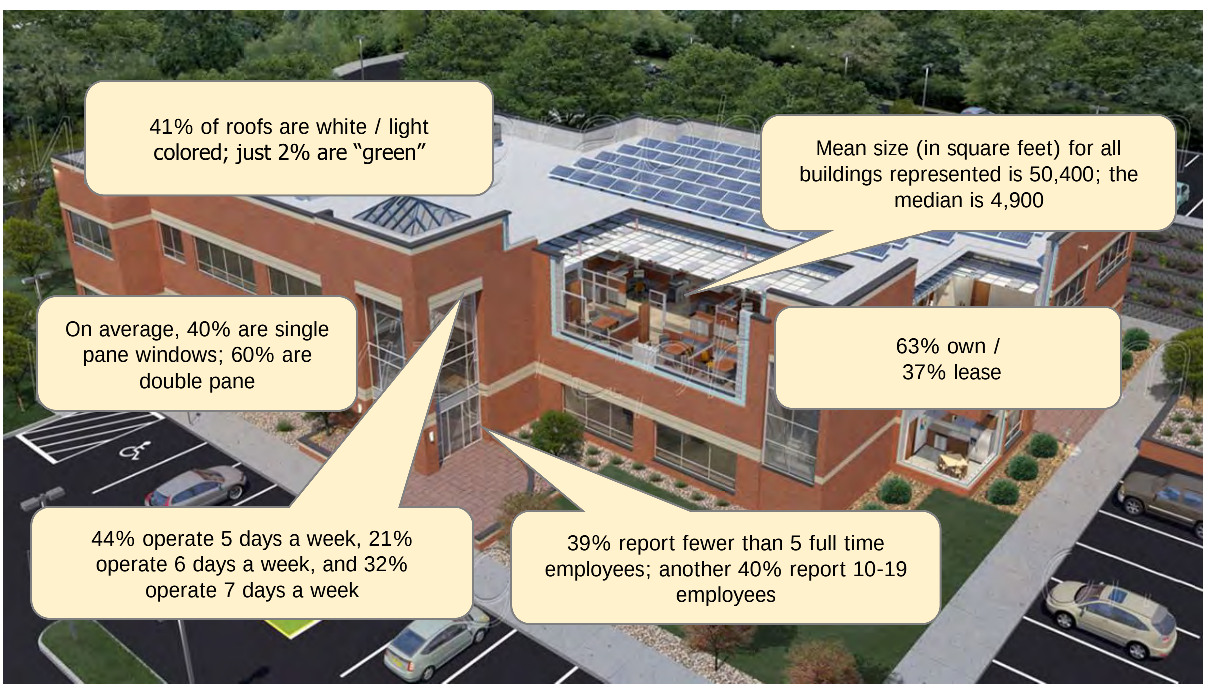


Figure 2-2 Summary of Business and Building Characteristics (N=752 All Respondents)

3

ENERGY EFFICIENCY POTENTIAL ANALYSIS

This portion of the analysis develops estimates of energy and peak demand savings potential for the energy efficiency (EE) resource in the KCP&L service territory. To perform the analysis, AEG used a detailed, measure-level approach beginning with the primary study objectives. We characterized the market, projected the baseline forward, and calculated potential savings. These steps are all described in detail in Volume 3 of this report.

In this study, the energy efficiency potential estimates represent net savings[3] developed into several levels of potential. This section focuses on analysis at the measure-level, that is, before consideration of program delivery mechanisms, program costs, and the application of portfolio strategy and measure bundling. At the measure-level, we analyze four levels of potential: technical, economic, maximum achievable, and realistic achievable potential.

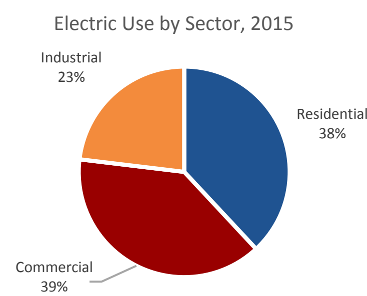
MARKET CHARACTERIZATION

In order to estimate the savings potential from energy-efficient measures, it is necessary to understand how much energy is used today and what equipment is currently being used.

Total electricity use for the residential, commercial, and industrial sectors for KCP&L in the study's base year of 2015 was 22,553 GWh. As shown below, the commercial and residential sectors are nearly equal in size, with 39% and 38% of use respectively. Industrial is slightly smaller in terms of overall consumption at 23%. Table 3-1 shows this information in tabular format along with peak demand data. In terms of summer peak demand, the total system peak in 2015 was 5,302 MW, while the winter system peak was lower at 4,250 MW. The residential sector has the highest contribution to peak. This is due to the high peak coincidence and healthy saturation of air conditioning equipment and electric heating.

Table 3-1 KCP&L Electricity Use by Sector, 2015

Sector	Annual Electricity Use (GWh)	% of Sales	Summer Peak Demand (MW)	Winter Peak Demand (MW)
Residential	8,585	38%	2,786	2,043
Commercial	8,760	39%	1,578	1,384
Industrial	5,208	23%	938	823
Total	**22,553**	**100%**	**5,302**	**4,250**



SUMMARY OF MEASURE-LEVEL EE POTENTIAL

In order to estimate the energy efficiency potential for the various cases, we first develop a baseline projection that shows what energy consumption would be in the absence of any future energy efficiency programs. The baseline does, however, include the effects of equipment standards, building codes, and naturally occurring energy efficiency. Then, each of the potential cases involve the implementation of all applicable measures and interventions from a bottom-up level.

[3] "Net" savings mean that the baseline forecast includes naturally occurring efficiency. In other words, the baseline assumes that energy efficiency levels reflect that some customers are already purchasing the more efficient option.

Figure 3-1 shows a line graph of the projected energy consumption under the baseline and various potential cases for all sectors combined. We summarize the savings potential in each of these cases below. All impacts are presented at the customer meter.

