

Exhibit\_\_\_\_(DN-2)

# **An Economic Analysis Of Achievable New Demand-Side Management Opportunities In Utah**

Prepared ~~f~~For ~~t~~The Systems Benefits Charge Stakeholder Advisory Group  
~~t~~To ~~t~~The  
Utah Public Service Commission

By

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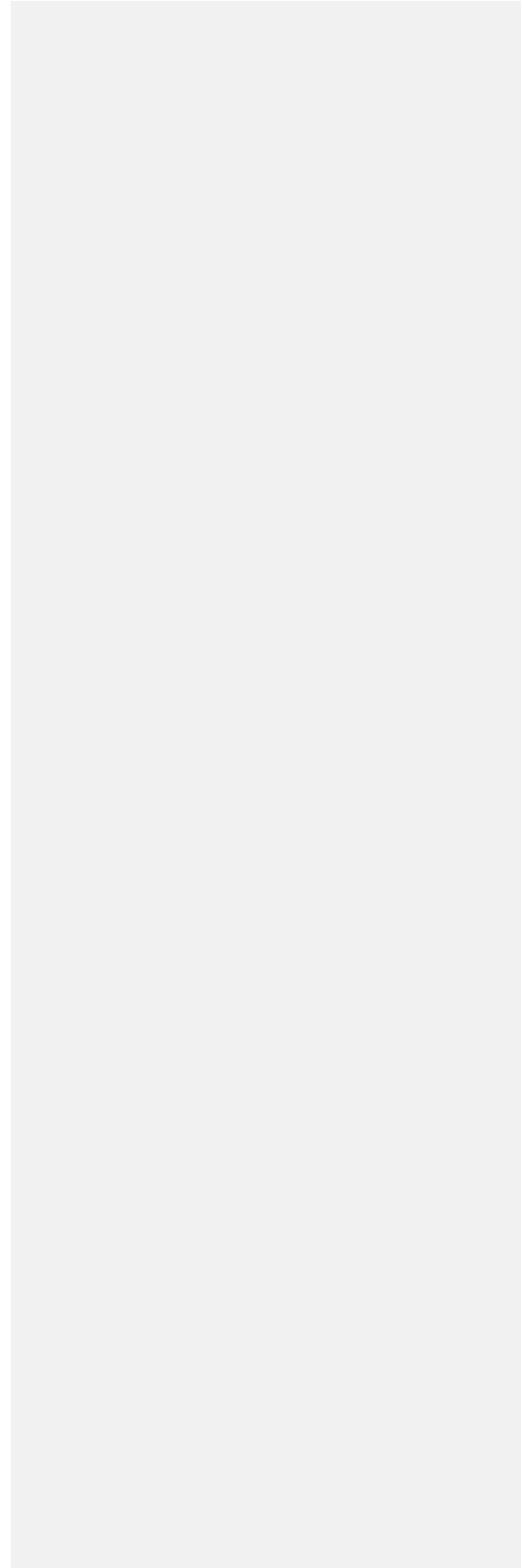
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## Executive Summary

There is substantial potential for achieving cost-effective electric energy and demand savings through a second generation of demand side management in Utah. The point of departure of this study is the potential for new and additional demand-side savings, after taking into account the effects of past electric demand side management (DSM) as well as existing market trends and policies. New load management, energy efficiency, and combined heat and power (CHP) measures were evaluated and their costs compared with their benefits. A portfolio of DSM options was assembled from measures whose resource value promises to substantially exceed their resource costs. Resource value is measured by future electric energy and capacity costs that can be avoided through demand-side measures. Resource costs consist of the incremental technology cost of demand-side measures, the costs for administration of programs to increase the market penetration of measures, financial incentives used to induce customer participation in programs, and any additional resources used by the electric DSM measures (water or gas).

~~The potential for cost-effective DSM in Utah is greater than is reflected in the portfolio of DSM options quantified in the present study. The study does not quantify the full amount of savings that would cost less to achieve than the electricity supply costs avoided. The focus here is on savings that are potentially achievable through the application of new DSM program funding to vigorously energetically promote those demand-side measures that can produce significant amounts of savings. We modeled implementing new DSM through a multi-year initiative, with a year 2001 phase-in and full-scale operation during 2002 through 2006. Beyond 2006, the full lifetime savings from measures installed during this period are included. The simple program features are incorporated in order to motivate a realistic analysis of achievable DSM. These are not specific program proposals. The report is intended as an informational resource.~~

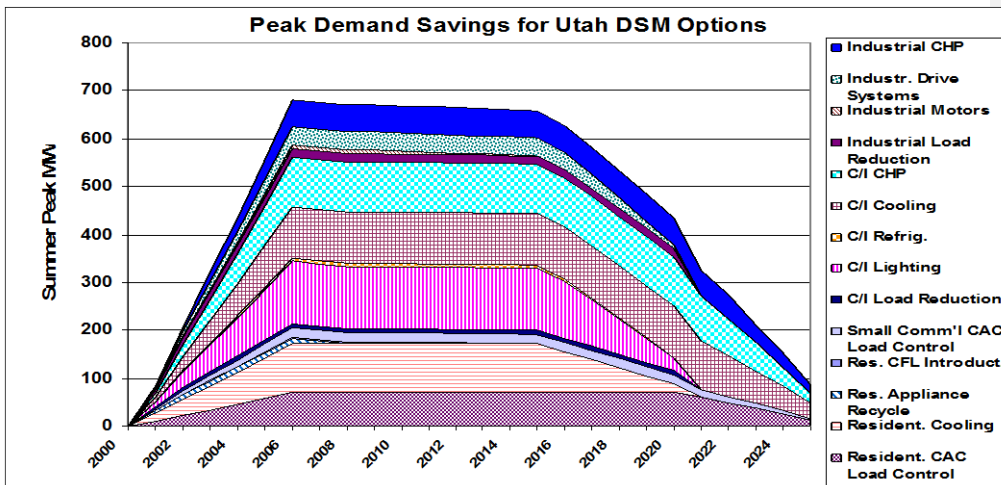
Assessment of a range of demand-side technologies and practices led to inclusion of the following major groups of measures in the DSM portfolio that is evaluated in this report:

<u>Residential Measures</u>	<u>Commercial/Institutional Measures</u>	<u>Industrial Measures</u>
Load control of air conditioners	Load control of <del>air conditioners</del> <u>A.C.</u>	Load management
Efficient cooling equipment	Load management	Efficient motors
Residential lighting	Efficient cooling equipment and systems	Motor drive improvements (fans, pumps, compressed air)
Appliance recycling	Commercial lighting	Combined heat & power
	Efficient <del>r</del> Refrigeration	
	Combined heat & power	

In addition to the basic economic comparison —total resource benefits ~~versus~~ total resource costs—, the DSM measures and programs are evaluated from other cost-effectiveness perspectives. The cumulative impact upon average electricity rates is estimated for each measure and for groups of measures. The estimated net reductions in air emissions from the measures included in the portfolio are quantified, and other environmental impacts of DSM are discussed.



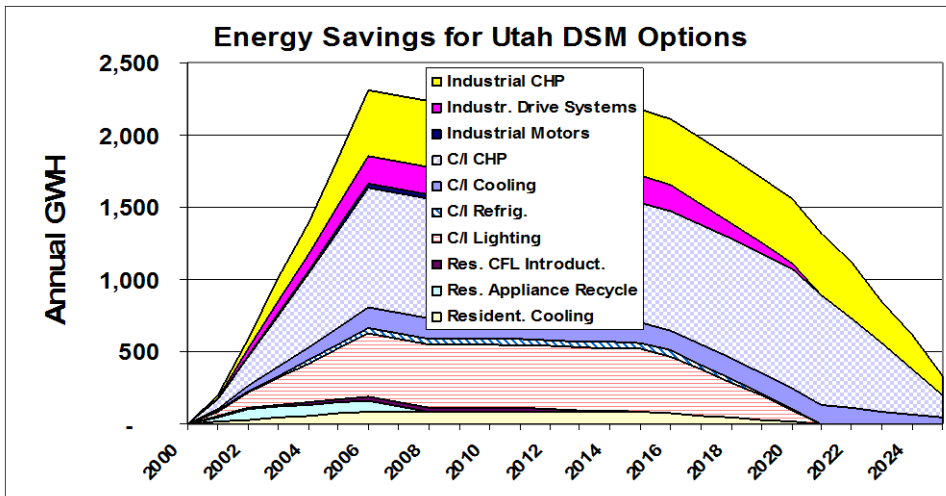
Statewide electricity savings from the DSM portfolio, calculated for the period 2001 through 2025 are displayed in the graphs that follow. Reductions in summer peak demand would grow to 680 ~~megaWatts~~ ~~megaWatts~~ (MW) in 2006, then decline very gradually thereafter. These results assume that the measures in the portfolio would expire at the end of the normal lifetime of equipment installations or removals made before 2007. In addition, commercial and industrial load reduction is not carried beyond 2020. In practice, DSM measures may be replaced with new measures of equal or higher efficiency, and C/I load reduction may be carried further, so the tapering off shown in the graphs need not occur.



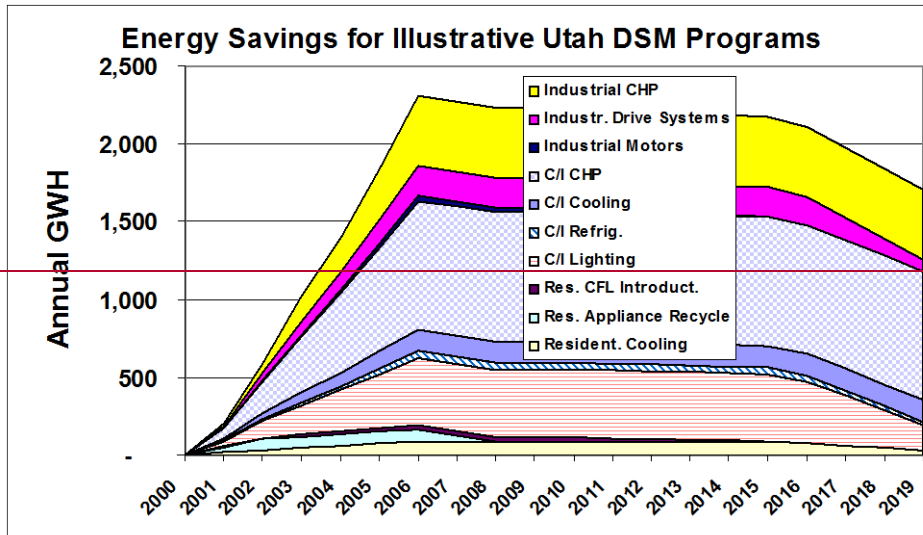
The demand reductions shown in the graph above result from load management, energy efficiency, and CHP measures together. Load management measures are specifically designed to [provide incentives](#) and technologies to enable electricity users to reduce their electricity use during periods of the highest electricity demand, including [the time of](#) maximum peak demand. ~~They~~ ~~These measures~~ typically have little or no effect on cumulative consumption of electric energy. ~~By contrast, e~~Energy efficiency measures reduce electricity use throughout the periods of time when ~~the affected equipment is used by customers~~ ~~customers use the affected equipment~~. The contribution of efficiency measures to peak demand reductions is a byproduct of their ongoing lower levels of [electricity](#) usage. The reduction in demand from the CHP measures arises from the fact that they are producing electricity for use in the host facilities instead of obtaining power through the electric grid. The CHP measures in the portfolio were sized to meet electricity needs in their host facilities and not sized to supply power to the electric grid.

The fourteen options graphed above are groupings of individual measures. Each of the 14 options contains one or more major measure. Savings in electric energy from the energy

efficiency and CHP options in the portfolio are shown in the following graph. Annual energy savings increase to 2,300 ~~gigaWatt-hours~~ ~~gigaWatt-hours~~ (GWh) in 2006, then decline gradually. Cumulative energy savings total 40,700 GWh through 2025. Savings from efficiency options installed during 2001-2006 would extend for several years after the period shown in the graph.



Energy efficiency options reduce the amount air pollutants emitted from power plants. For example, there are reductions in nitrogen oxide (NO<sub>x</sub>) emissions, which are of concern from a health standpoint. These are calculated relative to the new, efficient gas-fired generation units that are used as the basis of the study's avoided cost estimates. Although the gas-fired CHP systems included in the portfolio would produce emissions of their own, there is a net reduction in emissions because the overall efficiency of electricity generation and on-site heating is increased through CHP. The total cumulative reductions in emissions from the DSM portfolio for the period through 2025 would exceed 14,600 tons of NO<sub>x</sub>.



The cumulative present value of energy resource savings from the options in the portfolio is \$2.62 billion (2000 dollars). With total resource costs of \$370 million, the net benefit is \$2.25 billion and the benefit to cost (B/C) ratio is 6.5 to 1. Each DSM option is all cost effective, with B/C ratios ranging from 3.5 for commercial/institutional efficient cooling up to 17.6 for residential efficient cooling. In addition, all of the measures within each option are cost effective, with B/C ratios ranging from 2.3 for a large commercial efficient chiller up to 69.8 for residential evaporative cooling in place of refrigerated central air conditioning. Measure specific results in the report and appendices are intended to facilitate preliminary consideration of alternative mixes and levels of potential DSM measures, funding, and programs.

Energy efficiency options reduce the amount air pollutants emitted from power plants. There are reductions in the sulfur oxide (SO<sub>x</sub>) and nitrogen oxide (NO<sub>x</sub>) emissions that are of particular concern from a health standpoint. These are calculated relative to the new, efficient gas fired generation units that are used as the basis of the study's avoided cost estimates. ~~[DAVE - I'M NOT SURE THIS IS TRUE - MAY BE CALCULATED RELATIVE TO STATEWIDE AVERAGE GENERATION]~~. Although the gas fired CHP systems included in the portfolio would produce emissions of their own, there is a net reduction in emissions because the overall efficiency of electricity generation and on-site heating is increased through CHP. The total cumulative reductions in emissions from the DSM portfolio for the period through 2019 are 28.6 million tons of SO<sub>x</sub> and 103.6 million tons of NO<sub>x</sub>.

In addition, the efficiency and CHP options would yield net reductions in emissions of carbon dioxide (CO<sub>2</sub>), the chief gas that contributes to warming of the global atmosphere and is the subject of national and international discussions about how to avert climate change. ~~T~~Through 2025, total cumulative portfolio reductions in CO<sub>2</sub> are emissions would exceed 16 million cumulative 3.4 billion tons.

Emissions savings such as these are among the “externality” benefits of DSM ~~which and~~ are thus not reflected in direct economic savings, ~~which such as~~ are summarized ~~next~~ above. Reductions in the impacts on land use and on water resources due to electricity production and consumption are among other environmental externalities whose benefits are not monetized.

Economic costs and benefits for the DSM portfolio were evaluated for the period from 2001 through 2025. The cumulative present value of energy resource savings from the options in the portfolio is over \$1.44 billion (2000 dollars). With total resource costs of \$370 million, the net benefit is \$1.08 billion and the benefit to cost (B/C) ratio is 3.9 to 1. Each DSM option is cost-effective, with B/C ratios ranging from 2.4 for commercial/institutional efficient cooling up to 10.1 for residential efficient cooling. In addition, all of the major measures within each option are cost-effective, with B/C ratios ranging from 1.5 for new industrial premium efficiency motors in lieu of rewinding existing ones, up to 40.0 for residential evaporative cooling in lieu of refrigerative air conditioning. Measure-specific results in the report are intended to facilitate preliminary consideration of alternative mixes and levels of potential DSM measures, funding, and programs.

Because DSM reduces total customer bills for electricity, it frees up net disposable income for other uses. When all of the economic impacts of DSM are considered, its net impact on local employment is normally found to be small. In studies of the impact of DSM on state economies and net employment, it has uniformly been found to be a net plus. No study of these indirect economic effects was conducted for the present report. However, evidence for the existence of this indirect economic “externality” benefit, from the prior studies, is noted.

The entire portfolio includes DSM funding totaling \$283 million (present value 2000 dollars) for the six-year study period. This amount is assumed to be collected in rates for application by utilities or other program administration entities.

The long-run impact of the DSM options on average rates was estimated based on projections of PacifiCorp’s current rates. Taken as a group, the energy efficiency and load management options would reduce rates. That is because the electricity supply cost savings they yield are greater than the sum of DSM funding and utility lost revenues. The cumulative net reduction to rates, after DSM funding, would be about ~~\$132.4~~ \$1.1 billion. Due to the reductions in electric utility revenues that they produce at the levels of market penetration we included, two residential options, efficient lighting and appliance recycling, would increase average rates. However, the residential options as a whole, inclusive of these two, would decrease average rates. Other options that would increase rates are commercial efficient refrigeration, efficient industrial motors, and especially commercial/institutional combined heat and power.

