Time-Sensitive Valuation of Electricity Savings in the Southwest

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The information and views presented in the report are solely those of the Southwest Energy Efficiency Project, not of the individuals or utilities listed above, or the U.S. Department of Energy.

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Acronyms and Abbreviations

APS	Arizona Public Service Company
CC	Combined Cycle Generator
CT	Combustion Turbine Generator
DSM	Demand Side Management
ERP	Electric Resource Plan
IRP	Integrated Resource Plan
MTRC	Modified TRC Test
NPC	Nevada Power Company
PCT	Participant Cost Test
PNM	Public Service Company of New Mexico
PSCo	Public Service Company of Colorado
RIM	Ratepayer Impact Test
RMPU	Rocky Mountain Power – Utah
SCC	Social Cost of Carbon
SCT	Societal Cost Test
SPPC	Sierra Pacific Power Company
SRP	Salt River Project
T&D	Transmission and Distribution
TEP	Tucson Electric Power
TRC	Total Resource Cost Test
UCT	Utility Cost Test

Executive Summary

In evaluating the cost effectiveness of utility energy efficiency and other demand-side management (DSM) programs, utilities compare the avoided costs of alternative resources to the cost of adopting energy efficiency and load management measures. Utilities in the Southwest use a variety of inputs and methods to calculate avoided costs. This paper focuses on the avoided costs that six major investor-owned electric utilities and one large publicly-owned utility in the Southwest use in their analysis of the cost-effectiveness of energy efficiency programs.

The paper reviews how the utilities in the Southwest determine avoided generation capacity and generation capacity costs, avoided energy costs, transmission and distribution investment deferrals, and any value for avoided pollutant emissions.

The paper then examines the actual value of energy savings for specific programs and end-uses based on data provided in utility DSM program annual reports and program evaluation studies. We present the total net present value of all avoided costs per unit of lifetime energy savings by program type. In considering the value of energy savings across different types of programs and measures, the paper highlights the time-varying value of energy savings.

This analysis shows that residential cooling programs tend to yield a higher value per unit of energy savings than do other types of programs, for each utility. Likewise, residential lighting programs tend to yield a lower value per unit of energy saving than do other types of programs. These results are logical given that residential cooling programs result in greater peak demand reduction per unit of energy savings, while residential lighting programs result in relatively little peak demand reduction, and energy savings on peak are more valuable than energy savings off peak. All of the utilities in the Southwest are summer peaking utilities.

The paper concludes with a set of recommendations for the valuation of energy savings in utility resource planning and DSM program cost-effectiveness analysis. The recommendations include: 1) value all of the benefits (i.e., avoided costs) produced by energy efficiency programs and measures, and do so accounting for time-varying avoided costs; 2) at most use the after-tax weighted-average cost of capital to determine the net present value of avoided costs, and consider using a lower discount rate than the after-tax WACC given the different nature of utility supply-side investments and energy efficiency programs; 3) establish avoided generation capacity costs based on time-varying marginal generation resources identified in the preferred plan of an IRP, rather than using a generic resource, such as a generic combustion turbine; 4) include avoided transmission system costs in the valuation of energy savings, and possibly avoided distribution system costs as well; and 5) monetize and value avoided CO2 emissions and possibly other pollutant emissions.

Introduction

Hourly avoided costs are one of the primary inputs to calculating the time-dependent value of energy efficiency. Utilities in the Southwest use a variety of inputs and methods to calculate avoided costs. This paper focuses on what components of avoided costs investor-owned utilities in the Southwest include in their energy efficiency benefit-cost analyses. In addition to the components each utility includes in its avoided cost, this paper also assesses whether these utilities use time-dependent avoided cost values.

This paper focuses on the avoided cost approach used by the seven largest electric utilities in the region where SWEEP works. These include both investor-owned utilities and one public-power utility:

- Arizona Public Service Company (APS)
- Salt River Project (SRP)
- Tucson Electric Power (TEP)
- Public Service Company of Colorado (PSCo)
- NV Energy, dba Nevada Power Company and Sierra Pacific Power Company (NPC and SPPC)
- Public Service Company of New Mexico (PNM)
- Rocky Mountain Power – Utah (RMPU)

With the exception of RMPU, all of the utilities conduct planning for service territories in a single state. RMPU is part of PacifiCorp, a multi-state utility operating in five states.[1] Because of its size and degree of integration, PacifiCorp conducts its planning at the multi-state system level.

The discussion below summarizes how the selected Southwest utilities value the energy savings from their DSM programs by considering four dimensions:

- The utility cost-effectiveness tests and the utility discount rate used by each utility;
- A description of the steps each utility uses to develop its avoided costs and to account for externalities such as avoided pollutant emissions;
- The methodology utilities employ to value energy savings, including their time-dependent value, in the face of planning constraints and regulatory requirements;
- A comparison of the value of energy savings across different types of energy efficiency programs and end-uses.

The sources of the analysis include recent integrated resource plans, energy efficiency program plans, energy efficiency annual reports, and DSM program evaluation reports filed by each utility. These documents are supplemented by interviews with key utility personnel.