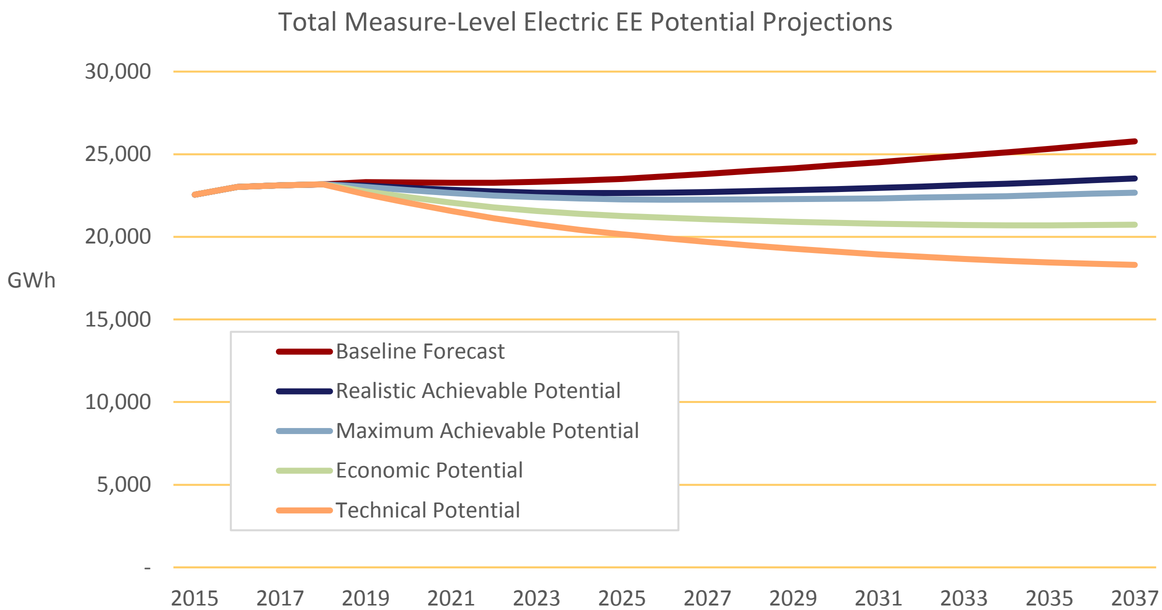


Figure 3-1 Summary of Baseline and Measure-Level EE Potential Projections

Summary of Annual Measure-Level EE Energy Savings

Table 3-2 and Figure 3-2 summarize the EE savings in terms of annual energy use for all measures for the levels of potential relative to the baseline projection. The table presents the baseline end-use projection, developed specifically for this study but aligned with the KCP&L official forecast, cumulative net savings in GWh and as a percent of the baseline, and incremental net savings in annual GWh and as a percent of the baseline[4].

- **Technical potential** reflects the adoption of all EE measures regardless of cost-effectiveness. Cumulative gross savings in 2021 are 1,719 GWh, or 7.4% of the baseline. By 2037 cumulative savings reach 7,475 GWh, or 29% of the baseline.
- **Economic potential** reflects the savings when the most efficient cost-effective measures are taken by all customers. By 2021, cumulative savings reach 1,209 GWh, or 5.2% of the baseline. By 2037, cumulative savings reach 5,051 GWh, or 19.6% of the baseline projection.
- **Maximum achievable potential** refines the economic potential by taking into the account the maximum expected participation and customer preferences without budget constraints. By 2021, cumulative savings reach 624 GWh, or 2.7% of the baseline. By 2037, cumulative net savings reach 3,101 GWh, or 12.0% of the baseline projection. The average annual incremental savings are 1.2% of the baseline (the average of the annual incremental savings in each year).
- **Realistic achievable potential** further refines maximum achievable potential by considering budgetary constraints and what could be realistically achievable with participation and awareness. By 2021 cumulative savings reach 431 GWh, or 1.9% of the baseline projection. By

[4] Please note that the sum of incremental savings will typically exceed cumulative savings in any given year, mainly due to the effects of measure persistence. Cumulative savings take into account the fact that measures installed in earlier years will have to be repurchased at their end of useful life. Incremental savings capture the total amount of measure purchases in a given year, which includes both new purchases and repurchases.

2037, cumulative savings reach 2,245 GWh, or 8.7% of the baseline projection. The average annual incremental savings are 1.0% of the baseline each year.

Table 3-2 Summary of KCP&L Cumulative Measure-level EE Potential

	2019	2020	2021	2030	2037
Baseline Projection (GWh)	23,304	23,289	23,278	24,331	25,779
Cumulative Net Savings (GWh)					
Realistic Achievable Potential	203	318	431	1,440	2,245
Maximum Achievable Potential	283	455	624	2,032	3,101
Economic Potential	549	888	1,209	3,488	5,051
Technical Potential	726	1,236	1,719	5,232	7,475
Cumulative as % of Baseline					
Realistic Achievable Potential	0.9%	1.4%	1.9%	5.9%	8.7%
Maximum Achievable Potential	1.2%	2.0%	2.7%	8.3%	12.0%
Economic Potential	2.4%	3.8%	5.2%	14.3%	19.6%
Technical Potential	3.1%	5.3%	7.4%	21.5%	29.0%
Incremental Net Savings (GWh)					
Realistic Achievable Potential	203	166	167	251	333
Maximum Achievable Potential	283	226	226	336	440
Economic Potential	549	442	431	569	689
Technical Potential	729	616	603	787	984
Incremental as % of Baseline					
Realistic Achievable Potential	0.9%	0.7%	0.7%	1.0%	1.3%
Maximum Achievable Potential	1.2%	1.0%	1.0%	1.4%	1.7%
Economic Potential	2.4%	1.9%	1.9%	2.3%	2.7%
Technical Potential	3.1%	2.6%	2.6%	3.2%	3.8%