Rate impact estimates are rough and are based on cumulative present value. The year-to-year pattern of rate impacts will vary. DSM involves up front expenditures ~~which that~~ produce streams of savings over subsequent years. Under ordinary circumstances, this creates rate impacts that are less favorable in the early years than they are after the investment period. However, the extraordinarily high wholesale price levels in Western markets at the time of this report are also not included in the analysis. The level of these prices is such that, if DSM is

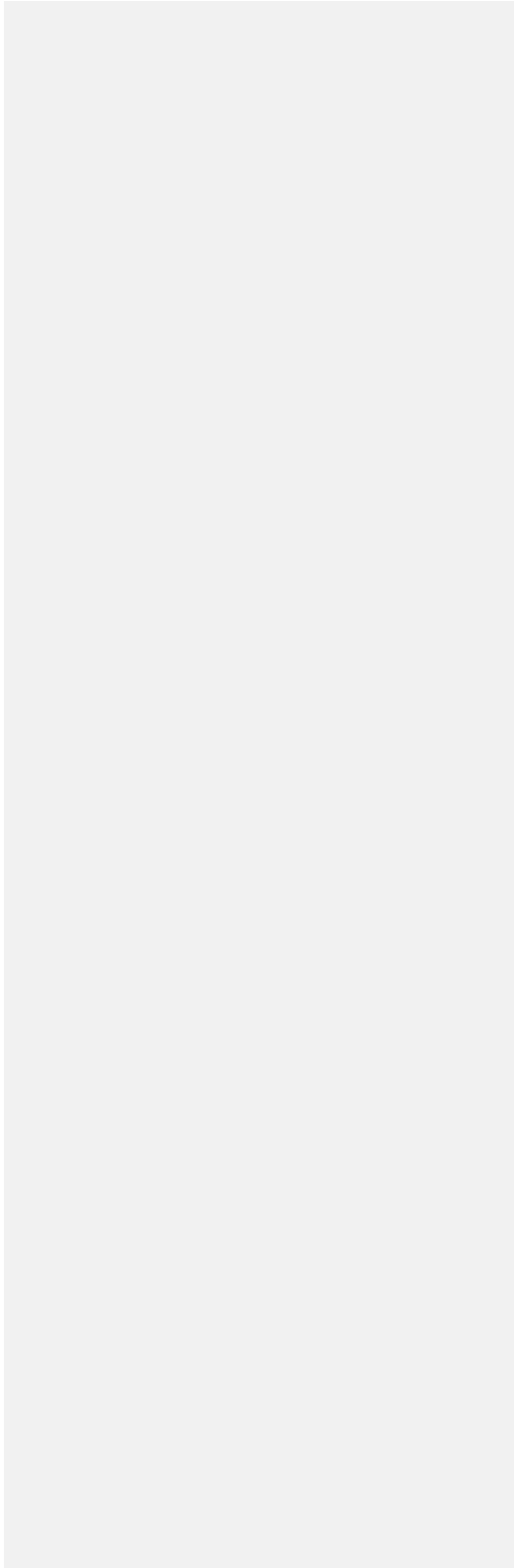
implemented beginning in 2001, its near-term savings are likely to provide net benefits to rate levels in early years as well as subsequently.

In using the information in this report, a number of points should be kept in mind.

- Some DSM measures that may be cost-effective were not assessed for this study, such as better non-residential building construction practices and industry-specific efficiency measures ~~in~~for chemical sector and process heat applications.
- The DSM options and the measures comprising them can be ranked according to different results. They can be ranked in terms of energy savings, demand savings, or environmental benefits. They can be ranked in terms of resource value, i.e., their avoided cost benefits net of all measure and program costs. They can be ranked in terms of their impact on average rates. Such rankings can aid in deliberations about appropriate levels of DSM funding.
- Rankings of options and measures should be used with caution. In characterizing the measures, this study necessarily makes assumptions about typical applications and practices. Measures which rank lower on some dimension may nevertheless have site-specific applications in which their benefits are greater than average. For example, CHP systems may have greater benefits in some specific application than in the typical applications we identified for them. Real-world DSM programs often have flexibility to incorporate custom measures which pass basic cost-effectiveness criteria. Real-world DSM programs also may include pilot tests of innovative measures to gain field experience and to improve their cost-effectiveness in the future.

The results described above are for Utah as a whole. Given the strong preponderance of PacifiCorp's service area in terms of population, economic activity, and energy use, the study's data and results are largely based on the nature, benefits, and costs of DSM opportunities in its area. However, the magnitude of achievable DSM for each option and overall would be somewhat less in the PacifiCorp service area than the totals shown here for the State as a whole.

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# 1. Introduction: Setting and Reason for Study

## 1.1 The Advisory Group

In its order in PacifiCorp’s 1999 General Rate Case, the Utah Public Service Commission called for establishment of a stakeholder advisory committee to assess a range of issues relating to the future of energy efficiency and renewable energy programs. This Systems Benefit Charge Stakeholder Advisory Group is co-chaired by PacifiCorp and by the Office of Energy Resources and Planning in the state’s Department of Natural Resources. After addressing key program and policy issues, the advisory group reports to the Commission early in 2001. The present study was prepared to provide information and analysis for the use of the advisory group in its evaluation of energy efficiency issues. The study focuses on the question of the nature, extent, and magnitude of untapped demand-side energy efficiency opportunities within the state.

## 1.2 Purpose of the Study

The study assesses the potential of achieving electric energy and demand savings by accelerating the market penetration of known and available efficiency technologies. The focus is on demand-side measures and practices that reduce energy users’ need for electricity from the “grid” through energy efficiency, load management, and combined heat and power systems. The term “demand-side management” or DSM is sometimes used to refer to such measures or to initiatives to support their market penetration.

The point of departure of the study is the potential for new and additional savings, after taking into account the effects of past DSM as well as existing market trends and policies. One key element of the study is the economic costs of these demand-side measures, i.e., the costs of saving demand or energy through efficiency technologies. Additionally, the study estimates the economic value of incremental efficiency savings, in order to provide members of the advisory group with insight into the potential range of economic benefits associated with feasible new programmatic initiatives. Finally, the study quantifies the reductions in air emissions of carbon dioxide and oxides of sulfur and nitrogen that would result from the DSM measures incorporated in the analysis.

The potential for cost-effective DSM in Utah is greater than is reflected in the portfolio of DSM options quantified in the present study. The focus here is on savings that are potentially achievable through the application of new DSM program funding to vigorously promote those demand-side measures that can produce significant amounts of savings.~~The study does not attempt to quantify the full amount of demand-side savings that would cost less to achieve than the electricity supply costs avoided. The focus is on savings that are potentially achievable through the application of new DSM program funding to energetically promote those efficiency~~

measures that can produce significant amounts of savings, with benefits clearly in excess of costs.

### 1.3 DSM and the Power Supply Situation in Utah and the Region

The population and economy of Utah have been growing faster than the national average, and its demand for electricity has proceeded to increase apace. Utah electricity consumers have long benefited from low-cost electricity supply anchored in an abundance of local coal for power generation. During the 1990s a robust rate of demand growth proved consistent with low electricity costs. Indeed, electricity prices fell steadily from 1986 through 2000.

Unexpected electricity price pressures materialized in 2000. These pressures had several sources. One specific source is transmission system constraints in the Salt Lake City region, which require Utah Power Company to purchase power during periods of peak demand. More generally, PacifiCorp, the multi-state electric utility of which Utah Power is a part, both buys and sells power in regional markets. PacifiCorp has positive net purchased power costs system-wide. Substantial increases in wholesale power prices began to occur in regional markets in 1998, sporadically at first, then on a more sustained basis in 2000. One cause of these increases was deregulation of generation in the largest states in the region. Another was a substantial increase in the price of gas, which affects the marginal costs of electric energy. Because of these price pressures, PacifiCorp's net purchased power costs had by the time of this study risen to a level over 50 percent higher than the level reflected in its Utah rates. PacifiCorp meets about four fifths of Utah's retail electricity demand, but Utah's numerous smaller electric utilities, which serve the remainder of demand, also have varying degrees of susceptibility to near-term power market trends.

The main economic benefit of electric DSM is savings in power supply costs. DSM consists of measures and practices which, like supply-side facilities, last many years once installed. For this reason the economic value of DSM is properly assessed against the long-run value of avoided electric supply resources. The strong increases in near-term electricity supply costs in 2000 helped to focus attention on the need for such a long-run economic assessment of achievable DSM savings. In addition, if DSM that is cost-effective in the long run is implemented beginning in 2001, its near-term savings can help to mitigate mounting electricity price pressures. By 2000, Utah and several other jurisdictions across the country had refocused on DSM as a strategy to help reduce the financial risks associated with providing electricity-related services to growing populations and economies.

### 1.4 Plan of the Report

The balance of the report consists of sections 2 through 8 and a list of acronyms. Volume II consists of appendices. Topical coverage of these elements is as follows.



**Section 2** overviews the pattern of electricity usage in the state. The major ways in which residential, commercial/institutional, and industrial consumers [in Utah](#) use electricity are introduced.

**Section 3** discusses measures to change the efficiency or timing of electricity use by customers. Measures considered and included in the study's DSM portfolio are described.

**Section 4** explains the perspectives used to evaluate the prospective cost-effectiveness of DSM measures and programs. Screening of potential measures for cost-effectiveness is described here as well.

**Section 5** addresses the resource value of DSM. Avoided cost methods and data sources are summarized.

**Section 6** discusses the environmental impacts of DSM. The impacts of the DSM portfolio on air emissions are quantified here.

**Section 7** presents the basic quantitative results of the study. The impacts of DSM upon electric energy consumption and peak demand are provided, along with annual and cumulative costs, savings, and environmental impacts.

**Section 8** evaluates the results of the study. Areas that require further analysis are identified, and the implications of the results for regulatory policy deliberations [is-are](#) discussed.

**Acronyms** are both identified when first used in the text and listed on page 45.

**Demand Side Input Assumptions** are summarized beginning on page 47. For full documentation, see Volume II.

Volume II, **Appendices**, provides supporting documentation as follows:

~~Emissions savings by DSM option and by year~~

- ~~The ECO<sup>tm</sup> software tool.~~
- ~~Electric avoided cost assumptions, Acknowledgment, Sources for input assumptions~~
- ~~Worksheets used in economic screening of DSM measures, including cost and performance assumptions and information sources, Measure screening worksheets of individuals who contributed information~~
- ~~Additional results, Other results and documentation~~

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## 2. Overview of the Electricity Demand Situation

### 2.1 Summary of State Demographics

Utah is rich in energy resources, and is also well equipped with resource extraction and processing facilities. It has oil fields, wells, pipelines, and refineries. As well it has gas fields, wells, and pipelines are also features of the energy landscape in Utah. Utah is a net exporter of gas and oil products. Utah also has coal fields and coal mines. Coal is the fuel for about 95 percent of the electricity currently being generated within the state. Net electricity generation in Utah has grown from 2,500 ~~GWh~~ GWh per year in 1960 to almost 35,000 ~~GWh~~ GWh currently. Much of the electricity generated in Utah is exported. Indeed, the largest power plant in Utah is owned by the City of Los Angeles, which has a direct transmission link with the plant.

Utah has some 2 million residents and over 800,000 electricity customers. The total annual energy expenditures of these households, businesses, institutions, and industries exceed \$3 billion. Over 20,000 GWh of retail electric energy are-is purchased annually within the state, at with expenditures on electric energy totaling over \$1 billion. Much detailed information concerning Utah's energy resources and consumption are-is assembled in *The Utah Energy Statistical Abstract*, which is maintained and updated by the Office of Energy Resource Planning. Unless otherwise indicated, energy data and calculations reported in section 2 are based on this source.

### 2.2 Energy Utility Service in Utah

Utah is served by 51 electric utilities. Utah Power, a part of PacifiCorp, is the state's only electric investor-owned utility (IOU). Utah Power provides over four-fifths of all retail electricity in Utah, including over nine tenths of statewide industrial electricity sales. In addition there are ~~40+~~ publicly owned utilities, nine cooperatives, and a federally owned utility. The great majority of households, non-residential buildings, and industries are also served by natural gas distributed by Questar Gas, an IOU.

### 2.3 Electricity Demand in Utah

The number of electricity customers in Utah has grown from about 250,000 forty years ago to over 800,000 today. Annual statewide sales of electricity during the period 1960 through 1997 grew from some 3500 GWh to 20,400 GWh, an average annual increase of 4.9 percent per year. Dividing the 1997 usage into the three broad categories of industrial, commercial, and residential users, the latter two groupings each accounted for about 36 percent of electricity sold. The commercial sector's usage growth rate since 1960, at an average of 6.8 percent per year, has been higher than the industrial growth rate of 3.9 percent per year. Residential usage was about 28 percent of the 1997 total, and grew at an average annual rate of 4.8 percent during 1960

through 1997. Not included in these figures are small amounts of electricity self-generated by industrial, commercial, and a very few residential users.

Forecasts of future electricity usage are useful in both energy resource planning and in DSM assessment. It was not necessary to develop a forecast of future electricity usage for the present study. It is not so much forecasts themselves as the underlying data behind forecasts –such as numbers of customers and the expected intensity of their use of electricity for different purposes– that are useful in projecting the potential impacts of possible DSM measures and programs over a multi-year period. The study team examined PacifiCorp electricity forecasts and forecasts of state population, employment, households, commercial floor space, and other demographic measures derived from sources identified in the appendices.

#### 2.4 Major End-Uses by Customer Class in Utah

The study team reviewed the principal uses to which electricity is put within broad customer grouping. Summaries for the residential, commercial, and industrial sectors follow.

**Residential usage.** According to PacifiCorp estimates, electricity use in single-family Utah homes is accounted for by the following end-uses, arranged in order from most to least usage: food refrigeration, central refrigerated air conditioning, clothes washing (washing machine plus electric water heaters), lighting, space heating, evaporative cooling, clothes drying, dish washing (washing machine plus electric water heaters), cooking, room air conditioners, well pumps, freezers, and other. The pattern of usage is similar in apartments and mobile homes in the Utah Power area, and probably similar in other services areas. Heating ~~space-homes~~ with electricity is quite energy-intensive, but total usage for [household](#) space heating is in the middle of this list because the vast majority of houses in Utah use natural gas for their primary space heating fuel.

**Commercial usage.** ~~The e~~Electricity used ~~of-in~~ commercial/institutional facilities as a whole is accounted for by the following broad technology categories, listed in estimated order of usage, most to least: lighting, motors and drives (in cooling, ventilation, and other applications), air conditioning, office machinery, refrigeration, and other. Most space heating uses gas as the primary fuel, but some 70 percent of the floor space of nonresidential facilities is electrically air conditioned, mostly with refrigerated ([compressor-driven](#)) systems. There is some evaporative cooling in the commercial sector as well.

**Industrial usage.** The broad types of industry in Utah, in order of electricity usage, are: primary metals; chemicals; mining (coal, quarry, oil and gas, and metals); petroleum refining; stone, clay, and glass products; electronics; transportation equipment; food processing; and agriculture. Every broad industrial category uses electricity for motors and motor-driven equipment and processes. Specific patterns of usage vary considerably both among and within these broad industry types. However, motors and motor drive power account for over half of the electricity consumed in this sector as a whole.

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**Other usage.** Electricity used in agriculture is often grouped with industrial usage when dividing total usage into three broad groups. Similarly, municipal street lighting and certain other types of usage are often grouped with commercial/institutional usage.

## 2.5 DSM Activity in Utah

Utah has seen electric DSM in the past, particularly in the late 1980s and early 1990s. Utah Power Co. operated programs addressing nonresidential lighting and new construction, residential lighting, industrial conservation, and other efficiency and load management measures. The scale of this first generation of utility DSM investment declined from an amount equal to 1.6 percent of Utah Power’s electric revenues in 1993 to 0.25 percent or less of revenues by the late 1990s. The only full-scale DSM program operated by Utah Power in recent years is its “FinAnswer” program, which promotes energy efficient equipment choices in nonresidential new construction and in existing nonresidential facilities. On a cumulative basis, the FinAnswer program has implemented measures estimated to save 85 GWh of electricity per year, and a total of 17 MW in non-coincident demand.

The Utah Municipal Power Agency (UMPA) has pursued some demand-side programs since 1996 as part of its integrated resource planning. Cumulative savings since 1996 are estimated to be nearly 4 MW and 8 GWh. The largest source of estimated savings is upgrading street lighting to sodium lamps. (UMPA is an entity that was formed by several of the larger municipal utilities to obtain power supplies.)

