The Pecan Street Project:

Developing the Electric Utility System of the Future

by

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Professional Report

Presented to the Faculty of the Graduate School of
The University of Texas at Austin
in Partial Fulfillment
of the Requirements
for the Degree of

Master of Public Affairs

The University of Texas at Austin
August 2009

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The Pecan Street Project:

Developing the Electric Utility System of the Future

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Acknowledgments

I would like to acknowledge first and foremost the assistance of my supervisors David Eaton, Ph.D. and Michael Webber, Ph.D. Their support and guidance allowed me to stay motivated to complete this project. I will forever be grateful to David Eaton for his generous support during my entire time as a graduate student.

I would like to thank my parents, David and Deborah Smith, who taught me the value of education and continue to inspire me to challenge myself academically. I especially thank my father for inspiring me with his dedication to improving the environment.

I would like to express my gratitude to Austin Energy and Environmental Defense Fund for allowing me to participate in the Pecan Street Project and learn from this collection of remarkable individuals. In particular, I would like to thank Roger Duncan and Jeff Vice for the opportunity to work with and now for Austin Energy. The wonderful experiences I have had with Austin Energy have motivated me to seek a career in the electric utility industry. Other Austin Energy staff who provided support during this project include John Baker, Daena Bruce, Andres Carvallo, Norman Muraya, Matthew Russell, Susan Peterson, and Kurt Stogdill. I would also like to thank Environmental Defense Fund staff members Jim Kennerly and Colin Meehan.

This endeavor would not have been a success without the time and generosity of several University of Texas at Austin Lyndon B. Johnson (LBJ) School of Public Affairs staff and University of Texas at Austin students. In particular, I would like to thank LBJ School staff members Lucy Neighbors, Martha Harrison, Kristen Hotopp, and Jayashree Vijalapuram for their support. I would also like to thank all the project team members of the LBJ School of Public Affairs research project entitled “Sustainable Energy Options for Austin Energy.”

August 2009

Disclaimer

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August 2009

Abstract

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by

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The University of Texas at Austin, 2008

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The Pecan Street Project (PSP) is a public-private initiative that seeks to establish the City of Austin and its electric utility, Austin Energy (AE), as leaders in developing the electric utility system of the future and clean energy economy. The four main components of the project are to: 1) develop a local, public-private consortium dedicated to research and development of clean energy technologies and distributed power generation; 2) open up the city's electric grid to act as a lab to test emerging clean energy technologies; 3) develop a new business model to ensure AE's continued profitability; and 4) show the world how the new business and systems model can work.

This report provides a case study of PSP and describes an analytical approach for evaluating projects, programs, and policies proposed by PSP working groups to develop a cleaner, more efficient electric system. This report includes a history of the project, discusses opportunities and challenges identified by PSP, and evaluates the potential economic, environmental, system, and other impacts of different project ideas through a technical analysis. This report concludes with a series of recommendations to PSP and identifies policy implications for the City of Austin, AE, other policymakers, and other electric utilities.

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Glossary of Acronyms

ACPP	Austin Climate Protection Plan
AE	Austin Energy
ARRA	American Reinvestment and Recovery Act
CHP	Combined Heat and Power
CO	Carbon Monoxide
$CORR_2$	Carbon Dioxide
Council	Austin City Council
DOE	US Department of Energy
DSM	Demand-Side Management
EDF	Environmental Defense Fund
ERCOT	Electric Reliability Council of Texas
EV	Electric Vehicle
GHG	Greenhouse Gas
kW	Kilowatt
KWh	Kilowatt-hour
MMBTU	Thousand Thousand British Thermal Units
MW	Megawatt
MWh	Megawatt-hour
NIST	National Institute of Standards and Technology
NO_x	Nitrogen Oxides
PEV	Plug-In Electric Vehicle
PHEV	Plug-In Hybrid Electric Vehicle
PSP	Pecan Street Project
PV	Photovoltaic
SEMATECH	Semiconductor Manufacturing Technology
SO_2	Sulfur Dioxide
TOU	Time-Of-Use
US	United States