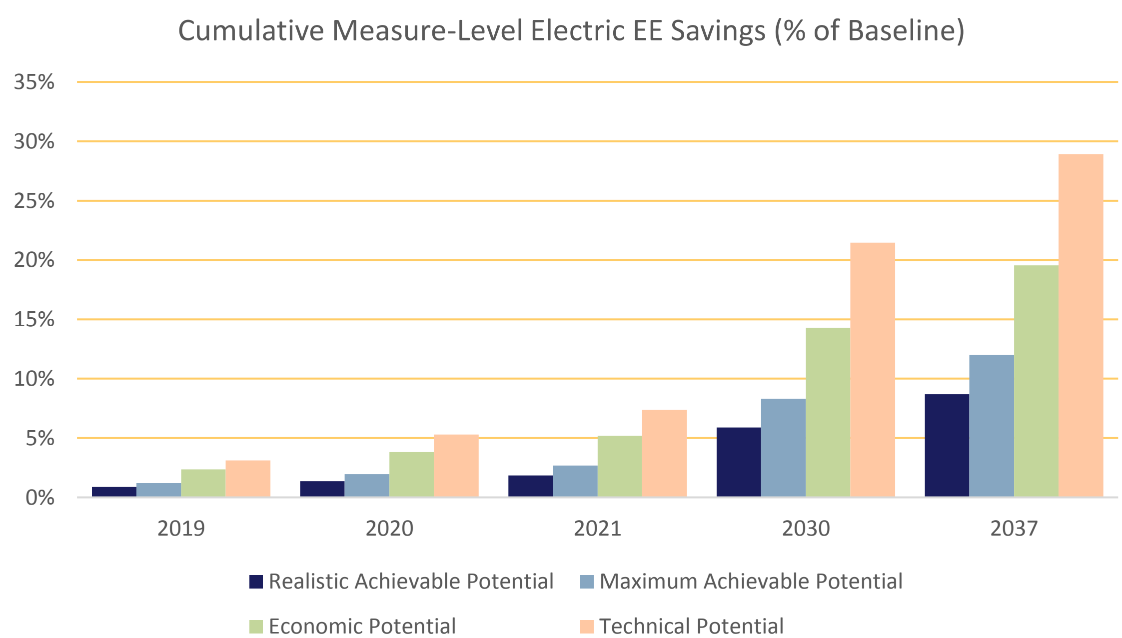


Figure 3-2 Summary of Measure-level Cumulative EE Potential

Summary of Annual Measure-Level EE Peak Demand Savings

Table 3-3 summarizes the summer peak demand savings from all EE measures for the levels of potential relative to the baseline projection.[5] We also investigate winter peak impacts in the more detailed Volume 3 materials, but KCP&L is a summer-peaking system, and this is therefore the primary peak of interest discussed here.

- **Technical potential** for summer peak demand savings is 319 MW in 2021, or 5.7% of the baseline summer peak projection. This increases to 1,485 MW by 2037, or 24.2% of the baseline.
- **Economic potential** is estimated to be 216 MW or 3.8% reduction in the 2021 summer peak demand baseline projection. In 2037, savings are 974 MW or 15.8% of the summer peak baseline projection.
- **Maximum achievable potential** is 108 MW by 2021 or 1.9% of the baseline projection. By 2037, cumulative saving reach 558 MW or 9.1% of the baseline projection.
- **Realistic achievable potential** is 77 MW by 2021, or 1.4% of the baseline projection. By 2037, cumulative savings reach 407 MW, or 6.6% of the baseline projection.

Table 3-3 Summary of Cumulative Measure-level EE Summer Peak Demand Potential

	2019	2020	2021	2030	2037
Baseline Projection (MW)	5,548	5,585	5,615	5,875	6,150
Cumulative Net Savings (MW)					
Realistic Achievable Potential	37	57	77	263	407
Maximum Achievable Potential	48	78	108	366	558
Economic Potential	96	157	216	672	974
Technical Potential	132	227	319	1,046	1,485
Cumulative as % of Baseline					
Realistic Achievable Potential	0.7%	1.0%	1.4%	4.5%	6.6%
Maximum Achievable Potential	0.9%	1.4%	1.9%	6.2%	9.1%
Economic Potential	1.7%	2.8%	3.8%	11.4%	15.8%
Technical Potential	2.4%	4.1%	5.7%	17.8%	24.2%

Summary of Measure-level EE Potential by Sector

Table 3-4 and Figure 3-3 summarize the range of electric achievable energy potential by sector. The residential sector provides the most energy efficiency potential in the early years. The commercial sector surpasses it after 2021, however, largely through lighting savings; and reaches a level of nearly double the residential sector by 2037. The industrial sector contributes the fewest savings. Since a number of the largest industrial customers have opted out from EE programs, the savings here come largely from the remaining, somewhat smaller facilities.

[5] Note that the potential savings from Demand Response and Demand-Side Rate options are not shown here. The Demand Response potential analysis was done separately at the measure-level from the Energy Efficiency analysis.

Table 3-4 Summary of Measure-level EE Potential by Sector

	2019	2020	2021	2030	2037
Realistic Achievable Potential					
Cumulative Savings (GWh)					
Residential	115	156	198	539	823
Commercial	75	135	194	727	1,135
Industrial	13	26	39	173	287
Total	**203**	**318**	**431**	**1,440**	**2,245**
Maximum Achievable Potential					
Cumulative Savings (GWh)					
Residential	145	204	263	697	1,046
Commercial	118	211	301	1,074	1,632
Industrial	20	41	60	261	423
Total	**283**	**455**	**624**	**2,032**	**3,101**

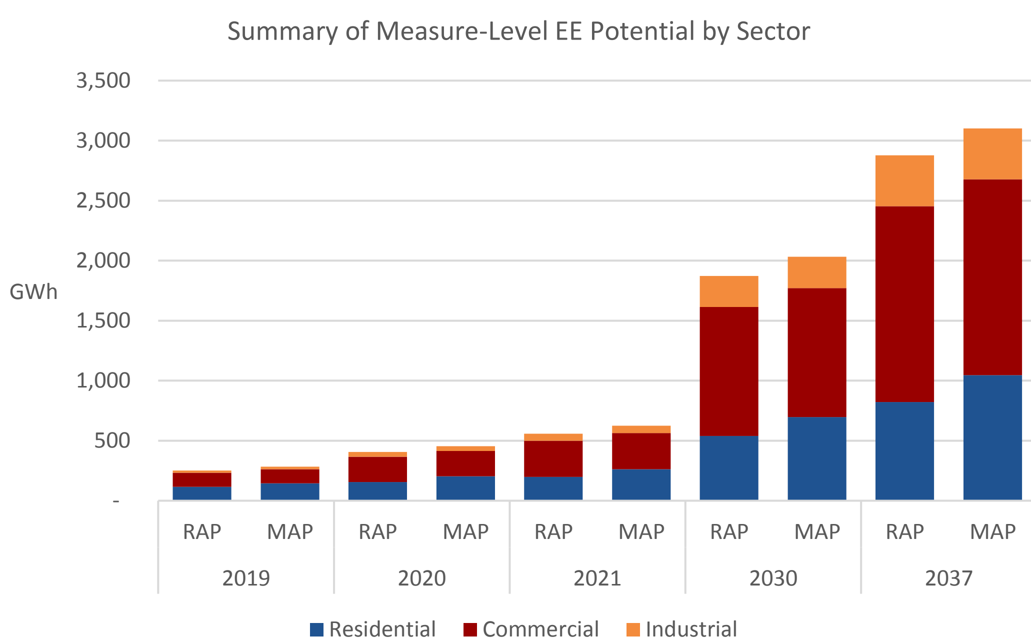


Figure 3-3 Summary of Measure-level EE Potential by Sector

4

Demand Response and Demand side Rates Potential

This portion of the analysis develops estimates of peak demand savings potential for the demand response (DR) and demand side rates (DSR) resources in the KCP&L service territory. To perform the analysis, AEG developed detailed modeling assumptions in alignment with the primary study objectives. The details of the analysis approach and modeling assumptions are all described in detail in Volume 3 of this report.

The structure and process for the DR and DSR potential assessment is similar to the EE potential analysis. The key difference is that DR and DSR are "program" concepts (not measures), meaning that customers will not take these actions without a utility offering. DR requires a program to induce savings (i.e., there is no naturally occurring DR). Similarly, DSR requires a "rate structure" to supply a price signal to induce savings or shift demand.