Lawrence Berkeley National Laboratory (Berkeley Lab) recently published a study on the time-varying value of energy efficiency, evaluating five energy efficiency measures in four regions of the country.[2] Among the findings in that study is that avoided transmission and distribution costs create some of the

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[1] PacifiCorp, 2017: 136

[2] Mims, Eckman and Goldman, 2017.

largest capacity benefits of the time-varying value of efficiency measures in the regions studied. This paper focuses on what components of avoided costs utilities in the Southwest include in their energy efficiency program analyses, as well as the actual value of energy savings for different types of programs in the region.

Utility Cost-Effectiveness Tests and the Discount Rate

Utility Cost-Effectiveness Tests

The National Action Plan for Energy Efficiency (2008) identifies five common cost-effectiveness tests that are used for evaluation of energy efficiency and other DSM programs: The Participant Cost Test (PCT), the Ratepayer Impact Test (RIM), the Societal Cost Test (SCT), the Total Resource Cost Test (TRC), and the Utility Cost Test (UCT). An additional test, used by PSCo and RMPU, the Modified TRC Test (MTRC), is the standard TRC plus an additional value ("adder") to account for non-energy benefits. These tests consider different components of measure, program, or portfolio, benefits and costs embodying different perspectives on economic effectiveness.

Cost-effectiveness tests are applied and reported at multiple levels: for the entire DSM portfolio, at the individual DSM program level, and, in some cases, at the level of individual efficiency measures. For example, for the Nevada utilities, individual programs and the portfolio must pass the TRC test. In contrast, in Colorado, groups of programs implemented at the sectoral level – Residential or Business – must pass the modified TRC test, but individual programs (termed "products" by PSCo) do not have to pass.

The utilities regularly calculate and publish the results of multiple benefit-cost tests, even when a state regulatory commission defines one test as its "primary" test. Table 1 describes the cost effectiveness test(s) used by each of the utilities discussed in this paper.

Table 1 - Cost-Effectiveness Tests used by Southwest Utilities

State	Utility	Tests Evaluated	Level	Primary Test
Arizona	Arizona Public Service	All five main tests.	Measure, Program and Portfolio	Societal Cost Test (SCT)
Arizona	Salt River Project	Total Resource Cost Test (TRC) and Ratepayer Impact Test (RIM)	Program and Portfolio	Total Resource Cost Test (TRC)
Arizona	Tucson Electric Power	Societal Cost Test (SCT)	Measure, Program and Portfolio	Societal Cost Test (SCT)
Colorado	Public Service Company of Colorado	Modified Total Resource Cost Test (MTRC)	Program, Sector and Portfolio	Modified Total Resource Cost Test (MTRC)
Nevada	Nevada Power Company and Sierra Pacific Power Company	Total Resource Cost Test (TRC)	Program and Portfolio	Total Resource Cost Test (TRC)
New Mexico	Public Service Company of New Mexico	Utility Cost Test (UCT)	Program	Utility Cost Test (UCT)
Utah	Rocky Mountain Power, Utah	All five main tests, plus the Modified Total Resource Cost Test (MTRC)	Program and Portfolio	Utility Cost Test (UCT)

Source: ACEEE, 2017

Discount Rate Used in Benefit-Cost Analyses

The utilities consistently use their approved weighted-average cost of capital (WACC) as the nominal discount rate in calculating the net present value of energy savings in their various benefit-cost analyses. Arizona utilities regulated by the Arizona Corporation Commission use their approved WACC as the discount rate, rather than a societal discount rate, for valuing energy savings under the Societal Cost Test.[3] As shown in Table 2, the majority of utilities examined in this paper employ an after-tax value of their WACC as the discount rate used in valuing energy efficiency.

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[3] The ACC has opened a docket examining a number of issues related to DSM program benefit-cost analysis including what is the appropriate discount rate for use in the SCT. See ACC, 2017.

Table 2 - Nominal Discount Rates Used in Valuing Energy Efficiency

State	Utility	Nominal Discount Rate (%)	Pre-Tax or After-Tax
Arizona	APS	7.50	After-Tax
	SRP	7.12	After-Tax
	TEP	7.04	After-Tax
Colorado	PSCo	6.78	After-Tax
Nevada	NPC	8.09	After-Tax
	SPPC	7.62	After-Tax
New Mexico	PNM	10.77	Pre-Tax
Utah	RMPU	6.66	After-Tax

Sources

APS	ACC, 2017.
TEP	ACC, 2017.
SRP	Dreiling and Morey, 2017.
PSCO	PSCo, 2016a: Volume 2: 181.
NPC	NPC, 2015: Volume 7: 36.
SPPC	SPPC, 2015: 21.
PNM	NMPRC, 2016: 55-69.
RMPU	PacifiCorp, 2015: Volume 1: 141.

Calculating Utility Avoided Costs and the Derivation of Load Shapes

The components of utility avoided costs combine values from: 1) avoided generation costs (including reserves), 2) avoided costs of transmission and distribution investments, 3) avoided O&M costs, 4) avoided fuel costs, and 5) in some cases, valuation of avoided pollutant emissions. The methods Southwest utilities use to assess each component are described in this section.