UT-Austin	The University of Texas at Austin
VOCs	Volatile Organic Compounds

Chapter 1. Development of the Pecan Street Project

Introduction

During the spring of 2008 a team of seven policymakers and energy experts sat around a table and envisioned the electric utility system of the future. The seven original team members were: Isaac Barchas, Director, The Austin Technology Incubator; Jose Beciero, Director of Clean Energy at the Greater Austin Chamber of Commerce; Roger Duncan, General Manager, Austin Energy; Marcia Inger, University of Texas at Austin Computing Center; Council Member Brewster McCracken; Joel Serface, Director, Austin Clean Energy Incubator (later replaced by Colin Rowan); and Dr. Michael Webber, Department of Mechanical Engineering, The University of Texas at Austin. Convened by then Austin City Council (Council) Member Brewster McCracken, this team crafted what would become The Pecan Street Project (PSP), an initiative to turn the City of Austin into the clean energy capital of the United States (US) through collaborative efforts with public and private entities to integrate clean energy technologies and emerging smart-grid technologies into the electric grid. As a partner of PSP, Austin's municipally-owned utility, Austin Energy (AE), agreed to open up its grid to test these emerging technologies and increase the amount of distributed energy resources that supply power to its system.

PSP may be the nation's most comprehensive effort to redesign the electric utility system, going beyond the implementation of just a smart grid by changing the source of the electricity as well as the way it is delivered. Electric utilities have traditionally built large central station power generation plants to provide electricity for customers. Such plants have burned fossil fuels (coal, oil, or natural gas), derived power from force or energy of moving water (hydropower), or derived energy from the fission of uranium (nuclear) to provide relatively constant and reliable electricity. The traditional business model approach has been to make the utility the producer and supplier of electricity, capital investments driving their rate of return. Advancements in distributed generation, particularly solar photovoltaic (PV) technologies, create an opportunity for the consumer to become a producer by locally distributing generation. These technologies are becoming increasingly appealing from an economic perspective as well as an environmental perspective, particularly given the assumption that some form of carbon regulation will be imposed in the near future.

Technologies, tools, and techniques related to a smarter grid may prove to be the systematic approach that will dramatically change the way electricity is produced and delivered. A smart grid could reduce environmental impacts by increasing system efficiency and linking cleaner energy technologies to the local grid, lowering demand by enabling consumers to have greater control of their energy consumption and offering more demand reduction programs, and enabling the switch to a cleaner electric transportation system. The smart grid, as a system, will be enabled by a range of complementary technologies that are identified by PSP.

One of the primary drivers of PSP is that relatively cheap and reliable traditional power generation sources have come at an environmental cost. Environmental impacts associated with traditional plants include air and water pollution, land and water use, and hazardous waste generation. Aging infrastructure, impending carbon regulation, and societal demands to use cleaner energy sources have led the electric utility industry to reevaluate the way energy is generated and delivered to customers. The combination of new technological opportunities and increased concern, both socially and economically, regarding the environmental impacts of traditional power generation sources makes components of PSP appealing to AE and other electric utilities.

While the ability to turn the lights on at any time has been taken for granted for many decades, the public is becoming increasingly aware of the challenges as well as the opportunities facing the future of energy production and use in the US. In response, there may be public support for policymakers to invest in technologies and practices that change the way that energy is produced and delivered. The Council and Austin community has a distinctive history of supporting a cleaner environment and AE strives to improve the quality of its service to meet the demands of its customers. As a result, PSP appears to have both the political and community support to achieve its goals. PSP has the potential to become a model for other cities and electric utilities to follow in developing the electric utility system of the future.

History and Background

The vision of a cleaner Austin was first defined by a set of major City policy goals approved by Council in 2007. On February 7, 2007, City of Austin Mayor Will Wynn unveiled an ambitious plan for Austin to address global warming by reducing greenhouse gas (GHG) emissions. On February 15, 2007 Council passed Resolution Number 20070215-023, outlining the Austin Climate Protection Plan (ACPP) and setting the goal of making Austin "the leading city in the nation in the effort to reduce and reverse the negative impacts of global warming."[1] Components of the plan include a municipal plan, a utility plan, a homes and buildings plan, a community plan, and a "go neutral" plan.

The ACPP sets forth specific goals and guidelines for the development of the city's utility plan. Specific deliverables outlined by the plan include:[2]

- establishing an upper bound on carbon dioxide (CO_2) and a carbon reduction plan for existing utility emissions;
- achieving carbon neutrality on any new generation units using carbon-based fuels through the utilization of lowest-emission technologies, carbon sequestration if it is proven to be reliable, mitigation and other prudent measures;
- achieving 700 megawatts (MW) in new savings through energy efficiency and conservation efforts by 2020; and
- meeting 30 percent of all energy needs through the use of renewable resources by 2020, including 100 MW of solar power.