While DR and DSR are quite different from the customers' perspective, they are similar with respect to modeling requirements, so we analyze them together. Some programs will target the same customers so we take steps to avoid double-counting and overstating of participation.

The major analysis steps are listed below:

- Define the relevant DR and DSR resource options
- Characterize the market and develop a baseline projection
- Develop DR and DSR program assumptions
- Estimate DR and DSR potential
    - In order to estimate the potential, we first looked at each program on a standalone basis (and without an economic screen) in order to assess them individually.
    - Secondly, we impose a participation hierarchy so that customers can only participate in a maximum of one program of the same type. This eliminates double counting. In this "integrated" case, we also apply an economic screen to remove programs that do not have a TRC benefit to cost ratio > 1.0. These are achievable potential estimates. Note that technical and economic potential are not concepts typically applied to DR and DSR resources.

Identify Demand Response and Demand-side Rate Options

This study considers a comprehensive list of demand response programs available in the DSM marketplace today and projected into the 20-year study time horizon. These are controllable or dispatchable programmatic options where customers agree to reduce, shift, or modify their load during a limited number of event hours throughout the year. We briefly describe each of those options in Table 4-1 below.

In addition to the demand response options, we also identified demand-side rate based options that are designed to incentivize customers to reduce, shift, or modify their load. Toward this end, AEG and Brattle held workshops with KCP&L staff and Stakeholders. Out of these discussions, we identified the DSR options shown in Table 4-2 for inclusion in the quantitative models.

Table 4-1 List of Demand Response Program Options in Analysis

Program Option	Eligible Customer Segments	Mechanism	Current Utility Offering?
DLC Space Cooling DLC Room AC DLC Water Heating DLC Space Heating	Residential, Small C&I	Direct Load Control switch installed on customer's equipment and operated remotely, typically by RF.	
DLC Smart Appliances	Residential, Small C&I	Internet-enabled control of operational cycles of white goods appliances.	
DLC Smart Thermostats	Residential, Small C&I	Internet-enabled control of thermostat set points.	Yes
Curtailment Agreements	Large C&I	Customers enact their customized, mandatory curtailment plan. May use stand-by generation. Penalties apply for non-performance. Various delivery mechanisms, contractual payment and penalty structures used – interruptible tariffs, third party aggregation, etc.	Yes
Ice Energy Storage	Small C&I	Peak shifting of primarily space cooling loads using stored ice.	
Battery Energy Storage	All	Peak shifting of loads using batteries on the customer side of the meter (stored electrochemical energy).	
Electric Vehicle DLC Smart Chargers	Residential	Smart, connected EV chargers that would automate vehicle charging such that it occurred preferentially during overnight, off-peak hours.	

Table 4-2 List of Demand Side Rate Options in Analysis

Program Option	Eligible Customer Segments	Mechanism
Demand Rates	Residential	Opt-in rate that includes a billing component based on a customer's peak demand in a given month. This rate structure has traditionally been reserved for C&I customers, but better reflects the grid's evolving underlying cost structure and is being considered for residential application. Opt-in and opt-out options correspond to RAP and MAP respectively. We also investigate the effects of this rate on customers with electric vehicles, who would in effect have an "enabling technology" in the form of their EV that would enable them to shift large amounts of usage and demand by charging their EV during off-peak hours.
Time-of-use Rates	Residential, Small C&I, Large C&I	Higher rate for a particular block of hours that occurs every day. Requires interval meters. Opt-in and opt-out options correspond to RAP and MAP respectively. Similar to the demand rate, we also investigated TOU rates for customer with electric vehicles.
Real-time Pricing	Small C&I, Large C&I	Dynamic rate that fluctuates throughout the day based on energy market prices. Requires interval meters. This is modeled with an opt-in roll-out, which is the only typical implementation that has been observed in the industry. Low and high opt-in participation levels are assumed for RAP and MAP respectively.
Inclining Block Rates	Residential	Higher per-unit price for incremental blocks of monthly energy usage. This is modeled with a mandatory roll-out, which is the only typical implementation that has been observed in the industry. We investigate two cases here, one where the fixed charge remains the same, and another where the fixed charge increases in a manner that is often done in these implementations to preserve revenue stability.

Demand Response and Demand-side Rate Potential Results

In this section, we present estimates of DR and DSR savings potential. It is important to note that potential savings going into the study time horizon are essentially comprised of savings from existing KCP&L programs, which means the incremental new potential occurring in 2019 and beyond is smaller than the cumulative total by the amount of savings that KCP&L is already implementing. All impacts are presented at the customer meter.

The potential savings are presented here as achievable potential for programs in a real-life, integrated basis with the participation hierarchy in effect to prevent double-counting of customer impacts in overlapping programs. Table 4-3 presents the aggregate potential from DR and DSR options for the RAP and MAP in the summer season. Peak demand savings potential for RAP start at 199 MW at the beginning of the study and rise to 676 MW by 2037. For MAP, savings start at 416 MW in 2019 and increase to 818 MW in 2037. Savings potential in the final year corresponds to reductions of 11% for RAP and 13% for MAP from KCPL's projected 2037 summer system peak. The effect on the peak load forecast is shown in Figure 4-1.

Table 4-3 Overall Summary of DR & DSR Achievable Potential for 2037 (Summer Peak)

	2019	2020	2021	2027	2037
Baseline Projection (Summer MW)	5,548	5,585	5,615	5,875	6,150
Potential Savings (MW)					
Realistic Achievable Potential	199	291	420	636	676
Maximum Achievable Potential	416	509	595	772	818
Potential Savings (% of baseline)					
Realistic Achievable Potential	3.6%	5.2%	7.5%	10.8%	11.0%
Maximum Achievable Potential	7.5%	9.1%	10.6%	13.1%	13.3%