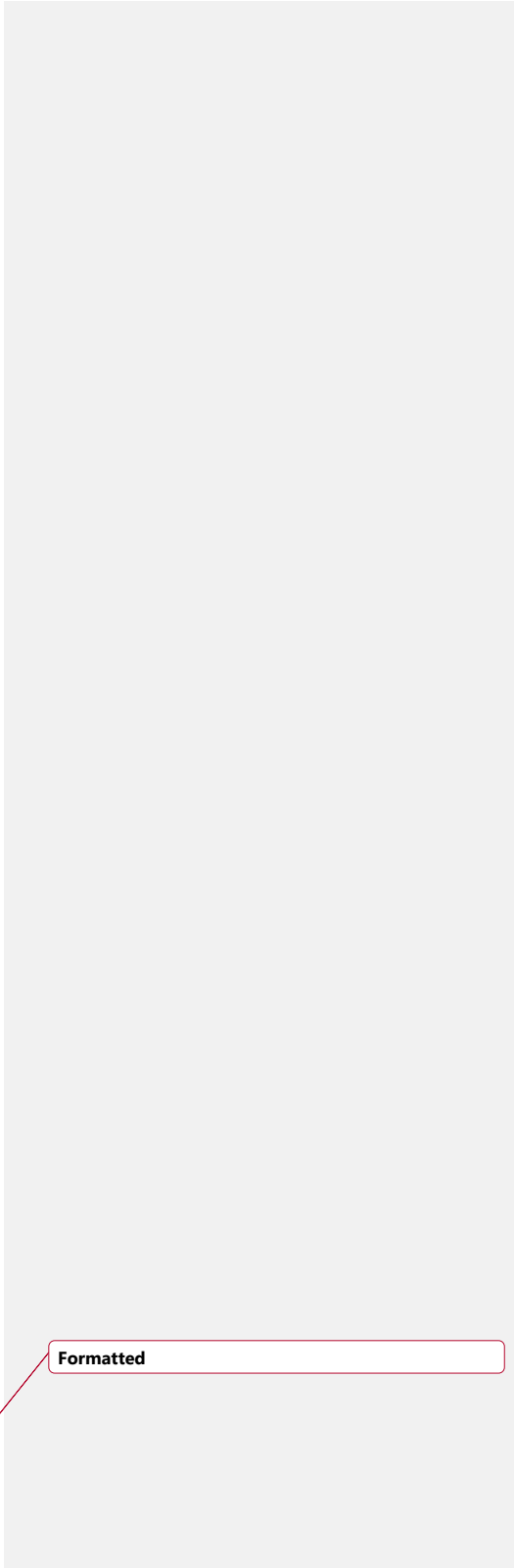
Utah has had a state energy saving systems tax credit of ten percent. This tax credit program leveraged a cumulative investment in gas and electricity saving measures of some \$25 million during the period 1980 through 1985, mostly in the residential sector. During 1986 through 1995, the tax credit remained but generated considerably less activity.

As of 2000, a number of conservation programs are operated through the Office of Energy Services, consisting of a mix of information, energy audit, loan, and grant activities. Except for the low-income home “weatherization” program, these programs are modest in scale. The weatherization program is federally funded, with additional funding from gas and electric utilities. The weatherization program has operated for decades, ~~impacting-affecting~~ mainly ~~gas~~ ~~the use of gas~~ used for space heating in eligible housing. There are small electricity savings as well, due to the impacts of weatherization on cooling loads, the inclusion of compact fluorescent bulbs in the program, and the recent addition of a component to reduce electricity used for refrigeration.

In 2000 the Governor formulated a green buildings initiative which is to promote energy efficiency as well as the use of renewable resources by state facilities, and there are a number of other energy efficiency initiatives in the state. At this time of this report new state policy initiatives to reduce electricity usage are under active consideration.

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The nature and scope of recent and existing DSM programs were taken into account in developing the DSM measures in the present study. In most cases this was done judgmentally based on the scale of program activity. In the case of FinAnswer and UMPA, quantified estimates of program impacts on electricity use were available.



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### 3. Key DSM Opportunities

#### 3.1 Overview of DSM Opportunities

DSM consists of market interventions to increase the productivity with which electricity (or other forms of energy) is used. DSM originated over two decades ago when some electric utilities experiencing rapid load growth decided to develop programs to reduce customer demand during the peak and near-peak hours that were driving load growth. The key objective was (and remains) to defer construction and use of costly new electric generation capacity (a “supply-side” option) by instead investing in “demand-side” options. If “demand-side” options would cost the utility and its ratepayers less than “supply-side” options, they were to be pursued first, as least-cost resource options.

The process of assessing demand-side options and then implementing programs to cause them to be used eventually came to be known as demand-side management or “DSM.” The predominant technologies used in early DSM were load management and peak-oriented energy conservation. Load management refers to methods of reducing peak demand — for example, cycling the times that appliances are powered during peak hours, or promoting equipment that stores energy during off-peak hours for use on peak.

From its narrow early focus, DSM matured rapidly during the late 1980s and early 1990s to encompass a broader perspective, energy efficiency. Energy efficiency refers to reducing energy consumption (and with it demand) — for example, providing customers with incentives ~~incentives eustomers~~ to install the highest efficiency air conditioners so as to slow the growth in the use of electricity for cooling. The energy efficiency perspective thus encompasses the entire range of demand-side options that could increase the productivity (or efficiency) of electricity consumption. We include combined heat and power systems, which make use of heat that would be wasted in conventional electric generating plants ~~—~~ electricity is generated and the heat that would otherwise be wasted is used for process heating requirements, water heating, or other thermal loads.

The range of technologies and practices that can increase the productivity of electricity use is potentially vast. The present study does not attempt to assess all potential DSM measures. The approach is to focus on savings that are potentially achievable through the application of new DSM program funding to vigorously promote those demand-side measures that can produce significant amounts of savings. Section 4 discusses the methods used to identify, characterize, and evaluate measures that are consistent with this approach and which are prospectively cost-effective. Cost-effectiveness assessment is based principally on the total resource cost or “TRC” perspective. The TRC perspective identifies demand-side options the cost of which is lower than that of the electricity supply needed in their absence, and then asks whether market interventions to promote use of those options can be mounted at reasonable cost and with reasonable success by the utility (or by any other entity charged with assessing and implementing DSM).

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## 3.2 Discussion of Key Measures

### 3.2.1 Residential Measures

The residential measures included in the achievable DSM portfolio are: load control of central air conditioners, high-efficiency central air conditioners, evaporative cooling equipment, retirement and recycling of existing refrigerators and freezers, and compact fluorescent bulbs. Descriptions of each major measure follow. We also discuss measures that were considered but are not included in the DSM portfolio. Major measures consist of several technologies, which are described in Volume II, Appendix C, along with documentation ~~of~~ sources [of technology data](#).

**Residential load control.** Residential load control programs typically cycle central air conditioners (CACs) off for short periods during peak hours through central control equipment operated by a utility. A common pattern is cycling the controlled CAC units off for 15 minutes each [hour](#) during peak times when load reduction is needed, with the specific times of cycling distributed among participant CACs. Though water heaters are sometimes included in load control programs, this is less cost-effective [for summer peak demand reduction](#), and there are relatively few electric water heaters in Utah. While usually aimed at the residential market, load control programs can be extended to the small commercial market where the air conditioning technologies are similar, as discussed below. There is extensive experience with CAC load control in the electric utility industry, on the basis of which we estimate that 25 percent of residential households that have CACs can be signed up over a period of six years. The participation base for this program consists of the service area of the six largest electric utilities in Utah. The peak demand reduction is estimated at 0.8 kW per controlled CAC, based on savings of 0.5 to 1.0 kW in existing programs. A rate credit of \$40 per participant was used. This is toward the high end of the range of credits that successfully motivate substantial participation in other load control programs, and represents \$10 per month over four summer months. At the current time no utility in Utah operates CAC load control. Programs elsewhere are summarized in a Tellus report to the Citizens Utility Board (Illinois), *Reducing Peak Demands Through Customer-Side Initiatives*, September 2000.

**Efficient cooling equipment.** The efficient cooling grouping consists of two major types of measure, high-efficiency central air conditioners (CACs) and evaporative cooling systems.

- High efficiency CACs are those whose seasonal energy efficiency ratio (SEER) is substantially above the federally established minimum of SEER 10.0. The penetration of CACs in Utah has been steadily growing, especially in new homes. However, the market penetration of high-efficiency units is very low. Based on the strong growth in air conditioning load, and based on the fact that the costs of a well-designed efficient cooling program can be below the costs of supplying the electricity saved by such a program, an efficient cooling program is a viable DSM option. In order to develop an achievable market penetration projection for this option, the study assumes an aggressive incentive program providing 80% [percent](#) of the incremental cost of higher efficiency CACs, or \$440 [per unit](#)



on average. We define high efficiency as SEER 13 or greater.<sup>1</sup> Qualification for the incentive offer would require that contractors size units properly and install them according to industry standard procedures. The savings per participating CAC unit from these program features are a 1 kW reduction in summer peak demand and an annual energy saving of 800 kWh.

- Evaporative cooling works by introducing water vapor into air, thus cooling it. Since this process increases humidity, it is well suited to dry climates like Utah's. Evaporative cooling requires a supply of water of adequate quality, as well as maintenance of the equipment at least twice a year. Evaporative cooling uses about one fifth of the electricity that CACs use, making it attractive from a DSM viewpoint. Most of Utah's existing housing that has cooling equipment uses evaporative cooling, although some of this is changed over to refrigerative cooling each year. Sometimes evaporative cooling and refrigerative cooling are used in combination. Most of the new housing that has installed cooling equipment simply uses CACs. The installed cost of evaporative cooling is lower than the installed cost of CACs. Thus, unlike the other measures included in this study, evaporative cooling has negative incremental costs. In order to prevent the incentive for efficient CACs from tacitly supporting the ongoing market shift from evaporative to refrigerative cooling, we assumed that incentives for efficient CACs would also be made available for new or replacement evaporative systems. We estimated that this would slow by half the rate at which the shift from evaporative cooling occurs. We estimate savings per participant to be a 1.6 kW reduction in summer peak demand and an annual energy saving of 1600 kWh. Because some households would have installed new evaporative cooling anyway yet would participate in such a program, we reduced total savings from this measure by 20 percent.

**Appliance recycling.** The appliance recycling approach provides incentives to customers to allow their operable refrigerators or freezers to be disposed of. Appliance recycling has been operated successfully in several regions outside Utah, and its operating procedures are well developed and the electricity savings well documented. A recycling company is contracted to collect the appliances and dispose of them in an environmentally responsible way. The electricity savings result from the fact that the average stock of refrigerators and freezers now in use consumes more than twice the electricity of the new units available on the market today. This differential is the result of several successive waves of federal appliance efficiency standards. Appliance recycling programs provide savings whether they remove operating second refrigerators that are in use as spares, or primary ~~appliances which~~ appliances that are then replaced. Based on experience in California the costs for this program are estimated at \$175 per participant, of which \$50 is an incentive to participate, and the balance the costs to a recycling contractor for marketing, program operation, and disposal. Our summer peak demand savings estimate of 0.16 kW per appliance recycled is based on applying an estimated refrigeration peak factor of 1.25 to annual energy savings of 1149 kWh. The annual kWh energy savings are taken

<sup>1</sup> This is the efficiency level promulgated by the federal government early in 2001 for new CACs. If upheld, the standard will take effect beginning in 2006. Thus a SEER-13 program could be viewed as a transitional initiative to capture one-time efficiency opportunities which would otherwise be lost.

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from *Impact Evaluation of the Spare Refrigerator Program*, conducted for Southern California Edison Company by Xenergy, [and dated](#) April, 1998.

**Compact fluorescent bulbs.** Compact fluorescent light bulbs (CFLs) use much less electricity than do standard incandescent light bulbs. CFLs are well known and are available in retail stores in Utah. Of households responding to a 1999 PacifiCorp residential survey (*Energy Decisions Fact Sheets 1999, Report on Utah Customers*), nine percent indicated that they had purchased a CFL within the past three years. This result implies that most households have not yet installed CFLs, and that a DSM initiative to promote CFLs could be cost-effective. We developed a CFL option with incentives and savings based in large part on a CFL initiative underway in the Pacific Northwest, as part of the Northwest Energy Efficiency Alliance's lighting program. An achievable market penetration target consistent with the experience of that program is three CFLs per household, resulting in 500,000 additional CFLs in Utah by 2006. Assuming participants are urged with moderate success to use CFLs in areas where lights are on a lot, savings per participating household are estimated to be [0.03 kW](#) at the time of system peak, and 180 kWh per year.

**Measures not included in the portfolio.** A number of other DSM measures were considered during the pre-screening phase of the study. Efficient residential new construction was considered, but not included because its main energy benefit [in Utah would be](#) savings in gas [consumption](#). Energy efficient clothes washers, clothes dryers, water heaters, dishwashers, and low-E windows were considered but not included. In the case of clothes washing machines, clothes dryers, dish washers, and electric water heaters, the measures would save smaller amounts of electricity than the energy efficiency measures that are included in the portfolio. In the case of water heaters, efficiency improvements are costly as well. Two-stage evaporative cooling was researched, but no mass-produced residential product was found to be available yet in the U.S. market. Because refrigeration accounts for a large portion of residential electricity use, the highest efficiency new refrigerators were screened for cost-effectiveness. They were found to be not cost-effective, largely because the baseline efficiency of this equipment has been so much improved through the federal appliance standards program.<sup>2</sup> We decided instead to include accelerated retirement of older units ("recycling"), as described above.

### 3.2.2 Commercial/Institutional Measures

The measures for non-residential buildings that are included in the achievable DSM portfolio are load control of central air conditioners and a load management program for medium sized facilities; high-efficiency central air conditioners, chillers, and evaporative cooling equipment; refrigeration efficiency improvements; efficient electric motors and improvements to motor drive used in ventilating, pumping, and other applications; a wide variety of efficient lighting technologies and practices; and combined heat and power systems. A description of the nonresidential measures follows. Documentation of sources [of information used in compiling](#)

<sup>2</sup> Among influences on the federal standards levels may have been the nationwide Super-Efficient Refrigerator Program initiative (in which PacifiCorp was a participant) in the early 1990s.

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[data on nonresidential measures](#) is provided in the appendices. Industrial measures other than building energy use are treated in section 3.2.3.

**Small commercial load control.** If a residential load control program to cycle air conditioning equipment is established, it is cost-effective to extend the load control system to small commercial facilities in which the technologies (central air conditioners) are similar. Based on the experience of electric utilities which have included a small commercial component to their load control programs, we estimate that the number of participating customers is five percent of the households in the residential load control program that was described above. The estimated summer peak reduction per participant is 4.4 kW. This estimate was taken directly from Sacramento Municipal Utility District's documented results for its program, and is in the range of results achieved by programs elsewhere. The rate credit to participants per effective kW of demand reduction is the same as for the residential program summarized above.

**Medium-Medium-sized commercial customer load management.** This is included within a program described in section 3.2.3 below.

**Cooling in non-residential buildings.** A range of measures that can reduce cooling use in commercial and institutional facilities has been considered. Dozens of technologies potentially enter into non-residential cooling systems. The study approach was to select major types of equipment that can affect significant fractions of the electricity used for air conditioning as a way to capture and represent potential electricity savings. The technologies assessed were efficient packaged rooftop units, efficient chillers (both reciprocating and [absorption-centrifugal](#) types), a direct/indirect evaporative cooling system, and gas-fired engine driven chiller systems. Motor drive for ventilation and cooling was considered separately (see below). Though the gas cooling systems were found cost-effective from a total resource perspective during pre-screening, they were excluded from the final package because of their higher capital costs. Even with incentives to fully cover their incremental capital costs, gas air conditioning would be only marginally cost-effective from the customers' perspective.<sup>3</sup> The other cooling technologies noted are all included in the final DSM portfolio. Cost and savings assumptions for the chillers and rooftop systems were derived from the September 1998 U.S. Department of Energy report, *EIA—Technology Forecast Updates—Residential and Commercial Building Technologies—Reference Case*, and are described further in the appendices to this report. Incremental installed equipment costs for these technologies range from \$68 to \$155 per ton of cooling capacity, which we assumed to be fully covered through program incentives. Savings range from 0.03 to 0.37 kW per ton. Data for evaporative cooling systems were obtained from Colvin Engineering of Salt Lake City and other sources.