Avoided Capacity and Energy Costs

Utilities in the Southwest value energy savings from DSM programs by analyzing the avoided costs as electricity consumption is reduced. The sources of avoided capacity and energy costs vary by hour, and are generally one of three types:

1. The hourly avoided cost for a fixed generation resource, such as a gas combustion turbine (CT) or a combined cycle (CC) plant;
2. The hourly cost of the marginal generation resource, typically taken as the output from the utility’s production cost model or distribution cost model; or
3. A combination of these methods, i.e., treating the output of a production cost model or a load forecasting model as if it were a fixed resource.

In every case, avoided costs are calculated by the utility on an hourly basis, but are reported on an annual or monthly basis. For a given utility, the avoided cost for generation capacity is developed as part of a specific resource plan, and avoided energy costs are developed through a production cost model using a resource plan as an input.

The Arizona investor-owned utilities, APS and TEP, derive their avoided capacity costs from their preferred resource plan. In these plans, the marginal deferrable resource identified is a combustion turbine or similar resource, although other resource types could be selected. The avoided capacity cost value is established for the resource based on the peak-hour cost plus the reserve-margin cost for the forecast peak summer day. These values are used as an input to the utility's production cost model, which determines the hourly value of an avoided MWh. [4]

PNM bases its avoided capacity costs on the results of the production cost model used in their IRP analyses. The cost of the selected marginal resource forms the basis for the avoided cost of capacity. The economic benefit of DSM is the product of the reductions in capacity and energy and the avoided cost of generation. [5]

Both PSCo and the Nevada utilities employ a hybrid model. PSCo has created a generic avoided cost resource it calls the "Resource Acquisition Period (RAP) CT".[6] The avoided cost values are established using the Strategist Model, but with an assumption that the avoided generating resource (i.e., a generation plant not constructed) would be a company-owned combustion turbine.[7]

The Nevada utilities derive avoided generation costs from their load forecast and dispatch model. These costs are based on the generation costs during a 16-hour peak period in the summer months. Once developed, the avoided cost profile is applied across the entire year as a series of monthly costs per MWh saved.[8] SRP takes a similar approach; avoided generation costs are derived using a 6-hour peak period over the summer months.

PacifiCorp calculates a levelized cost of electricity savings for similar groups, or "bundles," of DSM measures. These bundles and their associated costs are entered into their system optimization model and compete directly with supply-side resources on an hourly basis. The levelized costs of resources that are selected provide the basis of the avoided costs.[9]

Avoided Transmission and Distribution Costs

The assumptions regarding avoided transmission investments and their valuation vary widely among the seven utilities. Some utilities include values for avoided transmission and distribution costs; some include terms for avoided transmission in their planning assumptions but set the underlying value of these terms at $0/kW-year. For example, both the Nevada utilities and PacifiCorp include a "transmission and distribution deferral credit" in their calculation of DSM costs.

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[4] Lindemann, 2017 and Wontor, 2017.
[5] O'Connell, 2017.
[6] PSCo, 2017a: 107-109
[7] CPUC, 2014: 31-33
[8] Vukanovic, 2017.
[9] PacifiCorp, 2017: 113-139 and Morris, et. al. 2017.

APS, TEP and SRP include a value for avoided transmission costs in their avoided costs, but do not disclose this value.

In New Mexico, PNM does not assume any value for avoided transmission and distribution costs in its valuation of the benefits from utility energy efficiency and DSM programs.[10]

In Colorado, PSCo includes avoided T&D capacity investments in its calculation of avoided costs. This value is based on a system planning method to determine deferred T&D projects resulting from forecast DSM achievements. This value was previously set at zero, but a new study was performed that estimated avoided T&D costs of approximately $11-16/kW-yr. during 2017-37.[11] This new value is being used starting in 2017.

The Nevada utilities include a significant avoided transmission cost based on the approved marginal cost study filed in each utility's General Rate Case. The value is currently $52.15/kW-year. The Nevada utilities do not include a value for avoided distribution system investments in their valuation of energy savings.[12]

RMPU applies a transmission and distribution deferral credit in its calculation of the avoided costs from energy efficiency and other DSM programs. The deferral credit is currently $13.56/kW-year. This value is derived from PacifiCorp's system-wide resource planning.[13]

Although RMPU uses its transmission and distribution deferral credit to account for avoided distribution system investments, assessing an accurate value for these deferrals is complicated by several factors.[14] Not only do local distribution nodes that can benefit from deferrals have to be identified (i.e., at the substation level), strategies for geo-targeting DSM programs to address potential overloads also have to be developed.[15] Because of these challenges, none of the utilities explicitly value distribution system investment deferrals independently from transmission deferrals.

Avoided O&M and Fuel Costs

Avoided O&M and fuel costs are typically embedded in the cost of the avoided generation resource that is used to calculate a utility's avoided cost. The range of costs that are included in a generation resource includes variable fuel costs, fixed and variable O&M costs, and capital costs for emissions reduction equipment.

APS, TEP, and PNM use the hourly marginal generator cost from their production cost model; in doing so, the avoided fuel and O&M costs are embedded in, and vary by, the selected resource. This method applies to both existing and planned resources. In its 2017 IRP, TEP commissioned a "Flexible

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[10] Lindemann, 2017.
[11] PSCO, 2016b: 342.
[12] Vukanovic, 2017.
[13] PacifiCorp, 2017: 57-74.
[14] Morris, et. al., 2017.
[15] Neme and Grevatt, 2015.