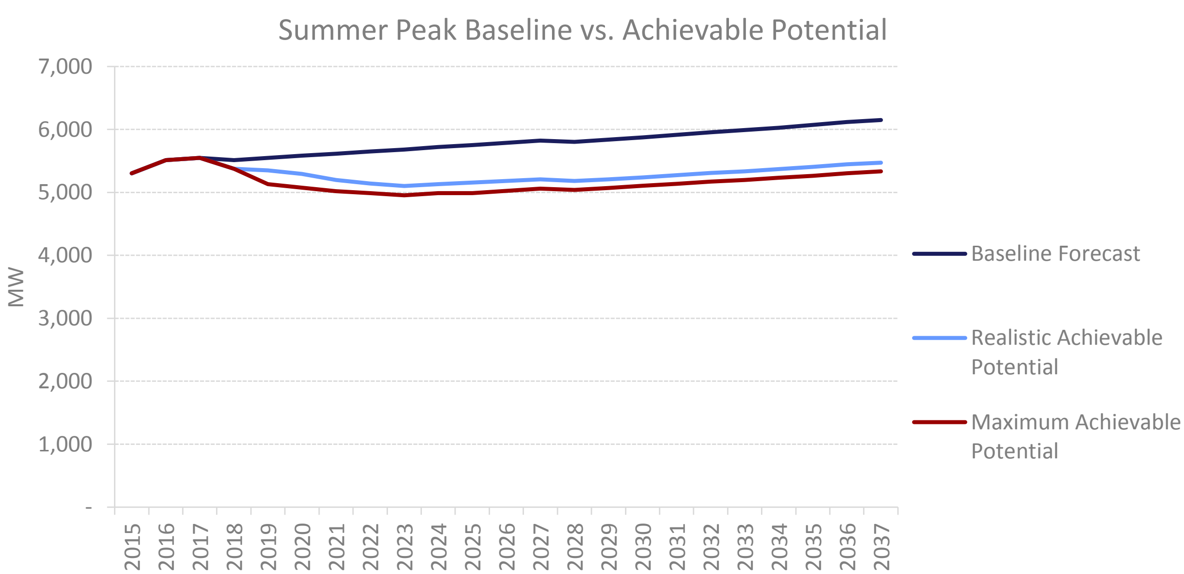


Figure 4-1 Baseline and Achievable DR & DSR Potential Forecasts (Summer Peak MW)

Table 4-4 provides the summer peak savings potential by program option for the realistic achievable potential case. Figure 4-2 presents this same data graphically, making it easy to see that the largest savings come from Direct Load Control of Smart Thermostats and Curtailment Agreements programs with large C&I customers.

Contribution by program is similar in the maximum achievable potential case, and can be found in more detail in the full description of the analysis in Volume 3.

Table 4-4 Realistic Achievable Potential by Option (Summer Peak)

	2019	2020	2021	2030	2037	2037 as % of Baseline
Baseline Forecast (Summer MW)	**5,548**	**5,585**	**5,615**	**5,875**	**6,150**	
Achievable Potential (MW)	**198.72**	**290.76**	**420.09**	**636.36**	**675.96**	**10.99%**
DLC Space Cooling	6.26	19.00	44.86	70.52	75.21	1.22%
DLC Water Heating	1.18	3.60	8.54	13.98	15.39	0.25%
DLC Smart Thermostats	61.01	85.14	107.79	167.33	178.05	2.90%
Curtail Agreements	80.06	103.67	128.12	184.71	190.07	3.09%
Time-Of-Use w EV	0.30	1.05	2.79	12.16	17.26	0.28%
Time-Of-Use	9.18	26.66	59.20	80.66	84.35	1.37%
Demand Rate w EV	0.30	1.06	2.81	12.10	17.08	0.28%
Demand Rate	8.11	22.07	42.64	50.48	52.64	0.86%
Real Time Pricing	0.11	0.95	3.28	29.52	30.38	0.49%
Inclining Block Rate	32.20	27.55	20.05	14.90	15.54	0.25%

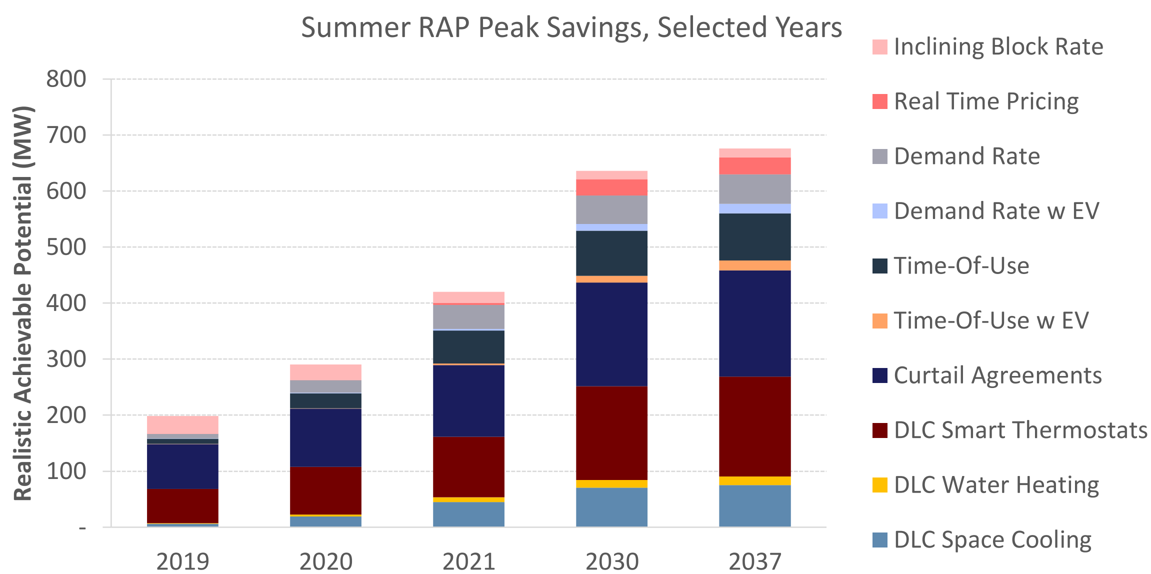


Figure 4-2 Realistic Achievable DR & DSR Potential (Summer MW)

5

Combined Heat and Power Potential Analysis

As the third and final component of the measure-level analyses in this study, AEG developed estimates of the potential for energy and peak demand savings from customer-sited combined heat and power (CHP) systems in the KCP&L service territory.

The methodology is similar to the energy efficiency analysis, with the added wrinkle that CHP systems generate electricity (rather than conserve it) and both consume and offset natural gas usage. As such, a custom version of the LoadMAP model was constructed to natively assess all impacts in parallel. We refer to the impacts of CHP electricity generation as energy and demand savings from the perspective of system resource planning, which is analogous and consistent to how we treat other DSM resources in this report.

The major analysis steps are to define relevant CHP technologies and research technical data, characterize the market and develop a baseline projection, develop technical applicability and achievable adoption rates, and finally to estimate CHP savings potential.

To calculate the economic viability of each system based on all streams of costs and savings, we consider all benefits and costs:

- Benefits: offset of purchased electricity with onsite generation, offset of typical boiler operation with waste heat recovery.
- Costs: first-year installation costs, utility program administration costs, purchase of natural gas fuel, persistent non-energy O&M.

Figure 5-1 below illustrates the energy flows associated with these costs and benefits, first in a traditional setting with no CHP, and second with a CHP system instead. The CHP system is thermodynamically more efficient since it can provide the same total output to the customer – 60 units of useful energy to this example facility – for a smaller footprint of input energy. In the example, the input energy of the traditional system is 100 units of fuel to feed both Grid and onsite resources, which is reduced to 80 units of fuel all-in to feed the CHP system. The specific values of these energy flows will fluctuate based on the application, but all must be accounted for in this way when assessing CHP potential and economics.