**Lighting in non-residential buildings.** Hundreds of technologies potentially enter into non-residential lighting systems. A range of measures that can reduce lighting use in commercial and institutional facilities has been considered. The study approach was to select major types of

<sup>3</sup> If heat in the form of hot water were recovered from the gas cooling system to displace an electric boiler system, cost-effectiveness would be higher; but the number of potential applications for this combination is not known.

equipment that can affect most of the electricity used for lighting as a way to capture and represent potential electricity savings. The most common type of lighting used in many commercial buildings is ~~four-foot~~four-foot fluorescent lamps in ceiling fixtures. Thus one major technology considered was installation of more efficient ceiling lighting in replacement and new construction applications (e.g., T-8 lamps in lieu of T-12 lamps, with electronic ballasts in lieu of magnetic ballasts). The levelized cost of saving energy through these measures is under \$.02 per kWh saved. Under the federal appliance efficiency program, magnetic ballasts are not to be manufactured for new applications beginning in mid-2005. Including the electronic ballasts in the Utah DSM portfolio is a logical phase-in to the period in time when they will begin to dominate the market. Note that the federal standard allows continued manufacture of magnetic ballasts after 2005 to meet replacement requirements. Also included in the DSM portfolio is a mix of measures identified in *Emerging Energy-Saving Technologies And Practices For The Buildings Sector*, prepared in 1998 for the Association of State Technology Transfer Institutes. These measures include indirect lighting, electrodeless lamps, ~~sulphur~~sulfur lighting, advanced fluorescent lighting, improved daylighting, integrated lighting fixtures, metal halide replacements, light-emitting diode (LED) lighting, and others. The levelized cost of saving energy through a weighted average mix of these measures is over \$.03/kWh saved. As lighting throws heat into buildings, we added electricity savings from reduced air conditioning needs to the direct electricity savings from the lighting measures themselves. The cooling savings are 0.19 kWh per annual kWh of lighting savings, ~~and 0.48 kWh per summer peak kWh of lighting savings~~ ~~(DAVE - WE DIDN'T ACTUALLY USE THE LATTER FACTOR, AS I RECALL - WE USED .19 FOR BOTH ENERGY AND PEAK)~~. Lighting efficiency programs in several other jurisdictions have impacted substantial portions of lighting energy use. The study therefore employs an aggressive market penetration target for the lighting measures, impacting one third of lighting energy use over the period 2001-2006. To motivate this aggressive target, we incorporate financial incentives equal to half of the incremental cost of the measures.

**Refrigeration.** Electricity is used for refrigeration in food stores as well as in food service establishments and in widely distributed devices such as ice machines. Included in the DSM portfolio is a mix of measures identified in *Energy Savings Potential ~~F~~or Commercial Refrigeration Equipment*, prepared in 1998 for the US DOE. Refrigeration measures are largely longer-lived improvements in mechanical systems, door seals, and controls. They are applicable to a variety of supermarket machines and display cases, reach-in refrigerators and freezers, ice machines, vending machines, etc. Costs and savings were developed for an average of these measures, weighted by the size of applicable commercial sectors in the State. Our study employs a 40 percent incremental cost incentive and targets one third of statewide electricity used for nonresidential refrigeration over the six-year study period, reducing this usage by 37 percent.

**Combined heat and power.** CHP systems, also known as co-generation systems, make use of heat wasted in conventional electric generating plants. Electricity is generated and the heat that would otherwise be wasted is used for process heating requirements, water heating, or other fairly continuous thermal loads. Considered here are CHP systems that are sized to meet electricity requirements at their host facilities. The potential for CHP is smaller in the buildings sector than in the industrial sector, but it is not insignificant. Several different CHP technologies

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were screened—micro-turbines, fuel cell systems, combustion turbine (CT) type systems, and internal combustion engines (ICEs, diesel type) at a variety of size configurations. Screening led to including 100 kW and 800 kW ICE systems in our portfolio, primarily in schools (including colleges and universities) and hotels, [along with a limited number of 30 kW "microturbines" in the later years of the program](#). This does not mean that larger or smaller systems could not be employed in such facilities, but only that these ~~two~~ systems are good choices to represent market potential for CHP systems that are cost-effective from the total resource cost perspective. The CHP potential for Utah is estimated in *The Market ~~a~~And Technical Potential ~~f~~For Combined Heat ~~a~~And Power ~~i~~n ~~t~~he Commercial/Institutional Sector*, prepared for the US DOE's Energy Information Administration (EIA) in January, 2000. Because it is a major system reconfiguration, institutional or owner-occupied facilities that expect long tenancy are good targets. We estimate that with an energetically marketed CHP program including an incentive equivalent to 30 percent of the installed cost of a CHP system, which we envision being used to create below-market loan financing, nine percent of the market potential identified in the EIA report could be realized by the end of 2006.

**Other measures.** The list of measures included in our DSM portfolio for non-residential building energy use is extensive, but it is by no means all-inclusive. Other improvements in water heating, cooking, clothes washing and drying, office equipment, and miscellaneous other uses were not incorporated. These additional efficiency opportunities are not unimportant, but most of the electricity used in nonresidential buildings is impacted by the measures that are included in the DSM portfolio. Consideration was given to specifying measures for a nonresidential new construction program. In addition to including energy-efficient equipment and lighting systems, such programs can promote optimization of all elements in a building project, including such factors as solar gain from its orientation, and they can be complemented by procedures to "commission" or properly test and calibrate systems and controls upon occupancy. We consulted building professionals in Utah and concluded that without first conducting a field survey of baseline practices in new construction, estimation of incremental costs and savings from such a program would be too speculative. However the impacts of the cooling, lighting, motor drive, and CHP measures described above were figured on the basis of all building floor space, including net additions during 2001-2006. Implicitly, therefore, the DSM portfolio includes the impacts of those major measures in new construction.

Motors and motor drive systems in non-residential buildings are used in cooling, ventilation, and other applications. A number of efficient motors and motor drive improvement measures were assessed. Though they there were screened and found cost-effective, they are not included in the portfolio due to uncertainty about the extent of energy saving opportunities—, [though some of these measures are likely to be implicitly included in programs such as non-residential efficient cooling](#).

### 3.2.3 Industrial Measures

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The major areas for efficiency gains in the industrial sector relate to (1) motor and motor drive improvements, and (2) introduction of CHP systems to meet thermal and electric requirements. The DSM portfolio includes motor and motor drive improvements, as well as introduction of CHP systems. In addition, it includes a load management program. Discussion of these measures follows. Documentation of sources is provided in the appendices.

**Medium commercial/industrial load management.** Load management programs for medium and large sized commercial and industrial electricity have typically take the form of rate credits in exchange for customer agreements to shed load under conditions specified in interruptible or curtailable rate contracts. PacifiCorp has special rate contracts with its largest electricity users which users that include provisions for interruption. In addition, at the end of 2000 PacifiCorp developed a load management program for customers in the 1 to 4 MW range. Participants will receive a quoted market price for hourly energy demand that they reduce, less what they would have paid for energy under their rate schedule. This is a “demand exchange” pilot program designed to secure economic benefits for PacifiCorp during periods of high system demand and high power market prices. For the DSM study we considered additional load management among PacifiCorp customers, focusing on customers whose annual demands fall in the 1 to 10 MW range, and who could offer at least 200 kW of non-firm load. In particular, we evaluated a more traditional type of load management program, pursuant to which participating customers would receive a rate credit derived from an incentive of \$50 per kW-year of non-firm (i.e., interruptible) load. This fixed credit is lower than the resource value of demand reductions. Such a program could co-exist with the demand exchange program, as it is common for utilities to offer a mix of voluntary load-management products. The program could appeal to sufficient customers to yield an additional 25 MW of interruptible load within two years. We assumed that participation from industry customers and commercial customers will be proportional to the energy usage among eligible customers from each sector.

**Combined heat and power.** Typically, a manufacturing firm purchases electricity for motors, plant lighting, electro-chemical processes, etc., and buys fuels to generate heat at on-site boilers or furnaces to meet its process thermal needs. The electricity is generated at power plants distant from the industrial site at an efficiency of 30 to 40 percent, so most of the energy content of the fuel is wasted as heat to the surrounding environment. Further energy losses occur in transmission of electricity from the power plants to the industrial site, and in distribution as well for companies served at lower voltages. At the same time, the on-site thermal energy is produced at efficiencies in the neighborhood of 70 percent. Instead of such separate generation of electricity and process heat, CHP systems generate electricity on-site, using heat that would be wasted in conventional power plants in order to meet in-plant thermal requirements. With an overall system efficiency of up to 90 percent, the incremental efficiency of co-generating the electricity can be greater than 80 percent. Several CHP technologies were screened — CT type systems and diesel ICEs at different size configurations, all fueled by gas. There is relatively little CHP in any sector in Utah at present — estimates range between 21 and 45 MW in total, mostly fueled by gas. The potential for CHP was estimated based on the distribution of energy use by type of industry in Utah, and on *The Market and Technical Potential for Combined Heat and Power in the Industrial Sector*, prepared for the EIA in January, 2000. Costs for

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CHP elements (boilers, turbines, generators, maintenance, etc.) were obtained from EIA reports and from individual vendors. We estimated that with actively marketed programs, delivering an incentive equivalent to 30 percent of the installed cost of a CHP system in the form of below-market loan financing, nine percent of the CHP potential in the EIA report, or 54 MW, could be realized by 2006.

**Efficient motors.** Motors and motor drive systems are used in every kind of industry and in many industrial applications. Savings are based on premium efficiency motors in lieu of replacement of existing motors with standard equipment, in lieu of rewinding older motors for continued use, and in new applications. Under the rubric of “efficient motors” are those premium efficiency motors being promoted by the Consortium for Energy Efficiency. In addition, better sizing of motor capacity to match loads is a source of energy savings. DOE’s MotorMaster software and program promote selection of the optimal combination of motor efficiency and motor sizing for given operating requirements. We presume that, following MotorMaster, a DSM program can combine optimal efficiency and proper sizing through the design of program incentives. We assumed that financial incentives would cover 40 percent of incremental capital costs of efficient motors measures. In practice, motor-related DSM programs elsewhere have often had more difficulty meeting their targets than DSM programs in other areas like lighting. Our market penetration target of affecting a cumulative 27 percent of electric motor energy over six years may therefore be near the practical limit of achievability.

**Improved motor drive practices.** In addition to properly sized efficient motors themselves, there is a range of other efficiency improvements possible for motor drive systems. Major types of improvement were summarized in the study *Opportunities for Industrial Motor Systems in the Pacific Northwest*, prepared for the Northwest Energy Efficiency Alliance in 1999, as follows:

- Compressed air systems — electricity savings can be pursued through improved control of compressed air drives, improvements in air delivery systems, plugging leaks, and other measures.
- Fan systems — savings can be pursued through variable speed controls of motor drive, improved fans and blowers, and other measures.
- Pump systems — improved pumps, more efficient piping, variable speed controls of motor drive, and other measures.

We include measures in all three areas in a motor drive efficiency program option with the same market penetration target and incentive assumption as for the efficient motors option.

**Other measures.** In addition to the motor drive opportunity areas, which cut across that cross-cut most types of industry, there are other industry-specific process measures that might provide cost-effective efficiency gains. Opportunities are often so site-specific that estimation of additional applicable measures and their incremental costs and savings should be based on energy audits of individual enterprises. As the efficient motors and motor drive improvements program measures have wide applicability across a range of industries, the present estimate of achievable industrial sector DSM is based on those measures; the CHP measures; and the load

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management program. In addition, industrial firms’ office buildings are generally served on commercial rates, and thus were included in preparing the commercial sector DSM potential.

### 3.3 Summary of DSM Opportunities

The range of demand-side measures (technologies and practices) that were assessed and found cost-effective are grouped into 14 sets of measures which constitute the achievable DSM portfolio:

<u>Residential Measures</u>	<u>Commercial/Institutional Measures</u>	<u>Industrial Measures</u>
<ul style="list-style-type: none"> <li>• Load control of air conditioners</li> <li>• Efficient cooling equipment</li> <li>• Residential lighting</li> <li>• Appliance recycling</li> </ul>	<ul style="list-style-type: none"> <li>• Load control of CACs</li> <li>• Load management</li> <li>• Efficient cooling equipment and systems</li> <li>• Commercial lighting</li> <li>• Efficient refrigeration</li> <li>• Combined heat &amp; power</li> </ul>	<ul style="list-style-type: none"> <li>• Load management</li> <li>• Efficient motors</li> <li>• Motor drive improvements (fans, pumps, compressed air)</li> <li>• Combined heat &amp; power</li> </ul>

The 14 groupings are comprised of some 30 major measures, each of which in turn is comprised of several technologies.

### 3.4 Delivering DSM Measures: Program Assumptions

In order to achieve real-world market penetration of DSM measures that may screen as cost-effective resource options, it is necessary to develop and field programs ~~which that~~ effectively promote changes in the market behaviors of the potential sellers, buyers, and users of the measures identified. Therefore, assumptions about DSM programs are built into cost-effectiveness screening and evaluation. In addition to the basic cost and performance characteristics of the measures, program assumptions include:

- adjusting savings estimates to incorporate program participants who would likely have installed the measure without any DSM program (“free riders”);
- assuming financial incentives for each measure;
- including administrative costs reflecting the marketing and overhead of the agency (utility or other) delivering DSM programs;
- combining some measures into one assumed program option (as shown in sections 3.3 and 4.4); and
- estimating the achievable market penetration of each program.

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The DSM program features assumed in this study are not specific program proposals or complete program designs. Rather, they are program assumptions used to motivate a realistic analysis of achievable DSM. Some programmatic assumptions were mentioned in the discussions of measures above. The full set of program assumptions used is reported in the appendices. Here, we discuss the methods used to develop the programmatic assumptions employed in the analysis.

**Free riders.** For some types of DSM programs, there will be participants who would have installed program measures without the program. Programs for which we made explicit free ridership assumptions are the evaporative cooling portion of the residential cooling program, the residential CFL program, the commercial lighting program, the commercial refrigeration program, and the commercial and industrial motors and motor drive programs. The free ridership assumptions reduce the savings attributed to each measure.

Some argue that free ridership need not be estimated, because DSM also has market transformation effects. For example, a DSM program may encourage energy conservation behaviors by consumers who do not participate in the program, or conservation behaviors by participants that go beyond the measures in the program. These behaviors are called “free driver” effects, and program evaluations sometimes attempt to identify them and quantify the “extra” savings. Further, the level of conservation behaviors in the market may be higher after a program comes to an end than it would have been absent DSM. Indeed, some evaluation studies have demonstrated such market transformation effects. Though “free driver” or market transformation effects are likely, their magnitude is uncertain. To be cautious in modeling a six-year DSM investment initiative, we quantified only savings that would result from participation in the programs, net of estimated free ridership.

Free ridership is zero for the load control and load management programs. Absent the development of these programs there is little reason to believe that the load reductions from them would occur. Free ridership is also zero for the CHP programs, because CHP is unlikely to become attractive in the Utah market during the analysis period. (Free ridership is implicit in the savings estimates for both the efficient CAC portion of the residential cooling program and the appliance recycling program, and thus zero.)

**Financial incentives.** The cumulative experience with DSM has been that programs with high participation rates combine financial incentives with other elements such as credible sponsorship, active marketing, effective liaison with dealers, vendors, and contractors, quality control (QC), and sufficient time in the market to gain recognition in all the relevant market channels. Creatively designed DSM programs have sometimes achieved some market penetration without the application of external funds to create financial incentives. Conversely, DSM programs using financial incentives have sometimes experienced much lower levels of participation than expected. However, incentives are usually a necessary part of an effective program, and we have included incentive assumptions with all measures in our portfolio. The incentives vary from 30 to over 100 percent of the incremental cost of the measure and are judgmentally selected based on the nature of the market, the attractiveness of the measure to potential users without incentives, and the previous experience of DSM programs.

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**Administrative costs.** Agencies or utilities delivering DSM programs incur costs for program design, communications and marketing, processing of applications, management of contractors, QC, and program monitoring, measurement, verification, and evaluation. These costs must be estimated and added to the costs of DSM measures themselves in order to capture the full resource cost of DSM. Only DSM programs whose resource savings exceed the costs of program measures and program administration are cost-effective choices. Explicit administrative costs have been estimated for each of the programs included in the DSM portfolio. Our program-specific assumptions are identified and documented in the appendices. Administrative costs generally consist of start-up costs to develop and roll out a program, plus ongoing annual costs thereafter.

**Market penetration.** The present study models a six-year DSM initiative, with a year 2001 phase-in and full-scale operation during 2002 through 2006. Though DSM investment is not assumed beyond 2006, the ~~full~~ lifetime savings of measures installed during this period are included in the analysis for the period through 2025. The six-year scenario could be extended out in time by assuming that even though base and efficient technologies evolve the cost-to-savings relationships of the present DSM portfolio persist into the future. The market penetration targets chosen for each measure and program are judgmentally derived based on the incentives we have assumed and on what has been achieved by effective DSM programs elsewhere. In the case of the evaporative cooling measure within the residential cooling program, there is very limited experience with comparable programs and the market penetration target is preliminary in nature.

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## 4. DSM Measure Cost Effectiveness Evaluations

### 4.1 The Nature of Cost-Effectiveness Evaluation

The total resource cost or “TRC” perspective identifies all demand-side options the cost of which is lower than that of the electricity supply needed in their absence. It then asks whether market interventions to promote use of those options can be mounted at reasonable cost and with reasonable success by the entity charged with assessing and implementing DSM.