Generation Technology Assessment" report, which provided engineering estimates of O&M and fuel costs of eight classes of supply-side and renewable resources.[16]

PSCo runs its resource planning model both with and without DSM programs included in order to determine avoided O&M and energy costs. In this manner, the model provides estimated annual avoided energy and O&M costs.[17] While the values are reported on an annual basis, they are derived from hourly analysis by the planning model.

The Nevada utilities use existing and projected O&M costs and fuel costs as inputs to its production model, PROMOD. The outputs of this model form the basis of the avoided resource used in the Nevada utilities' cost-effectiveness modeling.[18]

RPMU and PacifiCorp calculate a "Stochastic Mean NPVRR" value from its simulation studies. These studies produce a NVPRR risk value that accounts for fixed and variable O&M costs and for variable fuel costs over a range of planning scenarios. The result of this analysis is used to create a "Stochastic risk reduction credit" that is applied to the levelized cost of DSM resources.[19] The process that PacifiCorp uses to account for the levelized costs of new DSM measures, and to develop avoided costs for classes of resources, is discussed in the next section.

Derivation of Load Shapes

Due to the variations in the value of avoided cost both seasonally and hourly, the load shapes of energy savings are important for the valuation of different energy efficiency measures and programs. The derivation of load shapes for energy efficiency measures varies considerably among utilities. Each utility uses different sources and employs adjustments based on the impact of past experience with classes of measures and their regulatory requirements. While some utilities use publically available load shapes data (e.g., from the California DEER database) as the basis for their avoided cost calculations, these public load shape data are modified to reflect local weather conditions and specific evaluation results. The modified load shapes are generally treated as proprietary information, and are not publically available.

APS develops hourly avoided costs using a production cost model, and multiplies them by the hourly load shapes of DSM measures. Hourly load shapes are developed internally through territory-specific field work and annual M&V studies. Once developed, these load shapes, along with the portfolio-level savings targets specified by the Arizona EERS, are modelled using an internal spreadsheet model as APS develops its annual DSM plan.[20]

TEP uses measure-specific load shapes to calculate annual savings values, which are then aggregated into programs. Annual energy savings are determined by third-party evaluations, and then are

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[16] TEP, 2017: 307-346.
[17] PSCo, 2016b:342.
[18] NPC, 2016: 227-228.
[19] PacifiCorp, 2017: 166-168.
[20] Wontor, 2017.

apportioned to hourly load shapes to determine hourly impact of system load. These load shapes were originally developed in 2011 using values from the California Database for Energy Efficient Resources (DEER), the California Commercial End-Use Study (CEUS) and the Building America - National Residential Efficiency Measures Database. The load shapes were later modified to reflect the representative climate of the Tucson area.[21] TEP uses results from periodic program evaluations to update the load shapes used for specific measures.

SRP utilizes Cadmus' PortfolioPro model to evaluate the cost-effectiveness of measures and programs within the portfolio. The model is also used to determine program-related load reduction. PortfolioPro contains a set of sector, building, and end-use load shapes, which are used to derive the capacity reductions. The load shapes utilized were developed by SRP's third-party evaluator and calibrated to the Arizona desert climate.[22]

PNM relies on hourly impact shapes for classes of measures derived from the customized load shapes provided by the Strategist model, PNM's IRP planning model. The accuracy of these load shapes is verified through program impact evaluations that are carried out at least once every three years.[23]

The load shapes PSCo employs are adapted from measure-specific load shapes developed in Minnesota in the 1990s. These shapes were modified to match the Colorado climate and used to establish avoided cost values for four day-types across all 12 months in a year. These day-types correspond to a weekend day, the monthly peak-day, the non-peak weekday, and low-weekday load-shape.[24]

The Nevada utilities also use the PortfolioPro model to screen measures and determine the cost effectiveness of the measures and programs included in their DSM portfolios. The PortfolioPro model contains a set of measure load shapes calibrated to the utility service territories (Las Vegas for the Nevada Power Company and Reno for the Sierra Pacific Power Company).[25]

RMPU, through its parent company, PacifiCorp, has the most complex approach to modeling load shapes and avoided costs. As mentioned above, PacifiCorp operates in multiples states and models its avoided costs at the system level. To facilitate the construction of a manageable number of hourly supply curves, energy efficiency measures are grouped into "bundles" according to the measure's cost per MWh saved. These bundles, which range from measures costing less than $10.00/MWh saved to over $1,000/MWh saved, are converted to hourly load shapes that are differentiated by state, sector, market segment, and end use. These energy efficiency measure bundles, which represent a levelized cost of saved energy, net of the transmission and distribution credits and the Stochastic risk-reduction credit discussed above, are then inputted into the system planning model and compete against supply-side resources to develop the least-cost portfolio.

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[21] TEP, 2017b: 112-114 and Lindemann, 2017.
[22] Dreiling and Morey, 2017.
[23] O'Connell, 2017.
[24] Petersen and Walsh, 2017.
[25] Vukanovic, 2017.