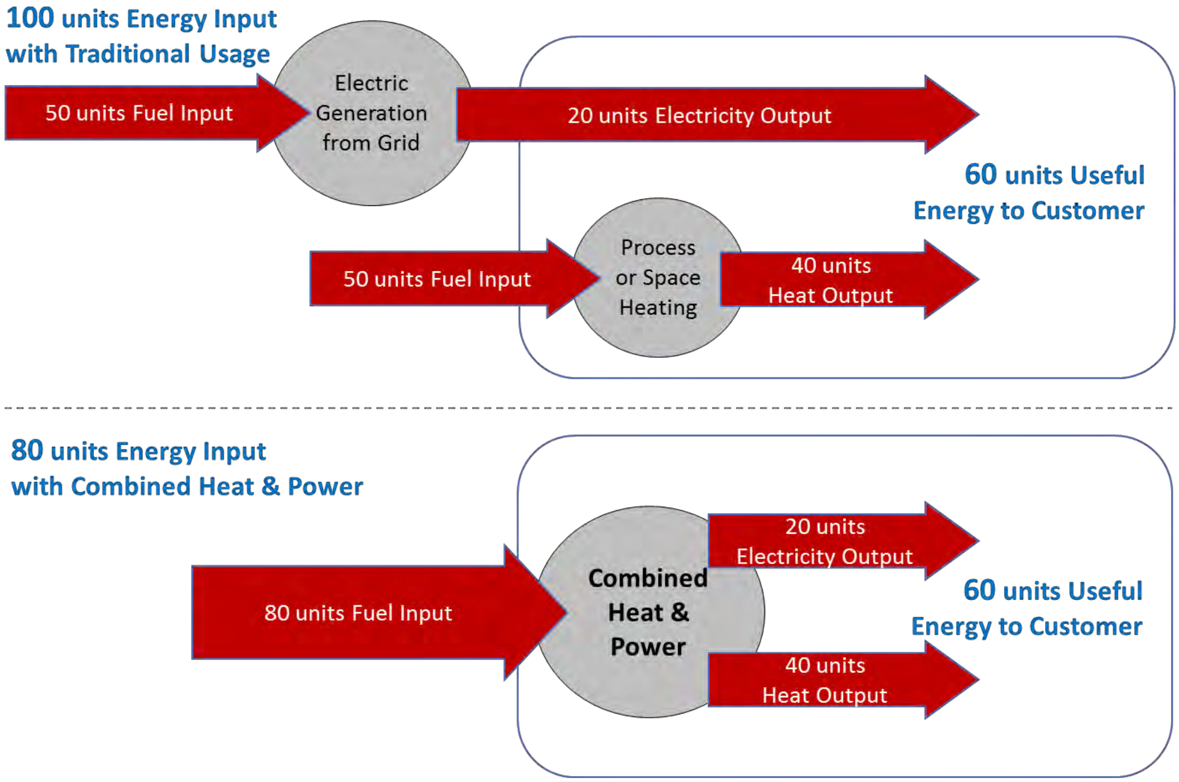


Figure 5-1 Review of CHP Energy Flows

CHP Options and Cost-Effectiveness

Table 5-1 lists the various CHP system options that are assessed and summarizes the total resource cost (TRC) test results in selected years. Only the steam turbine with heat recovery measure is cost effective for the entire study duration. Installed steam turbine costs are lower than other technologies since costs represent only the turbine itself. This assumes that the requisite upstream steam boiler is already installed onsite, which is typically the case for this subset of installations. This has the effect of lowering overall technical applicability of this measure since only select facilities use steam boilers.

Table 5-1 TRC Cost Effectiveness for CHP Measures, Selected Years

TRC Benefit-to-Cost Ratio in 2019	Commercial	Industrial	TRC Benefit-to-Cost Ratio in 2037	Commercial	Industrial
Fuel Cell w/ Heat Recovery	0.45	0.45	Fuel Cell w/ Heat Recovery	0.50	0.51
Recip Engine w/ Heat Recovery	0.68	0.72	Recip Engine w/ Heat Recovery	0.78	0.85
CT w/ Heat Recovery	0.76	0.84	CT w/ Heat Recovery	0.83	0.93
Microturbine w/ Heat Recovery	0.64	0.65	Microturbine w/ Heat Recovery	0.75	0.76
Steam Turbine w/ Heat Recovery	1.48	1.65	Steam Turbine w/ Heat Recovery	1.65	1.84

Overall CHP Potential Results

Table 5-2 and Table 5-3 summarize cumulative energy and demand potential for CHP in the combined commercial and industrial sectors. Recall that Missouri opt-out customers are removed from consideration for the MAP and RAP results. The 2021 cumulative realistic achievable potential of 1.9

GWh is much lower than the corresponding technical potential of 400.0 GWh in the same year. This is due to low cost-effectiveness of most applicable systems.

- Technical potential reflects the adoption of all CHP measures regardless of cost-effectiveness. Cumulative savings in 2021 are 400 GWh, or 2.8% of the baseline. By 2037 cumulative savings reach 2,533 GWh, or 16% of projected 2037 baseline sales.
- Economic potential reflects the savings when all applicable cost-effective measures are installed by all customers. In 2021, cumulative savings reach 7.4 GWh. By 2037, cumulative savings reach 46.9 GWh, or 0.3% of the baseline projection. All economic and achievable savings in this case come from steam turbine CHP systems.
- Maximum Achievable potential refines the economic potential by taking into the account the maximum expected participation and customer preferences without budget constraints. By the end of the study in 2037, cumulative savings reach 20.0 GWh.
- Realistic Achievable potential further refines maximum achievable potential with a lower level of program activity and customer adoption. By the end of the study in 2037, cumulative potential energy savings are 13.6 GWh.