To compare supply-side and demand-side options requires a common economic framework. In particular it requires a discount ~~rate which rate that~~ is not ~~that specific to of~~ any particular household or business, but rather one which reflects an aggregate or “societal” time value of money. For example, for fiscal 1999 the U.S. Office of Management and Budget used a discount rate of 6.9 percent real (net of inflation) as a starting point in cost-benefit analysis of public projects. In assessing DSM that may be funded through electric utility rates, the utility’s weighted long-term cost of capital is often used as a proxy for a societal discount rate. The real discount rate used in this DSM analysis is 4.9 percent, from a July, 2000, PacifiCorp filing before the Utah Public Service Commission.

The TRC perspective is holistic — that is, it asks what are the total resource costs of supply-side and DSM options for an aggregate group, in this case Utah’s electric utilities and customers as a whole. The intent is to minimize the total economic cost of meeting the needs served by electricity, *i.e.*, to maximize economic welfare.

The TRC perspective does not address the distribution of costs and benefits among members of the group. DSM provides resource savings by getting individual customers to voluntarily enlist in programs that are beneficial to them. Participants benefit directly, for when they implement efficiency measures made possible for them by DSM, their electric bills go down. But if there are increases in rates as a result of DSM, non-participants may not benefit, or may benefit only indirectly. The Rate Impact Measure or “RIM” test assesses the cumulative present value of DSM’s effect on rates in order to provide an initial indication of impacts on non-participants. Due to the increasing costs of electricity supply in Utah and the region, it appears that the DSM portfolio as a whole will contribute to rate decreases.

Additionally, issues of distributional equity have been addressed by creating a variety of DSM programs in which members of all customer classes may sooner or later participate, by limiting or capping the rate impact attributable to DSM, or by creating completely subsidized services for low-income households (as opposed to the partial subsidies usually employed as incentives in DSM programs).

The cost-effectiveness evaluations in this study do not place dollar values upon the non-economic benefits from DSM — for example, the fact that ~~#~~DSM measures (with the exception

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of CHP systems) produce no direct air emissions, whereas electric generation produces both air pollutants and greenhouse gases. Such “externalities” can be monetized, but here they are addressed qualitatively.

Cost-effectiveness evaluation proceeded in three stages:

- qualitative assessment;
- preliminary cost-benefit screening; and
- final cost-effectiveness evaluation using the ECO<sup>tm</sup> DSM model.

#### 4.2 Qualitative Assessment of Potential DSM Measures

Demand-side analysis begins with characterization of the attributes of potential DSM measures. Key attributes are identified in the following table.

**Key Attributes of DSM Options**

Attribute	Information about the Attribute
Applicability	To what sectors and end-uses can the DSM measure be applied? What is the size of the market for which the measure is applicable?
Reliability and lifetime	How has the measure performed in previous applications? What is its typical lifetime?
Efficiency	How much energy and power does the measure save, relative to standard equipment?
Capital and operating costs	What does it cost to own, operate, and maintain the technology?
Other resource impacts	Does the technology save and/or consume other resources, such as gas or water, and how much?
Environmental impacts	What are the impacts of the technology, relative to standard equipment?

The study team assembled data on the key attributes of potential DSM measures from databases of technologies, DSM evaluation studies, equipment and appliance vendors, Utah agencies, several utilities, groups specializing in efficiency (the American Council for an Energy-Efficient Economy, the Northwest Energy Efficiency Alliance, and others), engineers and technology specialists, and other sources, as acknowledged in the text and appendices of this report.

The first stage of the study was pre-screening or qualitative assessment. In this stage, an extensive set of technologies was scrutinized in order to make a preliminary and judgmental classification of options as high, mid, and low priority for inclusion in the study. The principal technologies-technology types considered are listed in the following table.

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## Electric End-Use DSM Measures

### Residential Sector

- Higher efficiency appliances (air conditioners, heat pumps, evaporative coolers, refrigerators, stoves, water heaters, electronic devices, others)
- Devices that save hot water (efficient washing machines, plumbing fixtures)
- Compact fluorescent lamps; automatic lighting controls
- Building envelope improvements (insulation, window improvements, orientation)
- Appliance recycling—refrigerators and freezers
- Load control—air conditioners and water heaters

### Commercial/Institutional Sectors

- Higher efficiency air conditioning (packaged AC, electric chillers, gas engine driven/chiller systems, indirect/direct evaporative cooling)
- Higher efficiency refrigeration equipment
- Higher efficiency lighting (fluorescent bulbs, lamp ballasts, and several other technologies)
- Controls: lighting, cooling, space heating, water heating
- Higher efficiency office equipment
- Building envelope improvements
- Electric motors, drives, and controls
- Load control—air conditioners
- Load management
- Combined heat & power—several systems

### Industrial Sector

- Higher efficiency electric motors
- Proper motor sizing
- Compressed air system improvements
- Pump system efficiency improvements
- Fan systems efficiency improvements
- Other process energy measures
- Load management
- Combined heat & power—several systems
- Applicable commercial/institutional sector lighting and cooling measures

### Other Sectors

- Higher efficiency pumping, cooling, and refrigeration equipment for the agricultural sector
- Higher efficiency lighting products for street lighting

Also assembled for use in screening were forecasts of residential population, housing types, households, and electric loads (energy, demand); commercial/institutional employment and floor space by building type, and electric loads; industrial employment by category of manufacturing, and electric loads; and allied demographic/economic/energy data as required to project the potential market penetration of each DSM measure.

### 4.3 Cost/Benefit Screening

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The second stage of the study involved formal screening of high and mid priority options. Using information on the key characteristics of DSM measures that had been assembled, including heuristic program assumptions, the list of measures was screened to determine which would be input to the DSM assessment model. Screening the list of DSM options involved application of quantitative and qualitative screening criteria (see box, below right).

In order to perform screenings, avoidable supply costs were developed, as described in section 5. Information on Utah Power Company rates and Questar Gas Company rates was also collected. Information on avoided costs and retail rates was not collected for the other electric utilities in the State. Our statewide screening results are thus indicative of costs and benefits outside the Utah Power Co. area only to the extent that avoided costs and retail rates are similar in those areas. Long-run avoided power supply costs are likely to be somewhat similar.

#### DSM Measure Screening — Outputs

- Life-cycle cost of energy-efficiency measure, vs. standard alternative
- Benefit/Cost ratios expressing cost-effectiveness of measure: Measures with B/C ratio much greater than 1:1 likely to be cost-effective, less than 1:1 not cost-effective, near 1:1 questionable
- Cost per unit energy saved (expressed as net capital/O&M costs per unit electricity saved)

Further qualitative assessment of customer acceptance

Four cost-effectiveness tests are calculated. The basic perspective used both in the screening stage and in the final cost-effectiveness assessment stage is total resource cost perspective, which identifies demand-side options the cost of which is lower than that of the electricity supply needed in their absence. The TRC perspective is holistic — it assesses the total resource costs of supply-side and DSM options for electricity consumers as a whole. When DSM options cost less than avoided supply, they reduce the total economic cost of meeting the needs served by electricity, *i.e.*, they reduce electric revenue requirements and increase economic welfare. The TRC used here is the Utah TRC, wherein benefits consist only of avoided electric supply costs, without any adders, as described in *Utah Demand Side Resource Program Performance Standards*, a report prepared for the DSR Cost Recovery Collaborative by its Performance Standards Subcommittee in 1995.

The TRC perspective does not address the distribution of costs and benefits among individual customers within a given state or utility service area. For comparison, when a utility adds generation, transmission, or distribution capacity the costs of that new plant investment are seldom allocated to those customers whose load growth created the need for new capacity. Rather, the costs are rolled into rates in ways that spread incremental costs among broad classes of customers. Similarly, DSM provides resource savings by getting individual customers to voluntarily enlist in programs that are beneficial to them. Participants benefit directly, for when they implement efficiency measures made possible for them by DSM, their electric bills go down. But if there are increases in rates as a result of DSM, non-participants may not benefit, or may benefit only indirectly. In order to estimate the cumulative rate impact of DSM, we employ the rate impact measure (RIM) cost-effectiveness test, as defined in the document cited above.

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The other cost-effectiveness tests calculated were the participant and utility perspectives, also as defined in *Utah Demand Side Resource Program Performance Standards*. The participant test assesses whether a DSM measure, inclusive of program incentives, is cost-effective for participants. The utility test assesses whether a measure, excluding the participant's contribution to its costs, is cost-effective compared to avoided electric supply costs.

Screening worksheets were used to assess cost-effectiveness for all the measures included in the final DSM portfolio. There were several options for which screening B/C results were “negative” (*i.e.*, below 1:1) or were not positive enough to warrant their inclusion: efficient residential refrigerators, several gas air conditioning systems, and several CHP systems.

For options included in the DSM portfolio, demand-side assumptions are summarized beginning on page 47, and worksheets that provide the essential screening inputs and results are included in the Volume II, Appendix C. The benefit/cost results in the worksheets are preliminary. The final evaluation of cost-effectiveness is accomplished using the ECO<sup>tm</sup> tool. The ECO<sup>tm</sup> software tool is described in Volume II, Appendix A.

#### 4.4 Cost-Effectiveness Evaluation

The DSM portfolio evaluated using ECO<sup>tm</sup> consisted of 14 major options comprised of some 30 major measures. The major measures are in turn comprised of specific technologies, as described in the Appendix Cees.

Results for the options and major measures are summarized in the following table. Benefit to cost ratios are calculated from an investment perspective. The incremental installed cost of a measure is its cost. All operating costs relative to standard equipment are benefits. Electricity supply savings are positive benefits, but if a measure incurs incremental operating costs, these are netted against the electricity supply benefits. Modest one-time program start-up costs that would be incurred in the first year are not included in the table. They are included in the summary tables on pages 39 and 40. ~~The ECO<sup>tm</sup> software is also described in the appendices.~~

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## Benefit/Cost Results for DSM Options & Measures

### Residential Options

Option	Major Measures	TRC B/C Ratio	RIM B/C Ratio
Load control	Control of central air conditioners (CACs)	6.4	2.2
Efficient cooling		10.1	2.6
	Efficient CACs	3.0	2.5
	Evaporative cooling	40.0	2.7
Residential lighting	CFLs	6.3	-1.0
Appliance recycling	Refrigerator/freezer pickup	2.8	-0.2

### Commercial/Institutional Options

Option	Major Measures	TRC B/C Ratio	RIM B/C Ratio
Load control	Control of CACs	6.8	4.9
Load management	Customer-specific load responses	5.8	2.9
Efficient cooling		2.4	2.5
	Medium package AC system	5.7	5.3
	Large chiller system	1.6	1.5
	Indirect/direct evaporative cooling (IDDEC) -- medium	1.7	1.8
	IDDEC -- medium/large system	3.0	3.2
	IDDEC -- large system	1.6	1.8
Commercial lighting		3.5	1.6
	Advanced measures	3.0	1.3
	T8/electronic ballast, & similar	6.8	3.0
Efficient refrigeration		4.6	-1.7
	Higher cost technologies	3.2	-1.2
	Lower cost technologies	6.0	-2.3
Combined heat & power		5.3	-10.7
(All CHP systems are gas-fired)	30 kW micro-turbine	4.4	-11.0
	100 kW diesel	6.1	-12.0
	800 kW diesel replacing electric boiler	6.1	-11.9
	800 kW diesel replacing gas boiler	2.1	-5.7

### Industrial Options

Option	Major Measures	TRC B/C Ratio	RIM B/C Ratio
Load management	Customer-specific load responses	5.8	2.9
Efficient motors		4.4	4.5
	Motor downsizing	8.2	7.4
	Premium efficiency motors in lieu of rewinding	1.5	1.5
	Premium replacement motors	5.0	5.1
Motor drive improvements		4.9	-0.1
	Compressed air system measures	10.6	-0.1
	Fan system measures	10.6	-0.1
	Pump system measures	3.6	0.0
Combined heat & power		2.5	3.1
(All industry CHP systems are gas-fired and assumed to replace natural gas boilers)	800 kW diesel	2.1	3.2
	3 MW diesel	2.4	3.5
	10 MW combustion turbine (CT)	2.8	2.9

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## 5. The Resource Value of DSM Savings

### 5.1 Resource Value

From the perspective of resource economics, the value of DSM is measured by the electricity supply costs that would be required without the DSM savings to electricity use. These supply-side costs are collectively referred to as “avoided costs.”

One key element of avoided cost is the capital costs of electric generating plants. The two main types of capacity built in today’s electric industry are combustion turbines (CTs) and combined cycle units (CCs) fueled by gas. Combined cycle units are built to serve loads that operate about 25 percent of the year’s hours or more. Simple combustion turbines have lower capital costs and higher operating costs than CCs, and are built to serve loads that operate for fewer hours, and to provide the reserve capacity that all electric suppliers are required to have available.

Another element of avoided cost is the cost of raising the capital to finance plants. This is a combination of debt and equity financing. The cost of capital under regulated electricity supply is lower than under competitive electric supply, mainly due to a higher cost of equity.

Another type-category of avoided costs is plant operating costs. The non-fuel operating and maintenance costs for power plants are sometimes referred to as “fixed O&M,” which are largely independent of the output of a plant over time,- and “variable O&M”, which do vary with output.

The cost of fuel is another element of operating costs. Fuel costs have historically shown periods of volatility and are difficult to forecast. But one or more plausible projections of fuel costs for generation must be made.

Transmission and distribution (T&D) investment and maintenance is related to the level of electricity load served. Ideally, T&D requirements are based on a plan which identifies and costs needs under a range of plausible load forecasts. In addition to capital and financing costs, annual T&D maintenance expenses can be avoided due to new DSM programs.

Energy is lost between the points of generation and the points of end-use consumption. When electricity sales are reduced through customer-side DSM, there are corresponding reductions in the energy losses in the transmission and distribution system.

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## 5.2 Avoided Cost Estimates

To estimate the capital costs of electric generating plants, we used PacifiCorp's estimates of the capital costs of CT and CC units, as contained in Utah Power and Light Company's July [and October 2000 avoided cost filings](#) with the Public Service Commission. Despite the increasing costs of gas, we base capacity costs on gas-fired generation. The capital costs of coal plants are much higher, and their environmental impacts greater.

PacifiCorp is embedded in regional markets, in which it buys and sells electricity. California and other jurisdictions in Western electricity markets have removed generation from cost-of-service regulation, so we assumed costs of equity financing higher than PacifiCorp's regulated equity costs. We applied this [modestly somewhat](#) higher cost of money to the CT and CC capital costs.

For the non-fuel O&M costs for power plants, we used PacifiCorp's estimates for CTs and CCs. These costs are contained in its avoided cost filing. For the fuel cost element of avoided costs, we created a gas price scenario that is between PacifiCorp's forecast (in its October 2000 application to the Public Service Commission) and the actual market price of gas during the six months before this report.

To develop an estimate of avoided costs for distribution and transmission system investment, the amount of gross utility plant that PacifiCorp had invested in each kind of facility by December 31, 1999 was escalated to year-end 2000 [dollars](#) using inflation [factors](#), then divided by the peak demand in 1998 to [get estimate](#) a dollar per kiloWatt-year figure. This result is a conservative proxy for the average cost, [in 2000 dollars](#), of expanding Utah utilities' transmission and distribution system [in 2000 dollars](#), over the next 20 years as load grows. We did not assume that annual T&D system expenses could be avoided due to new DSM programs, another somewhat conservative assumption.

As transmission and distribution lines become more fully loaded, the rate of [electricity losses during transmission and distribution](#) increases. To estimate [transmission and distribution](#) losses, we therefore took PacifiCorp's average system [transmission and distribution](#) losses, and increased them somewhat to represent marginal loss effects.

The set of assumptions described here is used to project long-run avoided costs over the analysis period, which extends throughout the lifetime of DSM measures assumed installed during 2001-2006. Very high short-term prices for firm and non-firm energy were occurring in regional power markets at the time of this study, reflecting high gas prices, generation market imperfections, and the market power of generators in deregulated markets. We do not reflect these extraordinarily high prices in our avoided cost sets, as the hope is that they will prove transitory. In presenting study results in section 7.4, we note the additional near-term benefits of DSM which arise from avoiding such wholesale prices.

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### 5.3 Results of Resource Value Estimates

Application of the avoided cost methodology resulted in two sets of avoided costs. The real levelized avoided costs in year 2000 dollars are summarized here. The components of avoided costs are detailed in Appendix B in volume II.

In the case of generation based on the CT, generation capacity and T&D capacity total some \$145 per kW per year. Avoided variable energy costs are \$0.04 per kWh. These avoided costs are used in evaluating DSM options that reduce cooling loads, with the capacity components only being applied in evaluating load management options.

In the case of generation based on the CC, generation capacity and T&D capacity total \$175 per kW per year. Energy costs are \$0.027 per kWh. These avoided costs are used for all remaining options.

### 5.4 Sensitivity Analysis

The cost of gas for electric generation that was used in developing electric avoided costs is \$4.50 per million Btu. This nominal dollar value was used in each year of the analysis period, resulting in a declining real cost of gas. The results described in 5.3 above and in Appendix B reflect this cost of gas assumption.