This process, which incorporates the hourly variations of similar bundles of energy efficiency measures, is used to develop PacifiCorp's avoided costs.[26] The methodology for developing these avoided costs is documented in PacifCorp's "Class 2 DSM Decrement Study"[27], which is published after the release of each IRP. This study creates nominal avoided costs, in $/MWh, for eight classes of energy efficiency measures (e.g., Residential Cooling, Residential Lighting, etc.) calibrated to meet the characteristics of its two regions, the West region (Oregon, Washington and California) and the East region (Idaho, Utah and Wyoming). When RMPU evaluates measure-based savings, or considers adding new measures to a program, it uses these nominal avoided costs in its planning. In some cases, these values are used in program evaluations with additional factors (e.g., a proxy value for non-energy benefits in the calculation of a modified TRC test).[28]

Accounting for Externalities: Valuing Avoided Pollutant Emissions

With respect to reduced emissions of the criteria pollutants (SOx, NOx, and PM10) and CO2, most of the utilities report emissions reductions associated with DSM savings, but few monetize emission reductions or include them in their avoided costs. The exception to this is PNM, which includes a value for avoided CO2 emissions on a per kWh basis beginning in 2022. The value starts at $0.0111/kWh in 2022 and increases to $0.0345/kWh by 2033.[29] As noted above, the Colorado PUC has approved non-energy benefits adders to the economic benefits of energy efficiency and other DSM programs. The non-energy benefits adders are intended to include some valuation of avoided pollutant emissions, but are not explicitly tied to specific avoided emissions. In addition, RMPU includes a proxy value for avoided pollutant emissions and other non-energy benefits in one of the benefit-cost tests that it runs.

Utility-specific Data and Results

In this section, we first present summary tables of key assumptions for utility avoided capacity, avoided energy, and avoided transmission costs for the seven utilities. These values reflect publically available information taken from the respective utilities IRPs and energy efficiency/DSM program annual reports. We then provide program-specific values for the total benefits per unit of lifetime energy savings for different program types and utilities. These values were derived from utility reports documenting annual program performance. The total benefits are primarily, and in some cases, entirely, the utility's avoided costs. For a few of the utilities, the benefits include valuation of avoided CO2 emissions or non-energy benefits more generally. The benefits are those calculated by the utility using the primary cost effectiveness test in each jurisdiction.

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[26] PacifiCorp, 2017: 113-139.

[27] PacifiCorp, 2015c.

[28] See Cadmus, 2017: 99.

[29] PNM, 2016: 20.

Table 3 - Values of Components of Avoided Costs

	Arizona		
	APS	**SRP**	**TEP**
Component	**2017**	**2016**	**2017**
Avoided Cost of Generation Capacity	Based on deferrable generation in IRP.	Avoided generation cost is the marginal cost calculated from production cost studies. Natural gas CT is used as the basis to determine the avoided cost.	Based on results of the hourly generation dispatch model.
Avoided Marginal Energy Costs	Values not publically disclosed.	Values not publically disclosed.	Values not publically disclosed.
Avoided Transmission Costs	Avoided cost for transmission embedded in overall avoided generation cost.	Avoided cost for transmission investments embedded in overall avoided generation cost.	Avoided cost for transmission investments embedded in overall avoided generation cost.
Avoided Distribution Costs	No avoided cost of distribution.	Avoided cost for distribution embedded in overall avoided generation cost.	No avoided cost of distribution.
Avoided Pollutant Costs	Avoided pollutants reported, but not monetized.	Not Provided.	Avoided pollutants reported, but not monetized.
	Colorado	**Nevada**	
	PSCo	**NPC**	**SPPC**
Component	**2016**	**2014 and 2016**	**2014 and 2016**
Avoided Cost of Generation Capacity	Resource Acquisition Period (RAP) CT: a gas-fired CT. Costs start at $8.31/kW-month in 2016 and escalate to $12.93/kW-month in 2035.	The avoided cost of generation is the marginal cost calculated from production cost studies. A natural gas-fired combined cycle plant used to develop the avoided capacity cost.	The avoided cost of generation is the marginal cost calculated from production cost studies. The type of resource used to develop the avoided cost of capacity is a natural gas-fired combined cycle plant.
Avoided Marginal Energy Costs	Simple Average Hourly Energy costs start at $32.98/MWh in 2016 and escalate to $66.19/MWh in 2035.	Monthly Capped Long-Term Energy Costs range between $17.88/MWh in April 2017 and $160.20/MWh in July 2046.	Monthly Capped Long-Term Energy Costs range between $18.15/MWh in April 2017 and $150.90/MWh in July 2044.
Avoided Transmission Costs	$0.00/kW-year (1)	$52.15/kW-year	$51.56/kW-year
Avoided Distribution Costs	$0.00/kW-year (1)	$0.00/kW-year	$0.00/kW-year
Avoided Pollutant Costs	Value of avoided pollutants not estimated but included as part of the 10% adder for non-energy benefits (25% adder for low-income programs).	The cost of emissions is embedded in Production Cost Model.	The cost of emissions is embedded in Production Cost Model.