Table 5-2 C&I CHP Energy Savings Potential – Opt-Out Removed from MAP and RAP

	2019	2020	2021	2030	2037
Baseline Forecast (GWh)	**14,222**	**14,220**	**14,225**	**14,916**	**15,737**
Cumulative Energy Savings (GWh)					
Realistic Achievable Potential	0.6	1.3	1.9	8.1	13.6
Maximum Achievable Potential	1.0	1.9	2.9	12.2	20.0
Economic Potential	2.4	4.9	7.4	29.6	46.9
Technical Potential	133.3	266.7	400.0	1600.0	2533.2
Energy Savings (% of Baseline)					
Realistic Achievable Potential	0.00%	0.01%	0.01%	0.05%	0.09%
Maximum Achievable Potential	0.01%	0.01%	0.02%	0.08%	0.13%
Economic Potential	0.02%	0.03%	0.05%	0.20%	0.30%
Technical Potential	0.94%	1.88%	2.82%	10.74%	16.01%

Table 5-3 C&I CHP Summer Peak Demand Savings Potential – Opt-Out Removed from MAP and RAP

	2019	2020	2021	2030	2037
Baseline Forecast (MW)	**2,521**	**2,521**	**2,522**	**2,617**	**2,735**
Cumulative Demand Savings (MW)					
Realistic Achievable Potential	0.1	0.1	0.2	0.9	1.5
Maximum Achievable Potential	0.1	0.2	0.4	1.4	2.3
Economic Potential	0.3	0.6	0.9	3.4	5.4
Technical Potential	15.4	30.6	46.0	183.8	291.0
Demand Savings (% of Baseline)					
Realistic Achievable Potential	0.00%	0.00%	0.01%	0.03%	0.05%
Maximum Achievable Potential	0.00%	0.01%	0.02%	0.05%	0.08%
Economic Potential	0.01%	0.02%	0.04%	0.13%	0.20%
Technical Potential	0.61%	1.21%	1.82%	7.04%	10.64%

6

Program Potential

As the final step of KCP&L's 2016 DSM Market Potential Study, AEG developed Program Potential. The program-level potential is when the previously discussed measure-level analysis components – energy efficiency, demand response, demand side rates, and combined heat and power – are considered and bundled in an integrated and holistic manner to ascertain the total potential savings, costs, and delivery structure of an actual and realizable portfolio of DSM resources. Program potential is defined as the portion of the achievable potential that might be reasonably achieved given the realities of implementation and the constraints of program resources. It is a subset of measure-level potential that is aligned with recent program accomplishments, available future budget, and long-term strategic goals.

We used program design, incentive structures, marketing approaches, budgets, and levels of staffing from field experience to refine delivery assumptions and participation rates to a level that can be accomplished given KCP&L's current DSM programs; and also to reflect the ramp-up time necessary for new initiatives. Incentive amounts and administrative budgets are associated with continuing KCP&L's current program momentum as well as launching new initiatives into the marketplace. We developed these assumptions based on discussions with KCP&L staff, review of existing program data, and AEG program benchmarking research.

The proposed DSM programs deliver an effective and balanced portfolio of energy savings opportunities across all customer segments. Program eligibility has been defined broadly to make programs as inclusive as possible. In general, participation guidelines are designed to include all customer sectors and end uses. Each program was designed to leverage the optimal mix of best-practice measures, delivery strategies, and target markets in order to most effectively deliver programs and measures to KCP&L customers.

KCP&L's programs have been aligned to offer customers consistent programs and incentives across all four service territories. . This will allow KCP&L to streamline implementation and marketing activities and provide equitable programs to all of their customers, regardless of whether they are located within KCP&L-MO, KCP&L-KS, GMO-MPS, or GMO-SJLP.

The resulting portfolio of programs is listed by sector below in Table 6-1.

Table 6-1 List of Programs in KCP&L DSM Portfolio

Residential Programs	Business Programs
Home Lighting Rebate	Business Energy Efficiency Rebate - Standard
Home Energy Report	Business Energy Efficiency Rebate - Custom
Income-Eligible Home Energy Report	Strategic Energy Management
Online Home Energy Audit	Retrocommissioning
Whole House Efficiency	Block Bidding
Income-Eligible Multi-Family	Online Business Energy Audit
Income-Eligible Weatherization	Small Business Targeted
Residential Smart Thermostat with DLC	Business Smart Thermostat with DLC
Central Air Conditioner DLC Switch	Demand Response Incentive
Water Heating DLC Switch	

In keeping with the structure of the preceding analysis components, program potential was developed for Program RAP and Program MAP. Two additional portfolios, RAP- and RAP+ (pronounced "RAP minus" and "RAP plus"), are extrapolated based on those program-level RAP and MAP portfolios in order to provide KCP&L with a more diverse set of planning cases. RAP- represents participation levels that are approximately 75% of the RAP scenario, while RAP+ represents participation levels at the average or midpoint between RAP and MAP. This results in the following set of scenarios from lowest to highest participation levels:

- Program RAP- (approximately 75% of RAP participation levels)
- Program RAP
- Program RAP+ (approximate average of RAP and MAP participation levels)
- Program MAP

Table 6-2 presents a high-level summary of each scenario's budget, cumulative energy savings, and cumulative summer peak demand savings for all of KCP&L. Following this, Table 6-3 presents additional detail for the RAP scenario. This includes the annual budget and incremental energy and demand savings by program for the first 3 years of the analysis horizon (2019-2021).[6]

For additional detail by program and scenario, please see Volume 4 and the final chapter of the Volume 5 appendices.

Table 6-2 Program Potential Case Summary – All KCP&L Service Territories

All KCP&L Service Territories	2019	2020	2021	2030	2037
Total Budget (000s)					
Program RAP-	$25,285	$27,691	$30,952	$33,826	$45,437
Program RAP	$36,323	$39,844	$44,427	$49,637	$67,541
Program RAP+	$46,845	$50,658	$56,201	$65,829	$90,043
Program MAP	$59,724	$64,642	$71,256	$86,368	$118,746
Net Cumulative Energy Savings (MWh)					
Program RAP-	135,266	220,256	307,938	1,010,795	1,450,099
Program RAP	177,284	287,497	401,301	1,312,666	1,886,204
Program RAP+	205,504	333,098	465,043	1,536,543	2,258,677
Program MAP	233,418	378,027	527,741	1,744,232	2,578,995
Net Cumulative Summer Peak Demand Savings (MW)					
Program RAP-	149	207	267	521	591
Program RAP	198	274	354	688	780
Program RAP+	206	305	395	779	895
Program MAP	215	336	436	867	1,001
Energy Savings as % of Baseline					
Program RAP-	0.6%	0.9%	1.3%	4.2%	5.6%
Program RAP	0.8%	1.2%	1.7%	5.4%	7.3%
Program RAP+	0.9%	1.4%	2.0%	6.3%	8.8%
Program MAP	1.0%	1.6%	2.3%	7.2%	10.0%
Summer Peak Demand Savings as % of Baseline					
Program RAP-	2.7%	3.7%	4.7%	8.9%	9.6%
Program RAP	3.6%	4.9%	6.3%	11.7%	12.7%
Program RAP+	3.7%	5.5%	7.0%	13.3%	14.6%
Program MAP	3.9%	6.0%	7.8%	14.8%	16.3%

[6] Note that we represent the incremental demand savings for DR programs as the total impact of all program participants in any given year who effectively re-enroll on an annual basis to continue curtailing and receiving incentive payments. This makes the incremental savings equal to the cumulative savings from a resource planning and accounting perspective.