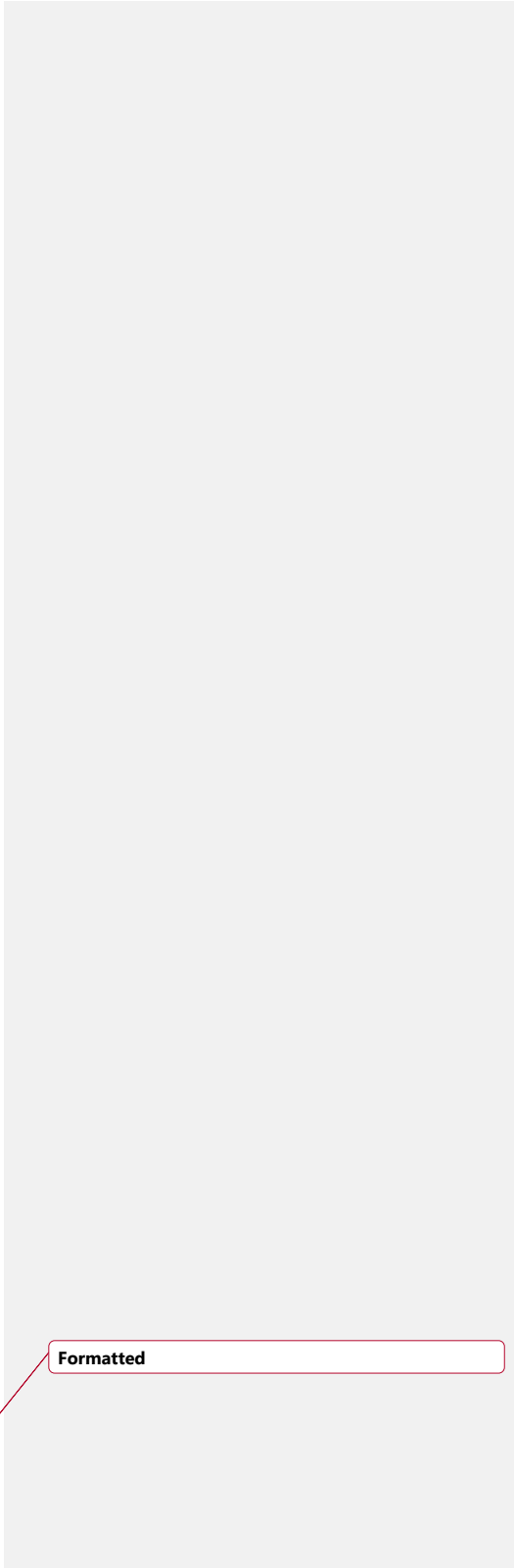
Though the authors regard \$4.50 as a mid-range assumption for gas costs, fuel prices are inherently uncertain and subject to volatility. An analysis was conducted to test the sensitivity of cost-benefit results to a lower gas cost price trajectory. For the sensitivity analysis the \$4.50 price was used only through 2002. Then gas prices used in the avoided costs filed by PacifiCorp with the Utah Commission in October, 2000, were employed. However, these prices were lagged two years, since at this writing gas prices appeared to be remaining well above the levels assumed in that filing. The results of the sensitivity analysis are described in section 7.5 and in Volume II, Appendix D.2.

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## 6. The Co-Benefits of DSM

### 6.1 Identifying DSM Co-Benefits

The main goal of DSM is to create economic benefits in the form of reductions in the direct economic costs of providing energy services. Additional benefits that result may be called co-benefits. Significant co-benefits from implementation of the measures included in the DSM portfolio would include:

- Reduction in emission of air pollutants
- Reduction in emission of greenhouse gasses
- Reduction in land use impacts of electricity supply
- Reduction in water use impacts of electricity supply
- Stimulation of the local economy

### 6.2 Air Ppollutants

Energy efficiency measures reduce the amount of air pollutants that are emitted from power plants. There are reductions in the sulfur oxide (SO<sub>x</sub>) and nitrogen oxide (NO<sub>x</sub>) emissions that are of particular concern from a health standpoint. These are calculated relative to the new, efficient gas-fired generation units that are used as the basis of the study's avoided cost estimates ~~DAVE NOT SO AT PRESENT~~. Although the gas-fired CHP systems included in the portfolio would produce emissions of their own, they also create a net reduction in emissions because the overall efficiency of electricity generation and on-site heating is increased through CHP. ~~The total cumulative reductions in emissions from the DSM portfolio for the period through 2019~~ The total cumulative reductions in emissions from the DSM portfolio for the period through 2025 are in the range of 500 to 780 tons of SO<sub>x</sub> and 16,700 to 26,100 tons of NO<sub>x</sub>. Because of the SO<sub>2</sub> cap and trade system established by the U.S. Clean Air Act Amendments of 1990, the benefits of the sulfur dioxide reductions are likely to be realized as additional monetary avoided cost savings rather than net reductions in emissions. ~~are 28.6 million tons of SO<sub>x</sub> and 103.6 million tons of NO<sub>x</sub>.~~

### 6.3 Greenhouse Ggasses

The energy efficiency and CHP measures in the DSM portfolio would yield net reductions in emissions of carbon dioxide, the greenhouse gas that contributes to warming of the global atmosphere and is the subject of national and international discussions about how to avert climate change. Total cumulative portfolio reductions in CO<sub>2</sub> emissions through 2025 are in the range of 16 to 25 million tons. ~~Total portfolio reductions in CO<sub>2</sub> are a cumulative 3.4 billion tons.~~

#### 6.4 Land and Water Use Impacts

Electricity generation requires both land for plant sites and water for cooling systems. In addition, transmission lines require land. Any reduction in the amount of electricity supply over time will tend to reduce these unavoidable impacts of electricity supply.

#### 6.5 Indirect Economic Impacts

Because demand-side management **DSM** reduces total customer bills for electricity, it frees up net disposable income for other uses. When all of the economic impacts of DSM are considered, its net impact on local employment is normally found to be positive. A recent study of these effects in a Western state is *Colorado's Energy Future: Energy Efficiency and Renewable Energy Technologies as an Economic Development Strategy*, by Skip Laitner and Marshall Goldberg, which quantified the co-benefits of energy efficiency in increasing state gross product, per capita expendable income, and net employment.

In other studies making quantitative estimates of the impact of DSM on state economies and net employment, it has uniformly been found to be a net plus. No study of these indirect economic effects was conducted for the present report.

## 7. Results

### 7.1 ~~The Goal of Estimating e-~~ Achievable DSM

This study aims to identify electricity savings that are potentially achievable through the application of new DSM program funding to actively promote those demand-side measures that can produce significant amounts of savings. We modeled implementing new DSM through a multi-year initiative, with a year 2001 phase-in and full-scale operation during 2002 through 2006. After 2006, we include the continuing lifetime savings from measures assumed installed during this period, up through 2025. Simple program assumptions regarding administrative costs and financial incentives for participation are incorporated to motivate a realistic analysis of achievable DSM.

### 7.2 Electricity Savings: Energy and Peak Demand

There is very substantial potential for achieving cost-effective electric energy and demand savings through a second generation of demand-side management in Utah. Statewide electricity savings from the DSM portfolio are graphed on pages 35 and 36 below. Reductions in summer peak demand would grow to 682 ~~megaWatts~~megawatts in 2006, then decline very gradually thereafter. These results assume that the measures in the portfolio would expire at the end of the normal lifetime of equipment installations or removals made before 2007. In addition, commercial and industrial load reduction is not carried beyond 2020. In fact, DSM measures may be replaced with new measures of equal or higher efficiency, and C/I load reduction may be carried further. Thus, the tapering off shown in the graphs need not occur in practice.

The peak demand reductions shown below result from load management, energy efficiency, and CHP measures combined. The contribution of efficiency measures to peak demand reductions is a byproduct of their ongoing lower levels of usage. The reduction in demand from the CHP measures arises from the fact that they are producing electricity for use in the host facilities instead of obtaining power through the electric grid.

Energy savings from the efficiency and CHP measures are shown in the second graph. Annual energy savings increase to 2,309 GWh in 2006, then decline gradually. Cumulative energy savings through 2025 are 40,700 GWh.

Tables ~~which~~ on pages 37 and 38 display the summer peak demand reductions and energy savings from the DSM portfolio for the period through 2025. The results described here are for Utah as a whole. Given the strong preponderance of PacifiCorp's service area in terms of population, economic activity, and energy use, the study's data and results are largely based on the nature, benefits, and costs of DSM opportunities in its area. Obviously, the magnitude of

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achievable DSM for each option and overall would in fact be somewhat less in the PacifiCorp service area than the totals for the State as a whole.

### 7.3 Economic Savings

The cumulative present value of energy resource savings from the measures in the portfolio is \$1,443,000 (2000 dollars). With total resource costs of \$370,000, the net benefit is \$1,073,000 and the benefit-to-cost (B/C) ratio is 3.9 to 1. Each option is cost-effective; B/C ratios range from 2.3 for commercial/institutional efficient cooling up to 10.0 for residential efficient cooling. All of the measures within each option are cost-effective, with B/C ratios ranging from 1.5 for new industrial premium efficiency motors in lieu of rewinding existing ones, up to 40.0 for residential evaporative cooling in lieu of refrigerative air conditioning. Measure-specific results in section 4.4 are intended to facilitate preliminary consideration of alternative mixes and levels of potential DSM measures, funding, and programs.

### 7.4 Cost-Effectiveness Rankings by Option

The cost-effectiveness of demand-side management measures can be aggregated to different levels. In the tables on pages 39 and 40 below, ~~this is done~~ results are reported for by the 14 major options into which we have bundled the various DSM measures.

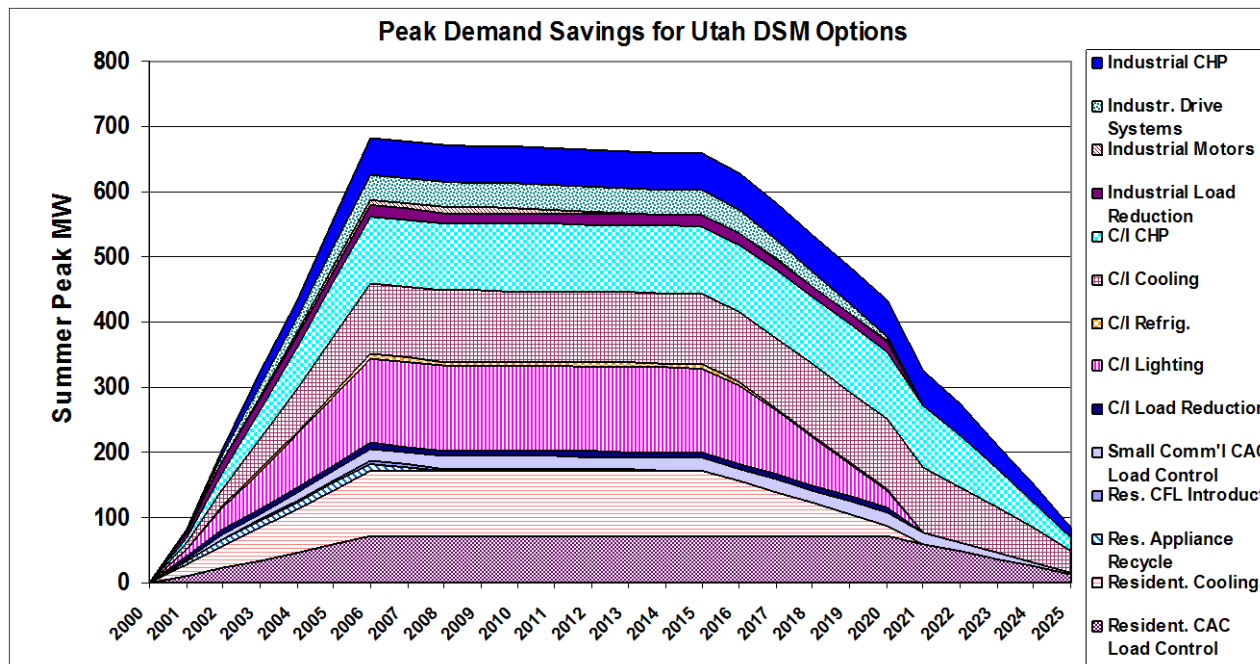
From the total resource cost perspective (page 39), all options are strongly cost-effective. The most cost-effective grouping is residential cooling. The relatively least cost-effective grouping is commercial/institutional cooling.

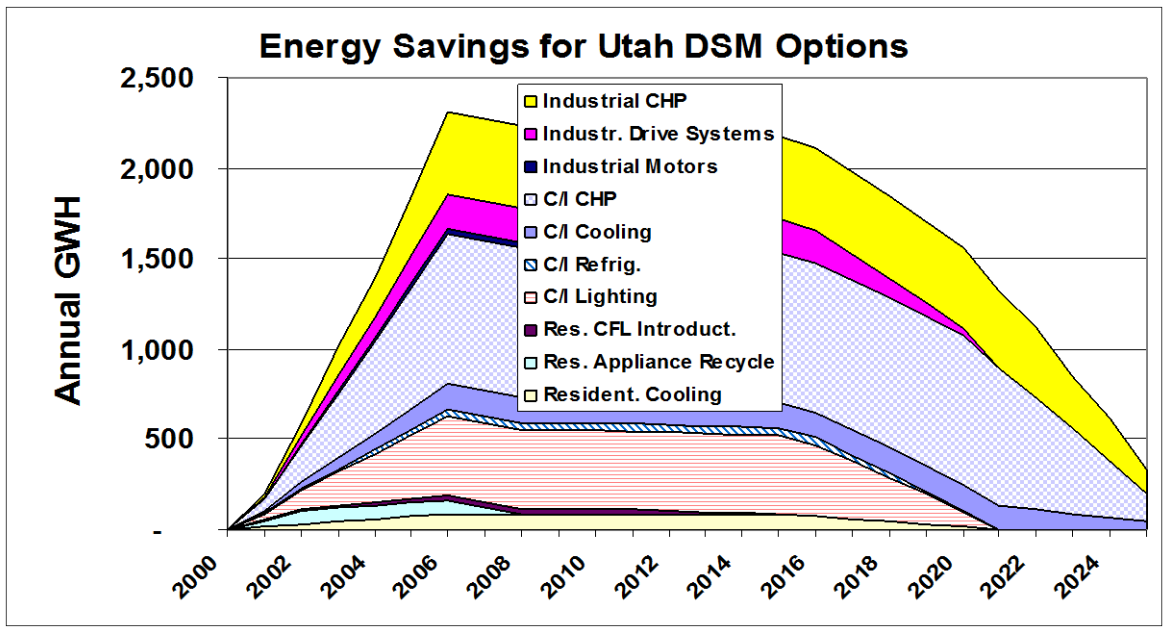
In the table on page 39, the costs of the measures themselves plus program administration are included in the “total costs” column. All of the changes in annual cash flows that result from installation of the DSM measures — avoided resource costs and incremental maintenance costs — are included in the “total benefits” column. If resource costs are incurred instead of saved, they are negative avoided resource costs (water and gas in the above table).

If customers incur incremental maintenance costs, they are deducted from total benefits rather than added to the total costs. (Where total costs do not equal customer plus utility costs, it is because some of the customer costs are maintenance costs subtracted from total benefits.)