	New Mexico	Utah
	PNM	RMPU
Component	2015 and 2016	2015 and 2017
Avoided Cost of Generation Capacity	Defined as the marginal generation resource at the summer peak hour. Value comes from the dispatch model. $80.00/kW-year for 2018 to 2034.	Sources are derived from the marginal resource at the system level, not at the state level.
Avoided Marginal Energy Costs	Cost escalates from $27.10/MWh in 2018 to $53.90/MWh in 2034.	Avoided costs vary by measure category. For 2017, nominal avoided costs vary between $38.44/MWh for Plug Loads and $162.74/MWh for Residential Cooling.
Avoided Transmission Costs	$0.00/kW-year.	T&D deferral credit of $13.56/kW-year.
Avoided Distribution Costs	$0.00/kW-year.	T&D deferral credit of $13.56/kW-year.
Avoided Pollutant Costs	Avoided CO2 emissions value starts at $11.10/MWh in 2022 and escalates to $34.50/MWh in 2034.	Not Estimated.

(1) As noted above, PSCo started to value avoided T&D costs in its 2017/2018 DSM program plan.

Sources

APS	Energy savings data for Estimated Avoided Cost Calculation: APS, 2017a. Technical details about system costs: APS, 2017b.
TEP	Energy savings data for Estimated Avoided Cost Calculation: TEP, 2017a. Technical details about system costs: TEP, 2017b.
SRP	SRP, 2017.
PSCo	PSCo, 2017.
NPC	Sources of Long Term Avoided Costs: NPC, 2016. Energy efficiency savings values: NPC, 2015: Volume 7.
SPPC	Data on Long-Term Avoided Costs SPPC, 2016b: Volume 10, 128-132 Energy efficiency savings values: SPPC, 2015.
PNM	Avoided Cost Information: PNM, 2017a, p. 20.
RMPU	Transmission Deferral Value: PacifiCorp, 2017: Volume 1 p. 153. Avoided Energy Cost: PacifiCorp, 2015c.

Table 4 provides the total value of lifetime energy savings in $/kWh saved for a set of common energy efficiency programs and end-uses, for each utility. These programs include residential lighting, residential cooling, residential home retrofits, residential new construction, commercial lighting, commercial cooling, commercial building retrofits and commercial new construction. Where available, separate estimates are presented for small business lighting and small business cooling programs. We chose to report the value of energy savings over the lifetime of the various measures or programs, rather than considering only first year energy savings, since the benefits (i.e., avoided costs) accrue over the lifetime of the programs.

The values in Table 4 were derived from the most recent annual DSM program reports for each utility (either the 2015 or 2016 annual reports) and/or individual program evaluation reports. The value of lifetime energy savings is generated by dividing the net present value of program benefits (i.e., avoided costs and in some cases non-utility benefits) by the lifetime energy savings, yielding a $/kWh saved metric. These values reflect the net present value of avoided costs over the estimated lifetime of each program or set of energy efficiency measures, depending upon the conventions used by each utility.

Calculating the values in Table 4 is complicated by the way each utility designs its programs and reports energy savings. In some cases, it was not possible to break out specific end uses. In other cases, a utility may combine different end-uses into a single program; for example, multiple commercial measures may be included under the rubric of a "Commercial Comprehensive" program. Frequently, a utility will

Table 4 - Estimates of Program-Specific Avoided costs per unit of Lifetime Energy Savings ($/kWh)

	Arizona			Colorado	Nevada		New Mexico	Utah
	APS	**SRP**	**TEP**	**PSCo**	**NPC**	**SPPC**	**PNM**	**RMPU**
Residential Programs/Applications								
Lighting	$0.0304	$0.0170	$0.0360	$0.0971	$0.0196	$0.0195	$0.0295	$0.0541
Cooling	$0.0488	$0.0590	$0.0765	$0.1579	$0.0565		$0.0158	$0.1631
Building Retrofit	$0.0496			$0.1946			$0.0419	$0.0536
New Construction	$0.0425	$0.0270	$0.1387	$0.1411				
Commercial Programs/Applications								
Lighting	$0.0284	$0.0130	$0.0573	$0.0432	$0.0163	$0.0200		$0.0512
Cooling			$0.0459	$0.0652	$0.0142	$0.0174		$0.0983
Building Retrofit							$0.0458	
New Construction	$0.0403	$0.0370	$0.0494	$0.0579			$0.0393	
Small Business Lighting	$0.0284	$0.0940	$0.0410	$0.0388				
Small Business Cooling			$0.0328					

Sources

APS	Energy savings data for Estimated Benefit Calculation: APS, 2017a. Technical details about system costs: APS, 2017b.
TEP	Energy savings data for Estimated Benefit Calculation: TEP, 2017a. Technical details about system costs: TEP, 2017b.
SRP	SRP, 2017.
PSCo	PSCo, 2017a and PSCo, 2017b.
NPC	NPC, 2016b: Tables DSM-4 and DSM-5, pp. 9-10.
SPPC	SPPC, 2015.
PNM	PNM, 2017b: Attachment SMB-2, Table 6-1, p 39.
RMPU	PacifiCorp, 2015c. 2017 Nominal Value.

present the first year energy savings for particular measures in a program but the net present value of lifetime benefits for the entire program. In that case, lifetime energy savings are calculated by multiplying the first-year savings by the reported effective useful life of a measure or program. Likewise, the benefits (i.e., avoided costs) are pro-rated by the proportion of the measure's first-year savings to the program level first-year savings. Beyond variation in reporting practices, the differences in valuation of benefits are due to the methodologies and assumptions each utility employs. Thus, these estimates are general indicators of the value of energy savings for specific programs and end-uses.