Table 6-3 RAP Program Potential Summary – All Service Territories

Program	Total Budget (000s)			Net Incremental Energy Savings (MWh)			Net Incremental Peak Demand Savings (MW)		
	2019	**2020**	**2021**	**2019**	**2020**	**2021**	**2019**	**2020**	**2021**
Home Lighting Rebate	$3,028	$2,242	$2,136	35,804	12,716	12,215	3.18	1.13	1.09
Home Energy Report	$1,444	$1,444	$1,444	34,766	34,766	34,766	15.96	15.96	15.96
Income-Eligible Home Energy Report	$462	$462	$462	9,100	9,100	9,100	4.26	4.26	4.26
Online Home Energy Audit	$336	$336	$336	-	-	-	-	-	-
Whole House Efficiency	$5,103	$5,145	$5,184	15,975	13,666	13,781	3.93	3.75	3.80
Income-Eligible Multi-Family	$1,344	$1,344	$1,344	1,921	1,585	1,585	0.37	0.34	0.34
Income-Eligible Weatherization	$1,752	$1,772	$1,792	3,037	2,465	2,521	0.12	0.06	0.06
Residential Smart Thermostat w DLC	$4,855	$6,645	$9,663	3,761	4,813	7,199	59.57	80.77	97.62
Central AC DLC Switch	$2,584	$4,091	$5,036	-	-	-	9.12	23.49	40.12
Water Heating DLC Switch	$1,386	$2,194	$2,670	-	-	-	1.75	4.53	7.72
Business Energy Efficiency Rebate - Standard	$5,741	$5,775	$5,812	32,322	34,430	34,654	5.25	5.56	5.59
Business Energy Efficiency Rebate - Custom	$3,813	$3,842	$3,871	17,929	18,074	18,219	4.62	4.66	4.70
Strategic Energy Management	$723	$723	$723	4,263	4,263	4,263	0.85	0.85	0.85
Retrocommissioning	$927	$927	$927	5,035	5,035	5,035	1.01	1.01	1.01
Block Bidding	$1,257	$1,257	$1,257	8,802	8,802	8,802	1.53	1.53	1.53
Online Business Energy Audit	$84	$84	$84	-	-	-	-	-	-
Small Business Targeted	$1,052	$1,053	$1,056	2,859	2,133	2,149	0.52	0.42	0.42
Business Smart Thermostat w DLC	$173	$220	$301	1,711	2,232	3,422	1.44	2.10	2.65
Demand Response Incentive	$259	$289	$330	-	-	-	84.14	102.49	125.46
Total Residential	$22,294	$25,673	$30,066	104,362	79,111	81,167	98.25	134.29	170.96
Total Business	$14,029	$14,171	$14,361	72,921	74,968	76,544	99.35	118.61	142.21
Total Portfolio	**$36,323**	**$39,844**	**$44,427**	**177,284**	**154,079**	**157,710**	**197.60**	**252.90**	**313.17**

Given the budgets and impacts for the program potential presented above, AEG performed the Total Resource Cost test (TRC) in order to gauge the economic merits of the portfolio. The cost-effectiveness analysis was conducted with AEG's BenCost software at the program and portfolio levels.

The cost-effectiveness results for the KCP&L RAP program potential are shown below in Table 6-4. The 3-year TRC ratio for the portfolio is 1.97, while a 20-year projected TRC ratio is 2.08. The levelized cost of energy saved is $0.036/kWh and the corresponding levelized cost of demand saved is $71/kW, both of which consider the long-term time period of 2019-2037. For cost of first-year savings, energy is $0.27/kWh and demand is $133/kW, both for the near-term period of 2019-2021

Several programs have better economics in 2019 than the following year due to the changing efficiency baseline standards for lighting in 2020, but average TRC ratios are above 1.0 for all programs in the first 3 years as well as in the full study timespan. The only exception to this is Income-Eligible Multi-Family and Income-Eligible Weatherization, but this is acceptable since income-eligible programs are not required to be cost-effective as long as the portfolio as a whole is still cost-effective.[7]

Table 6-4 RAP Program Potential Cost Effectiveness – All Service Territories

	3-Year TRC Ratio (2019-2021)	19-Year TRC Ratio (2019-2037)	Levelized $/kWh (2019-2037)	Levelized $/kW (2019-2037)	First-Year $/kWh (2019-2021)	First-Year $/kW (2019-2021)
Home Lighting Rebate	3.21	3.39	$0.012	$139	$0.12	$1,385
Home Energy Report	2.18	2.26	$0.041	$88	$0.04	$96
Income-Eligible Home Energy Report	1.90	1.97	$0.047	$100	$0.05	$109
Whole House Efficiency	1.08	1.11	$0.030	$109	$0.36	$1,270
Income-Eligible Multi-Family	0.61	0.61	$0.095	$533	$0.96	$5,328
Income-Eligible Weatherization	0.99	1.01	$0.045	$2,264	$0.69	$20,206
Residential Smart Thermostat w DLC	1.26	2.18	$0.201	$66	$1.28	$133
Central AC DLC Switch	3.78	2.94	n/a	$51	n/a	$292
Water Heating DLC Switch	1.37	1.11	n/a	$131	n/a	$804
Business Energy Eff Rebate - Standard	1.74	2.11	$0.015	$94	$0.17	$1,076
Business Energy Eff Rebate - Custom	1.31	1.46	$0.023	$88	$0.21	$828
Strategic Energy Management	1.30	1.42	$0.049	$247	$0.16	$812
Retrocommissioning	1.16	1.30	$0.056	$279	$0.18	$903
Block Bidding	1.72	1.88	$0.020	$116	$0.18	$1,011
Small Business Targeted	1.32	1.37	$0.041	$209	$0.44	$2,298
Business Smart Thermostat w DLC	5.04	5.66	$0.014	$70	$0.09	$159
Demand Response Incentive	227.68	217.25	n/a	$1	n/a	$1
Residential Total:	**1.60**	**1.90**	**$0.057**	**$103**	**$0.34**	**$313**
Business Total:	**2.68**	**2.77**	**$0.022**	**$46**	**$0.20**	**$61**
Portfolio Total:	**1.97**	**2.08**	**$0.036**	**$71**	**$0.27**	**$133**

Detailed program descriptions are available in Volume 4 of this report, including program-by-program information on: program description, objectives, target market, implementation strategy, risk management, measures, energy and demand savings, estimated program budget, and cost-effectiveness.

[7] Note also that cost-effectiveness of demand response programs has been modeled using a 10-year program lifetime based on lifetime of equipment, despite the annual or 1-year accounting used to track participation and incentive payments.

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