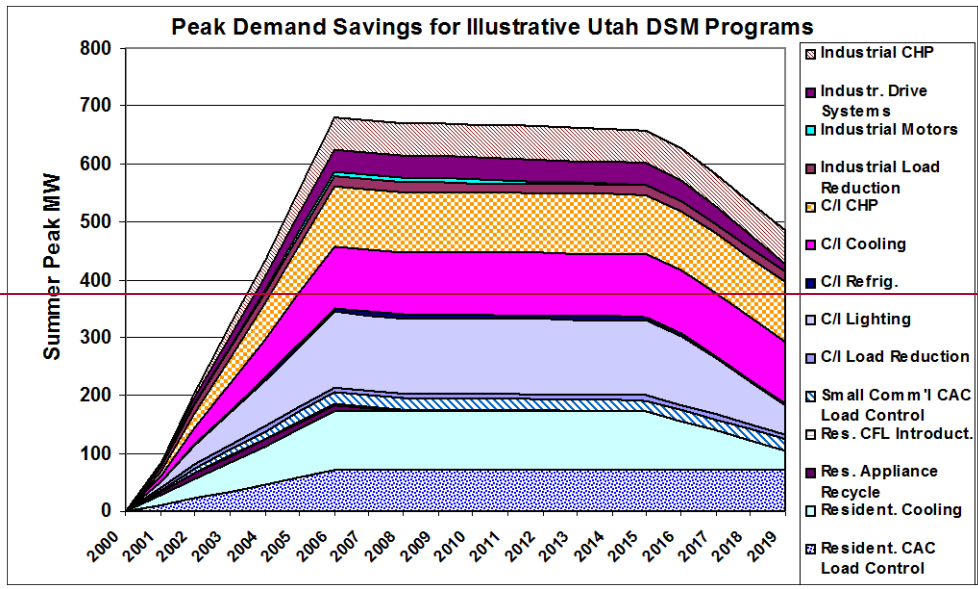
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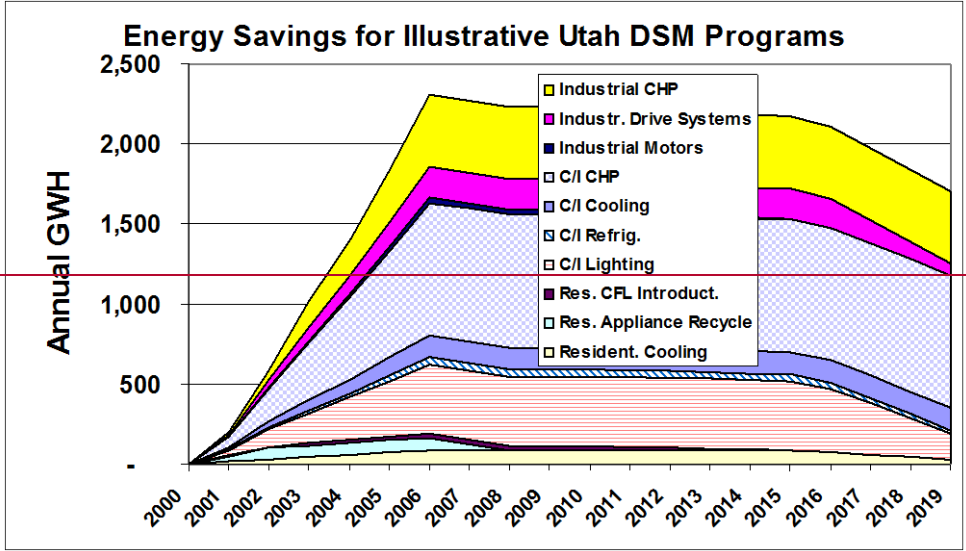




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MW Summer Peak Savings by Program and by Year

YEAR	Resident. CAC		Res. Res.		Small Comm'l		Industrial				Industr.			Total of			
	Load Control	Efficiency	Appliance Recycle	Res. CFL Introduct.	CAC Pro-gram	AC Load Control	C/I Load Reduction	C/I Lighting	C/I Refrig.	C/I Cooling	C/I CHP	Load Reduc-tion	Industrial Motors	Drive Systems	Motor CHP	All Programs	Total of All Options
2000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0
2001	11.1	16.5	8.3	0.2	9.4	8.3	56.6	2.7	46.9	44.8	16.7	3.7	16.2	21.0	322	322	
2002	28.4	33.6	10.8	0.7	16.2	8.3	104.8	5.6	87.8	83.5	16.7	7.0	30.5	40.4	555	206	
2003	71.0	100.6	10.8	3.9	19.5	8.3	130.0	6.3	108.0	103.4	16.7	8.8	37.9	56.6	682	682	
2004	34.1	49.7	10.8	1.5	9.4	8.3	56.6	2.7	46.9	44.8	16.7	3.7	16.2	21.0	322	322	
2005	146.1	166.5	10.8	0.2	12.7	4.2	99.4	0.5	66.1	64.0	16.7	5.4	23.2	27.2	434	83	
2006	28.4	33.6	10.8	0.7	16.2	8.3	104.8	5.6	87.8	83.5	16.7	7.0	30.5	40.4	555	206	
2007	71.0	100.6	10.8	3.9	19.5	8.3	130.0	6.3	108.0	103.4	16.7	8.8	37.9	56.6	682	682	
2008	34.1	49.7	10.8	1.5	9.4	8.3	56.6	2.7	46.9	44.8	16.7	3.7	16.2	21.0	322	322	
2009	71.0	100.6	10.8	3.9	19.5	8.3	130.0	6.3	108.0	103.4	16.7	8.8	37.9	56.6	682	682	
2010	49.1	60.5	10.8	3.9	19.5	8.3	130.0	6.3	108.0	103.4	16.7	8.8	37.9	56.6	682	682	
2011	58.4	60.5	10.8	3.9	19.5	8.3	130.0	6.3	108.0	103.4	16.7	8.8	37.9	56.6	682	682	
2012	71.0	100.6	10.8	3.9	19.5	8.3	130.0	6.3	108.0	103.4	16.7	8.8	37.9	56.6	682	682	
2013	71.0	100.6	10.8	3.9	19.5	8.3	130.0	6.3	108.0	103.4	16.7	8.8	37.9	56.6	682	682	
2014	71.0	100.6	-	-	19.5	8.3	130.0	6.3	108.0	103.4	16.7	0.7	37.9	56.6	660	660	
2015	71.0	100.6	-	-	19.5	8.3	130.0	6.3	108.0	103.4	16.7	0.7	37.9	56.6	659	659	
2016	71.0	100.6	5.5	3.4	19.5	8.3	130.0	6.3	108.0	103.4	16.7	5.3	37.9	56.6	667	676	
2017	71.0	100.6	-	-	19.5	8.3	130.0	6.3	108.0	103.4	16.7	3.8	37.9	56.6	665	671	
2018	71.0	100.6	-	-	19.5	8.3	130.0	6.3	108.0	103.4	16.7	2.3	37.9	56.6	662	671	
2019	71.0	100.6	-	-	19.5	8.3	130.0	6.3	108.0	103.4	16.7	0.3	37.9	56.6	660	670	
2020	71.0	100.6	-	-	19.5	8.3	130.0	6.3	108.0	103.4	16.7	0.3	37.9	56.6	659	669	
2021	71.0	100.6	-	-	19.5	8.3	130.0	6.3	108.0	103.4	16.7	0.3	37.9	56.6	659	669	
2022	71.0	100.6	-	-	19.5	8.3	130.0	6.3	108.0	103.4	16.7	0.3	37.9	56.6	659	669	
2023	71.0	100.6	-	-	19.5	8.3	130.0	6.3	108.0	103.4	16.7	0.3	37.9	56.6	659	669	
2024	71.0	100.6	-	-	19.5	8.3	130.0	6.3	108.0	103.4	16.7	0.3	37.9	56.6	659	669	
2025	71.0	100.6	-	-	19.5	8.3	130.0	6.3	108.0	103.4	16.7	0.3	37.9	56.6	659	669	

**GWH Savings by Program and by Year**  
**GWH Savings by Option and by Year**

YEAR	Resident					Industrial					Total of All Programs								
	Resident Cooling	Appliance Recycle	Res. CFL	C/I Lighting	C/I Refrig.	Industrial Motors	Drive Systems	Industrial CHP	Industrial Drive Programs										
2000	14	-	37	-	1	-	37	-	4	-	12	-	65	-	2	13	19	-	204
2001	29	14	76	37	5	112	37	11	4	36	201	85	46	2	62	13	586	19	204
2002	44	29	76	76	10	189	112	18	1	61	358	201	81	8	168	46	019	62	586
2003	58	44	76	76	16	268	189	26	1	87	511	21	116	15	218	81	397	168	1,019
2004	73	44	76	76	21	350	268	34	2	113	667	28	152	21	323	116	837	218	1,397
2005	88	58	76	76	27	433	268	42	2	140	826	33	190	21	453	116	309	218	1,397
2006	88	73	39	76	27	433	350	42	3	140	826	33	190	28	453	152	272	323	1,837
2007	88	88	-	76	27	433	433	42	4	140	826	33	190	35	453	190	234	453	2,309
2008	88	88	-	39	27	433	433	42	4	140	826	33	190	35	453	190	232	453	2,272
2009	88	88	-	-	26	433	433	42	4	140	826	33	190	35	453	190	225	453	2,234
2010	88	88	-	-	22	433	433	42	4	140	826	33	190	32	453	190	215	453	2,232
2011	88	88	-	-	17	433	433	42	4	140	826	33	190	27	453	190	204	453	2,225
2012	88	88	-	-	11	433	433	42	4	140	826	33	190	21	453	190	193	453	2,215
2013	88	88	-	-	6	433	433	42	4	140	826	33	190	21	453	190	181	453	2,215
2014	88	88	-	-	-	433	433	42	4	140	826	33	190	15	453	190	175	453	2,204
2015	88	88	-	-	-	397	433	42	4	140	826	33	190	9	453	190	107	453	2,193
2016	74	88	-	-	-	397	433	39	4	140	826	33	176	9	453	190	107	453	2,193
2017	59	88	-	-	-	322	433	31	4	140	826	33	143	3	453	190	976	453	2,181
2018	45	88	-	-	-	245	433	24	4	140	826	33	109	3	453	190	842	453	2,181
2019	45	88	-	-	-	245	433	24	4	140	826	33	109	3	453	190	842	453	2,175
2020	30	74	-	-	-	165	397	16	3	140	826	33	73	3	453	176	705	453	2,107
TOTAL 2017	1,306	59	455	-	244	6,417	32,624	2,274	13	362	2806	2,806	2,7130	-	184	913	-	453	1,976
2018	45	-	-	-	-	245	24	140	826	2	109	453	1,842	-	-	-	-	453	1,842
2019	30	-	-	-	-	165	16	140	826	1	73	453	1,705	-	-	-	-	453	1,705
2020	15	-	-	-	-	84	8	140	826	1	37	453	1,564	-	-	-	-	453	1,564
2021	-	-	-	-	-	-	-	130	761	-	-	434	1,325	-	-	-	-	434	1,325
2022	-	-	-	-	-	-	-	110	625	-	-	390	1,126	-	-	-	-	390	1,126
2023	-	-	-	-	-	-	-	89	468	-	-	285	842	-	-	-	-	285	842
2024	-	-	-	-	-	-	-	67	315	-	-	235	617	-	-	-	-	235	617
2025	-	-	-	-	-	-	-	43	159	-	-	130	331	-	-	-	-	130	331
TOTAL	1,321	455	244	6,501	632	2,854	16,515	297	2,843	9,056	40,718	-	-	-	-	-	-	-	-

**Ranking of DSM Options by TRC ~~Cost~~-Benefit:Cost Ratio**

Dollars~~Savings~~ in \$1000, Present Value 2000

Measure Group	Program Costs		Resource Savings		Total Benefits	Total Costs	Net Benefits
	"Utility"	Customer	Electricity	Other			
Residential Efficient Cooling	\$ 38,060	\$ (21,291)	\$ 297,672	\$ (2,699)	\$ 294,973	\$ 16,769	\$ 278,204
Commercial A.C. Load Control	\$ 6,524	\$ (1,757)	\$ 55,066	(water)	\$ 55,066	\$ 4,767	\$ 50,299
Industrial Load Management	\$ 9,892	\$ (4,885)	\$ 55,672		\$ 55,672	\$ 5,007	\$ 50,665
Commercial/Institutional L.M.	\$ 4,947	\$ (2,443)	\$ 27,839		\$ 27,839	\$ 2,504	\$ 25,335
Residential A.C. Load Control	\$ 53,301	\$ (35,139)	\$ 200,235		\$ 200,235	\$ 18,162	\$ 182,073
Commercial/Institutional C.H.P.	\$ 13,703	\$ 80,526	\$ 557,640	\$ (87,493)	\$ 420,073	\$ 44,155	\$ 375,918
Residential Efficient Lighting	\$ 1,919	\$ (467)	\$ 13,097	(gas)	\$ 13,097	\$ 1,452	\$ 11,645
Motor Drive Improvements	\$ 9,405	\$ 12,623	\$ 165,491		\$ 165,491	\$ 22,028	\$ 143,463
Efficient Electric Motors	\$ 1,381	\$ 4,223	\$ 23,951		\$ 21,582	\$ 3,235	\$ 18,347
C/I Efficient Refrigeration	\$ 1,923	\$ 2,596	\$ 30,075		\$ 30,075	\$ 4,519	\$ 25,556
Commercial Efficient Lighting	\$ 42,268	\$ 49,618	\$ 516,547		\$ 516,547	\$ 91,886	\$ 424,661
Industrial C.H.P.	\$ 13,873	\$ 63,068	\$ 292,757	\$ (52,069)	\$ 207,049	\$ 43,303	\$ 163,746
Residential Appliance Recycling	\$ 12,275	\$ (4,603)	\$ 30,404	(gas)	\$ 30,304	\$ 7,672	\$ 22,632
Commercial/Institutional Cooling	\$ 54,291	\$ 46,981	\$ 352,020		\$ 352,020	\$ 101,272	\$ 250,748
Sum of All Options	263,762	189,050	2,618,466		2,390,023	366,731	2,023,292

Option Group	Program Costs		Resource Savings		Total Benefits	Total Costs	Net Benefits	B/C Ratio
	"Utility"	Customer	Electricity	Other				
Residential Efficient Cooling	\$ 38,210	\$ (21,291)	\$ 172,018	\$ (2,718)	\$ 169,300	\$ 16,919	\$ 152,381	10.0
Commercial A.C. Load Control	\$ 6,717	\$ (1,826)	\$ 32,399	(water)	\$ 32,399	\$ 4,891	\$ 27,508	6.6
Residential A.C. Load Control	\$ 55,774	\$ (36,508)	\$ 117,817		\$ 117,817	\$ 19,266	\$ 98,551	6.1
Residential Efficient Lighting	\$ 2,019	\$ (467)	\$ 9,086		\$ 9,086	\$ 1,552	\$ 7,534	5.9
Industrial Load Management	\$ 10,228	\$ (5,046)	\$ 29,971		\$ 29,971	\$ 5,182	\$ 24,789	5.8
Commercial/Institutional L.M.	\$ 5,114	\$ (2,523)	\$ 14,987		\$ 14,987	\$ 2,591	\$ 12,396	5.8
Commercial/Institutional C.H.P.	\$ 13,804	\$ 87,505	\$ 437,553	\$ (144,579)	\$ 235,921	\$ 44,256	\$ 191,665	5.3
Motor Drive Improvements	\$ 9,605	\$ 12,623	\$ 108,883	(gas)	\$ 108,883	\$ 22,228	\$ 86,655	4.9
C/I Efficient Refrigeration	\$ 2,123	\$ 2,596	\$ 20,695		\$ 20,695	\$ 4,719	\$ 15,976	4.4
Efficient Electric Motors	\$ 1,679	\$ 1,985	\$ 15,279		\$ 15,279	\$ 3,664	\$ 11,615	4.2
Commercial Efficient Lighting	\$ 42,468	\$ 49,618	\$ 321,639		\$ 321,639	\$ 92,086	\$ 229,553	3.5
Residential Appliance Recycling	\$ 12,475	\$ (4,603)	\$ 21,438		\$ 21,438	\$ 7,872	\$ 13,566	2.7

**Ranking of DSM Options by RIM Benefit:Cost Ratio**  
Dollars in \$1000, Present Value 2000

Option Group	Bill Savings	Electricity Supply Savings	Total Benefits	Total Costs*	Net Benefits	B/C Ratio
Commercial A.C. Load Control	\$ -	\$ 32,399	\$ 32,399	\$ 6,717	\$ 25,682	4.8
Efficient Electric Motors	\$ 7,667	\$ 15,079	\$ 7,612	\$ 1,912	\$ 5,700	4.0
Industrial C.H.P.	\$ 190,764	\$ 233,221	\$ 42,457	\$ 13,974	\$ 28,483	3.0
Industrial Load Management	\$ -	\$ 29,971	\$ 29,971	\$ 10,228	\$ 19,743	2.9
Commercial/Institutional L.M.	\$ -	\$ 14,987	\$ 14,987	\$ 5,114	\$ 9,873	2.9
Residential Efficient Cooling	\$ 55,320	\$ 172,018	\$ 116,698	\$ 44,946	\$ 71,752	2.6
Commercial/Institutional Cooling	\$ 100,562	\$ 238,407	\$ 137,845	\$ 56,242	\$ 81,603	2.5
Residential A.C. Load Control	\$ -	\$ 117,817	\$ 117,817	\$ 55,774	\$ 62,043	2.1
Commercial Efficient Lighting	\$ 250,637	\$ 321,639	\$ 71,002	\$ 46,143	\$ 24,859	1.5
Motor Drive Improvements	\$ 109,413	\$ 108,883	\$ (530)	\$ 11,090	\$ (11,620)	0.0
Residential Appliance Recycling	\$ 24,004	\$ 21,438	\$ (2,566)	\$ 12,475	\$ (15,041)	-0.2
Residential Efficient Lighting	\$ 11,141	\$ 9,086	\$ (2,055)	\$ 2,174	\$ (4,229)	0.9





In the table on page 40, the program groups are ranked in order of cost-effectiveness from the perspective of the rate impact measure (RIM). From the RIM perspective, the most cost-effective groupings are the commercial and industrial load management options.