In considering these values, caution is necessary in comparing different utilities to one another. As explained above, different utilities estimate avoided costs differently and are more (or less) comprehensive in the types of avoided costs that are included. In addition, program performance varies in part due to differences in climatic conditions. Consider the value of energy savings for residential cooling programs. Residential cooling programs in the very hot Arizona climate generate energy savings most if not all of the year, while cooling programs in Colorado or Utah generate energy savings in the summer only. Thus, avoided costs per kWh saved, averaged over the year, may be higher in a place like Colorado compared to Arizona because more of the energy savings are during peak demand periods in Colorado.

Despite these limitations, the values in Table 4 suggest that residential cooling programs yield a greater value of energy savings than other types of programs, with a few exceptions. For example, a kWh saved by SRP's residential cooling program has 3.5 times the value of a kWh saved by the utility's residential lighting program. For RMPU, the same ratio is 3.0; for PSCo, it is 1.6; and for Nevada Power it is 2.9. These results are logical, given that cooling programs yield more "on peak" savings and thus have higher avoided capacity values than other types of programs.

All of the utility systems considered in this paper experience their peak demands during the mid-to-late afternoon hours during the summer months. Residential lighting savings mostly occur later in the evening, and thus do not provide as much peak demand reduction per kilowatt-hour saved. This does not mean that residential lighting efficiency programs are not cost effective or desirable; it simply points out that the energy savings from lighting efficiency measures tend to have less value than savings from other types of programs.

Commercial programs do not demonstrate the same relationship that residential programs do because of the differing load shapes for the same end use (e.g., lighting or cooling) between residential and commercial buildings. In commercial buildings, lighting and cooling are used for many more hours of the day than are typical in residential buildings. For some utilities, the value of a kWh saved is higher for the lighting program compared to the cooling program. This is because in commercial buildings, both lighting and cooling efficiency measures provide energy savings during peak demand periods.

Recommendations

The information in this paper highlights a number of practices that will improve the valuation of energy savings by utilities in the Southwest and elsewhere.[30]

Value All Avoided Costs and Take into Account the Time-Varying Value of Avoided Costs

It is important and appropriate to value all of the benefits (i.e., avoided costs) produced by energy efficiency programs and measures. For example, utilities should value avoided T&D capital costs as well as avoided generation costs, and value avoided CO2 and other pollutant emissions. Also, avoided cost valuation should be done considering the time-value of energy savings and demand reduction. A more comprehensive analysis of avoided costs could lead to more programs passing cost-effectiveness screening, as well as demonstrating for policy makers and other stakeholders the full benefits (value) of these resources.

Use an Appropriate Discount Rate

The selection of the discount rate is important to calculating the appropriate net present value of energy savings over the lifetime of energy efficiency measures. In calculating benefits, use of a lower discount is generally preferred, as it does not reduce benefits as rapidly over the lifetime of a measure. For all but one of the utilities discussed here, the after-tax weighted average cost of capital (WACC) from the utility’s last rate case is used as the primary discount rate. PNM is the outlier in that it uses a before-tax WACC. The use of the after-tax WACC is more appropriate as the utility cost of capital, because it reflects that actual net cost of capital for a utility. A recently published national manual for energy efficiency program cost-effectiveness evaluation acknowledges that the after-tax WACC is the proper utility cost of capital.[31]

In performing the TRC or UCT tests, an argument can be made for using a discount rate that is less than the utility’s after-tax WACC. This is because investments in energy efficiency programs and measures have a different risk profile than traditional utility capital investments. There is often little or no risk of a utility failing to recover the costs for its approved energy efficiency programs, as costs are often recovered through automatic utility bill surcharges rather than use of utility debt or equity. Likewise, energy efficiency programs consist of many discrete energy efficiency measures, and overall portfolio performance is well-established and relatively low risk. Therefore, utilities and their regulators should seriously consider using a lower discount rate than the WACC in valuing avoided costs from a TRC or UCT perspective.[32]

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[30] These best practices represent the observations of SWEEP, and do not necessarily reflect the opinions of the utilities referenced in this report.

[31] National Efficiency Screening Project (NESP), 2017, p. 75.

[32] NESP, pp. 72-84.

In addition, it is appropriate and widely accepted that a social discount rate should be used for determining cost effectiveness using the Societal Cost test.[33] This discount rate, such as the 10-year U.S. Treasury bond rate, is generally very low, in part to reflect low risk and inter-generational equity.