Measure Group	Bill Savings	Electricity Supply Savings	Total Benefits	Total Costs	Net Benefits	B/C Ratio
Efficient Electric Motors	\$ 7,658	\$ 23,951	\$ 16,293	\$ 1,599	\$ 14,360	10.19
Industrial C.H.P.	\$ 161,604	\$ 292,757	\$ 131,153	\$ 13,874	\$ 117,279	9.45
Commercial A.C. Load Control	\$ -	\$ 55,066	\$ 55,066	\$ 6,524	\$ 48,542	8.44
Commercial Efficient Lighting	\$ 248,394	\$ 516,547	\$ 268,153	\$ 45,943	\$ 222,211	5.84
Industrial Load Management	\$ -	\$ 55,672	\$ 55,672	\$ 9,893	\$ 45,780	5.63
Commercial/Institutional L.M.	\$ -	\$ 27,839	\$ 27,839	\$ 4,947	\$ 22,892	5.63
Residential Efficient Cooling	\$ 54,888	\$ 297,672	\$ 242,784	\$ 44,796	\$ 197,988	5.42
Motor Drive Improvements	\$ 108,416	\$ 165,491	\$ 57,075	\$ 10,890	\$ 46,184	5.24
Commercial/Institutional Cooling	\$ 86,092	\$ 352,020	\$ 265,928	\$ 56,042	\$ 209,886	4.75
Commercial/Institutional C.H.P.	\$ 505,487	\$ 557,640	\$ 52,153	\$ 13,703	\$ 38,449	3.81
Residential A.C. Load Control	\$ -	\$ 200,035	\$ 200,235	\$ 53,301	\$ 146,934	3.76
C/I Efficient Refrigeration	\$ 24,141	\$ 30,075	\$ 5,933	\$ 2,115	\$ 3,818	2.81
Residential Efficient Lighting	\$ 11,141	\$ 13,097	\$ 1,956	\$ 2,074	\$ (119)	0.94
Residential Appliance Recycling	\$ 24,004	\$ 30,404	\$ 6,401	\$ 12,275	\$ (5,874)	0.52
Sum of All Options	\$ 1,231,825	\$ 2,618,266	\$ 1,370,348	\$ 276,377	\$ 1,093,970	4.96

The long-run impact of the DSM options on average rates is estimated based on projections of PacifiCorp's 2000 rates. Taken as a group, the energy efficiency, load management, and CHP options would reduce rates. This occurs because the electricity supply cost savings they yield comfortably exceed the sum of DSM funding and utility lost revenues. The cumulative net reduction to rates, after DSM funding, would be about ~~\$132-\$1m-1 billion~~ \$132-\$1m-1 billion. Due to the reductions in electric utility revenues that they produce at the levels of market penetration we included, two residential options, efficient lighting and appliance recycling, would increase average rates. However, the residential options as a whole, inclusive of these two, would decrease average rates. Other options that would increase rates are commercial efficient refrigeration, efficient industrial motors, and especially commercial/institutional combined heat and power. Without commercial/institutional CHP, the overall RIM B/C ratio would be closer to 2.0, and the net benefit to rates would be some \$267 million.

Rate impact estimates are rough and are based on cumulative present value. The year-to-year pattern of rate impacts will vary. DSM involves up front expenditures ~~which that~~ produce streams of savings over subsequent years. Under ordinary circumstances, this creates rate impacts that are less favorable in the early years than they are after the investment period. However, the extraordinarily high wholesale price levels in Western markets at the time of this report are also not included in the analysis. The level of these prices is such that, if DSM is implemented beginning in 2001, its near-term savings are likely to provide net benefits to rate levels in early years as well as subsequently.

### 7.5 Low Gas Price Case

Economic results were also assessed using a lower cost of gas assumption, as noted in section 5.4 above. Use of these gas costs reduces calculated cumulative net resource benefits to \$910 million. The benefit/cost ratio from the total resource cost perspective is reduced from to 3.6.

From the aggregate rate impact perspective, net benefits to rates are reduced to a negative \$87 million. The B/C ratio from the RIM perspective is reduced to 0.7. With these low gas prices but without out the commercial/institutional CHP option, the DSM portfolio returns a cumulative \$153 million net benefit to average rates, and its B/C ratio from the RIM perspective is 1.6.



## 8. Implications of Results for Policy, and Potential Next Steps

This study is intended as an informational resource. Its results suggest that there are many DSM options in each major market segment which can increase the productivity of electricity use through measures and programs whose total costs are far less than the increasing costs of electricity supply. There is thus a real~~sound~~ basis for consideration of approaches to funding DSM ~~programs which~~programs that can tap this potential.

In addition to considering funding levels, issues of how to best implement DSM are timely. In many states~~ed~~ utilities are increasing their DSM implementation roles. In other states new approaches to implementing DSM — through state agencies or third-party “conservation utilities”— are under development. In order to realize the load response and energy efficiency ~~gains which this study shows~~gains that this study shows are achievable, a sound framework for DSM implementation is necessary.

Because DSM consists of marketing programs to change consumer behaviors through voluntary inducements, the design of programs is another critical element in realizing whatever amount and type of DSM the advisory committee may feel should be pursued. Fortunately Utah can draw on what is now a rather rich history of field experience with differing approaches to delivering DSM. This study does not present or evaluate specific program proposals. But the fact~~—~~that a variety of program approaches of proven effectiveness exist~~s~~ can perhaps provide a level of background comfort as the committee deals with the foundational policy issues of funding and administration.



| ~~and administration.~~

~~An Economic Analysis Of Achievable New Demand-  
Side Management Opportunities In Utah~~

~~Prepared For The Systems Benefits Charge Stakeholder Advisory Group  
To The  
Utah Public Service Commission~~

~~By  
Tellus Institute  
11 Arlington St., Boston, MA 02116~~

~~Volume II  
Appendices~~

~~David Nichols and David Von Hippel~~

~~January, 2001~~



## ECO<sup>tm</sup> Software

The platform for the energy efficiency assessment is the Energy Conservation Model (ECO) developed by Tellus Institute. ECO<sup>tm</sup> focuses on evaluation of the costs, impacts, and benefits of demand side measures. It calculates the costs, resource impacts, and environmental externalities of potential demand side management (DSM) programs. Aggregate revenue and rate impacts associated with these programs can also be determined. The model provides a framework for the analysis of costs and benefits of utility conservation and load management programs from a variety of perspectives. Because ECO can analyze DSM impacts on multiple fuels, it is a versatile planning tool for use in the context of integrated resource planning (IRP).

ECO is comprised of two basic components—a demand model and a supply model. The demand model calculates program costs (including technology, administration, and operations and maintenance), as well as impacts on both resources used at the customer's facility and environmental externalities emitted during this use. The supply model determines impacts on the supply of resources which result from the DSM programs. Resource supply costs which can be avoided as a result of the DSM programs are also calculated, as are the cost of externalities emitted during energy supply (e.g., pollutants emitted by power plants).

The ECO model departs from conventional energy conservation models in that it allows avoided environmental externality impacts to be calculated and valued separately from avoided supply costs. Because the production, distribution, and consumption of energy causes significant impacts on the environment, ECO is designed to allow these real costs to society to be quantified. Monetary valuation of these impacts, allowing them to be incorporated in both supply planning and DSM program design, is a user option that is an integral part of the model.

The ECO model includes a variety of parameters in order to produce both reliable and comprehensive output reports. One example is the consideration of interactive effects of DSM (e.g. the effects of an efficient lighting measure, which can increase a system's heating load). Identification of these interactions are made at the measure level, and appropriate adjustments are made before determining program aggregate impacts. Measures which have multiple impacts, such as efficient plumbing fixtures that reduce the demand for water and for the fuel used in water heating, can also be specified.

Another parameter included to increase output reliability is the degradation factor—the percentage of initial energy savings lost in each of the subsequent years of measure life. (ECO does not use first year consumption savings as the surrogate for annual savings, as this would fail to account for loss in measure efficiency and thus overstate savings attributed to the DSM programs under consideration.)

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## Acronyms

A/C	Air conditioner
B/C	Benefit to cost
CAC	Central air conditioner
CC	Combined cycle
CFL	Compact fluorescent light bulb
CHP	Combined heat and power (also known as cogeneration)
C/I	Commercial and industrial
CO <sub>2</sub>	Carbon dioxide
CT	Combustion turbine
DOE	Department of Energy
DSM	Demand-side management
ECO <sup>m</sup>	Energy Conservation Model
EIA	Energy Information Administration
EPA	Environmental Protection Agency
GW, GWh	GigaWatts, GigaWatt-hours
ICE	Internal combustion engine
IOU	Investor owned utility
KW, KWh	KiloWatts, KiloWatt-hours
LED	Light emitting diode
MW, MWh	MegaWatts, MegaWatt-hours
NO <sub>x</sub>	Nitrogen oxide
O&M	Operation and maintenance
QC	Quality control
RIM	Rate impact measure
SEER	Seasonal energy efficiency ratio
SO <sub>x</sub> , SO <sub>2</sub>	Sulfur oxide, sulfur dioxide
T&D	Transmission and distribution
TRC	Total resource cost
UMPA	Utah Municipal Power Agency

## Demand Side Input Assumptions

Demand side input assumptions incorporated in the DSM portfolio are summarized beginning on the following page.

Volume II, **Appendices**, contains fuller documentation of demand-side input assumptions, as well as other documentation of the study:

- [The ECO<sup>tm</sup> software tool.](#)
- [Electric avoided cost assumptions. Acknowledgment Sources for input assumptions](#)
- [Worksheets used in economic screening of DSM measures, including cost and performance assumptions and information sources. Measure screening worksheets of individuals who contributed information](#)
- Additional results.

**SUMMARY OF DSM MEASURE AND PROGRAM ASSUMPTIONS  
AS USED IN EVALUATING A DSM PORTFOLIO FOR UTAH**

PROGRAM/MEASURE	Units of Measure Application	Measure Lifetime (years)	Annual kWh Savings per Unit	Summer Peak Savings: kW/Unit	Incremental Installed Cost (\$/unit)	Incremental Annual O&M Cost (\$/unit)	Program Incentives	Ongoing Admin. Costs	Start-up Admin. Costs
<i>Residential Air Conditioner Load Control</i> Central AC Load Control	Customers	20	0	0.800	\$195	\$3	\$40/cust-yr	\$1/cust-yr	\$967,000
<i>Residential Efficient Cooling Equipment</i> High-efficiency Central AC Evaporative Cooling	AC Units AC Units	15 15	738 1873*	0.842 2.139*	\$550 \$100*	\$0 **	80% of incr. cost \$800/unit	4.5% of incr. costs	\$150,000
<i>Residential Lighting</i> Compact Fluorescent Lamps (CFL)	Bulbs	9	60.2	0.0086	\$2.50	\$0	\$3.75/bulb	50% of util. costs	\$100,000
<i>Residential Appliance Recycling</i> Second Refrigerator Pickup	Appliances	6	1,149	0.164	\$125	\$0	\$75/unit	(see note)	\$200,000
<i>Commercial Central AC Load Control</i> Small Commercial CAC Load Control	AC Units	20	0	4.4	\$1,082	\$12	\$40/cust-yr	\$4/cust-yr	\$96,700
<i>Commercial/Institutional Load Management</i> Commercial Load Reduction	kW reduct.	1	0	1	\$25	\$0	\$50/cust-yr	50% of incr. cost	\$5,000
<i>Commercial/Institutional Cooling</i> High-efficiency medium-sized package AC systems	systems	20	9,620	7.4	\$3,100	\$0		15% of util. costs	\$200,000
High-efficiency large centrifugal chillers	systems	24	45,500	35	\$54,250	\$0			
Indirect/direct evaporative cooling--medium-sized systems	systems	20	30,940	23.8	\$35,000	\$0			
Indirect/direct evaporative cooling--medium/large-sized systems	systems	24	182,325	140.3	\$120,000	\$0			
Indirect/direct evaporative cooling--large-sized systems	systems	24	232,050	178.5	\$280,000	\$0			
<i>Commercial/Institutional Lighting</i> Advanced Measures	MWh lighting energy	15	656	0.197	\$175	\$0	40% of incr. cost	10% of incr. costs	\$200,000
T8 lamps, electronic ballast, & similar	MWh lighting energy	15	227	0.068	\$27	\$0	40% of incr. cost		
<i>Commercial/Institutional Refrigeration</i> Higher-cost Technologies	MWh refrig. energy	15	366	0.055	\$65	\$0	40% of incr. cost	10% of utility costs	\$200,000
Lower-cost Technologies	MWh refrig. energy	15	290	0.043	\$27	\$0	40% of incr. cost		
<i>Commercial/Institutional Combined Heat and Power*</i> 30 kW Micro-turbines	CHP units	20	531,904	66	\$37,295	\$2,610	30% of incr. cost	5% of utility costs	\$100,000
100 kW Internal Combustion	CHP units	20	2,132,108	267	\$121,062	\$13,120	30% of incr. cost		
800 kW Internal Combustion replacing electric boiler	CHP units	20	13,160,619	1,645	\$743,295	\$68,480	30% of incr. cost		
800 kW Internal Combustion replacing gas boiler	CHP units	20	6,400,000	800	\$746,474	\$68,480	30% of incr. cost		



PROGRAM/MEASURE	Annual Program Participation (in measure units)						Notes
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	
<i>Residential Air Conditioner Load Control</i> Central AC Load Control	13,819	14,301	14,525	14,951	15,384	15,811	
<i>Residential Efficient Cooling Equipment</i> High-efficiency Central AC Evaporative Cooling	4,278 7,512	4,458 7,512	4,541 7,512	4,699 7,512	4,860 7,512	5,019 7,512	SEER 13.5 vs. 10.5 Evaporative vs. direct cooling
<i>Residential Lighting</i> Compact Fluorescent Lamps (CFL)	23,121	71,784	97,210	100,062	102,961	105,816	
<i>Residential Appliance Recycling</i> Second Refrigerator Pickup	32,400	33,531	0	0	0	0	Measure cost includes pickup cost and administrative costs
<i>Commercial Central AC Load Control</i> Small Commercial CAC Load Control	691	715	726	748	769	791	Participants <u>added</u> by year
<i>Commercial/Institutional Load Management</i> Commercial Load Reduction	4,183	8,333	8,333	8,333	8,333	8,333	Measure reflects customer's assumed reduced usage cost
<i>Commercial/Institutional Cooling</i> High-efficiency medium-sized package AC systems	540	1,109	1,139	1,170	1,202	1,234	20-ton size class
High-efficiency large centrifugal chillers Indirect/direct evaporative cooling-- medium-sized systems	13	26	26	27	28	29	350-ton size class
Indirect/direct evaporative cooling-- medium/large-sized systems	180	370	380	390	401	411	8000 cubic feet/min unit
Indirect/direct evaporative cooling-- medium/large-sized systems	5	10	10	11	11	11	60,000 cubic feet/min unit
Indirect/direct evaporative cooling-- large-sized systems	2	4	4	5	5	5	140,000 cubic feet/min unit
<i>Commercial/Institutional Lighting</i> Advanced Measures	45,903	94,360	96,985	99,682	102,454	105,273	Energy and peak savings include avoided cooling
T8 lamps, electronic ballast, & similar	45,903	94,360	96,985	99,682	102,454	105,273	Energy and peak savings include avoided cooling
<i>Commercial/Institutional Refrigeration</i> Higher-cost Technologies	3,783	7,776	7,992	8,215	8,443	8,676	
Lower-cost Technologies	8,827	18,144	18,649	19,168	19,701	20,243	
<i>Commercial/Institutional Combined Heat and Power<sup>a</sup></i> 30 kW Micro-turbines	0	0	0	5	10	15	Energy and peak "savings" are net output + EWH savings
100 kW Internal Combustion	15	30	40	40	40	40	Energy and peak "savings" are net output + EWH savings
800 kW Internal Combustion replacing electric boiler	2	4	4	4	4	4	Energy and peak "savings" are net output + EWH savings
800 kW Internal Combustion replacing gas boiler	1	3	3	2	2	2	Energy and peak "savings" are net output

<i>Industrial Load Management</i>							
Industrial Load Reduction	8,333	16,667	16,667	16,667	16,667	16,667	
<i>Industrial Efficient Motors</i>							
Motor Downsizing	19,941	51,095	52,406	53,792	55,258	56,897	
Premium Motors in lieu of Rewinding	4,985	12,774	13,102	13,448	13,815	14,224	
Premium Replacement Motors	74,779	191,606	196,524	201,721	207,218	213,363	
<i>Industrial Motor Drive Improvements</i>							
Compressed air system measures	28,515	73,062	74,938	76,919	79,016	81,359	
Fan system measures	26,268	67,306	69,033	70,859	72,790	74,948	
Pump system measures	44,923	115,107	118,061	121,183	124,486	128,177	
<i>Industrial Combined Heat and Power<sup>^^</sup></i>							
800 kW Internal Combustion Engine	3	3	4	4	4	4	
3 MW Internal Combustion Engine	0	1	0	1	0	1	
10 MW Combustion Turbine	0	0	1	0	1	1	