Base Avoided Generation Capacity Costs on Results of an IRP

It is preferable to establish avoided generation-capacity costs based on time-varying marginal generation resources identified in the preferred plan of an IRP, rather than using a generic resource, such as a generic combustion turbine (CT). The hourly avoided costs from the projected marginal resource are likely to be more consistent with future resource development and operation, as compared to basing the avoided generation capacity cost on a generic resource. In addition, values from the marginal generator are more likely to be consistent with fuel and O&M costs assumed in the IRP, as well as reflect the changing generation mix for a utility.

A secondary recommendation is to make the results of both the IRP preferred plan and any production cost models available for examination by interested parties. Most of the utilities discussed in this paper did not disclose the values of avoided generation capacity. When values are published, they are often aggregated to a monthly or annual value. Utilities and stakeholders should discuss opportunities for sharing and reviewing information on the valuation of avoided generation, potentially with the completion of confidentiality agreements.

Include Valuation of Avoided Transmission and Distribution Investments

Transmission deferral values are included in the valuation of energy savings by the Nevada utilities, RMPU, and by PSCo starting in 2017. Berkeley Lab recently published a study on the time-varying value of energy efficiency, evaluating five energy efficiency measures in four regions of the country.[34] Among the findings in that study is that avoided transmission and distribution costs create some of the largest capacity benefits of the time-varying value of efficiency measures in the regions studied.

Utility energy efficiency programs can provide energy savings (as a fraction of total retail sales) of 1% to 3% per year.[35] Thus, energy efficiency programs can have a significant impact on load growth, and combined with other factors (such as the impacts of federal energy efficiency standards and adoption of distributed energy resources), can eliminate load growth entirely. This means that energy efficiency programs will have an impact on the need for transmission investments over the long run. Thus, utilities should include a value for avoided transmission investments in their valuation of the benefits of energy efficiency programs.

Valuing deferred distribution system investments is done in some jurisdictions and is gaining credence.[36] We recommend that utilities consider including valuation of avoided distribution system costs in the economic analyses of their DSM programs. In addition, we recommend that utilities investigate

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[33] NESP, p. 83.

[34] Mims, Eckman and Goldman, 2017.

[35] Relf, Baatz and Nowak, 2017, p. 17.

[36] Neme and Grevatt, 2015.

opportunities for using energy efficiency in a more targeted manner, in order to defer distribution system upgrades in particular parts of the distribution network that are fully loaded or overloaded. If this is done, it would be logical to value avoided or deferred distribution system investments in the benefit-cost analysis of all geo-targeted energy efficiency programs at a minimum.

Monetize Emissions Reductions

Many utilities report emission reductions, including a reduction in CO2 emissions, from their energy efficiency and other DSM programs. However, in the Southwest, only PNM monetizes avoided CO2 emissions in the valuation of the benefits of energy efficiency programs. Emissions reductions have direct impacts on air quality and have indirect impacts on health and quality of life. We recommend that these benefits be monetized and included in the assessment of DSM program cost-effectiveness. The approach used by PSCo, which adds a fixed percentage to the utility system benefits in order to value non-energy benefits broadly (known as the non-energy benefits adder approach), is suboptimal in our view.[37] It does not provide an incentive for selecting programs or measures that could maximize emission-reduction benefits. Therefore, we recommend that utilities and policy makers directly value emissions reductions in energy efficiency and DSM programs benefit-cost analyses.

Conclusion

This paper examines the ways that seven utilities in the Southwest value the energy savings from their energy efficiency and other DSM programs. It reviews the approaches used by individual utilities including the approach to valuing avoided generation capacity and the steps taken to value transmission and distribution deferrals, avoided O&M and energy costs, and emissions reductions. It finds that there is considerable variation in the way that the utilities conduct this valuation, although all utilities employ methodologies that take into account time-varying values for at least some of the avoided costs.

The paper also presents the value of energy savings, in terms of the net present value of avoided costs per unit of lifetime energy savings, for various types of energy efficiency programs for each utility. This analysis shows that residential cooling programs tend to yield a higher value per unit of energy savings than do other types of programs, for each utility. Likewise, residential lighting programs tend to yield a lower value per unit of energy saving than do other types of programs. These results are logical given that residential cooling programs result in more peak-demand reduction per unit of energy savings than do residential lighting programs. All of the utilities in the Southwest are summer peaking utilities.

In addition, this review provides several recommendations for the valuation of energy savings including: 1) value all of the benefits (i.e., avoided costs) produced by energy efficiency programs and measures, and do so accounting for time-varying avoided costs; 2) use an appropriate discount rate—at most, the after-tax utility weighted cost of capital, and possibly a significantly lower discount rate; 3) base

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[37] However, a decision by the Colorado PUC has directed PSCO to include the Social Cost of Carbon (SCC) as a sensitivity case in Phase II of its 2016 ERP. The SCC begins at $43.00 per ton in 2022 and increases to $69.00 per ton in 2050; see CPUC, 2017: 25-31. It is currently unclear whether this decision, which is applied to PSCO's base modelling assumptions, will be applied to its cost-effectiveness modeling for its DSM resources.

avoided-generation capacity costs on time-varying marginal generation resources identified in the preferred plan of an IRP, rather than using a generic resource; 4) include avoided transmission costs and potentially deferred or avoided distribution system investments; and 5) value avoided CO2 and possibly other pollutant emissions.

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