Shortly after this resolution was passed, AE began a new resource planning process to determine how it would meet these goals by 2020. In July 2008, Roger

Duncan, AE's General Manager, presented to Council the utility's preliminary recommendations for meeting energy demand through 2020 while remaining under its proposed CO_2 cap and reduction plan.[3] AE proposed adding 1,375 MW of power generating capacity by 2020, with only 300 MW coming from fossil-fueled resources.[4] Under the proposed plan AE would meet the ACPP goals. AE has continued to evaluate its resource plan through 2020 by engaging the public in the planning process.[5] AE plans to announce its final recommendations to Council in the late summer of 2009. While ACPP and AE's resource planning process do not directly tie to PSP, they demonstrate the community and utility's commitment to the principles of developing a cleaner Austin.

During the course of this resource plan evaluation process, an ambitious project was announced by Austin Mayor Pro Tem Brewster McCracken to scale-up a massive amount of distributed generation in Austin and revolutionize AE's electric grid as a model for other electric utilities. This project, which became titled, The Pecan Street Project, was formerly initiated in October 2008 "to make the city of Austin into America's clean energy laboratory – a place for researchers and entrepreneurs to develop, test, and implement the urban power system of the future."[6]

The idea of PSP first originated from his discussion with local energy and economic experts on the idea of bringing solar into Austin and how this would create jobs and make clean energy directly relevant to citizens of Austin. Through further discussions with local technology experts it was realized that utilities would need to reinvent the way electricity was delivered and that solar would need to be coupled with storage, new meters, new billing and rates, and new appliances. Until the delivery system became advanced and more efficient, clean energy would remain a niche product.[7] McCracken arranged for the first meeting of seven-person team on April 16 to develop what would become PSP.[8] Meetings were subsequently held for 3 months every two weeks.[9] The project became called the Pecan Street Project because Pecan Street was once the name of Austin's original main street. McCracken has stated that the name is fitting because the intent of the project is to take energy away from the hinterlands such as from a coal-fired gas plant and bring it into Austin's main street.[10]

The four main components of the project are to: 1) develop a local, public-private consortium dedicated to research and development of clean energy technologies and distributed power generation; 2) open up the city's electric grid to act as a lab to test emerging clean energy technologies; 3) develop a new business model to ensure AE's continued profitability; and 4) show the world how the new business and systems model can work.[11]

Leadership, Partnerships, and Formal Creation of Entity

The idea of forming a public-private partnership between the City, the University, and a collection of private companies had been done many times in Austin, and it was considered suitable for PSP.[12] PSP brings together AE, the City of Austin, researchers at The University of Texas at Austin (UT-Austin) and other universities and organizations, and a host of private companies such as General Electric and IBM. Each of these entities plays a critical role in developing and implementing new technologies while creating jobs through economic development.

PSP's vision is to have 100,000 homes and businesses equipped with solar within 10 years which might require the move towards a reliable and cost-effective "energy internet" and a new business model in which customers become producers and consumers of energy.[13] The idea is to move away from centralized power generation that comes from large power plants and often must be transmitted and distributed tens to hundreds of miles to a de-centralized system that cuts down on transmission losses and its associated costs.

Shortly after the announcement of PSP, McCracken declared his candidacy for Mayor of Austin. The main issue that McCracken ran his campaign on was preparing Austin for the 21st century economy.[14] Consequently, his role with PSP scaled back and the Environmental Defense Fund (EDF) took leadership. During the economic recession of the late 1980's Semiconductor Manufacturing Technology (SEMATECH), a non-profit consortium that performs semiconductor research, development, and manufacturing was brought to Austin. SEMATECH was a partnership between US-based semiconductor manufacturers and the government to solve common manufacturing problems and become competitive in the global semiconductor industry.[15] This research center persuaded major semiconductor companies to bring operations to Austin and allowed Austin's economy to flourish during the 1990's. The model used to develop Austin into an economic leader in technology became called "The Austin Model."[16] PSP's goal was to use this model can be followed to make Austin the leader in clean energy research and the development of the electric grid of the future.

A Governance Group was formed to provide leadership during Phase 1 of the project in which project ideas would be formulized for implementation. This group consists of the following members: John Baker, Chief Strategy Office, Austin Energy; Jose Beceiro; Isaac Barchas; Dave Allen, UT-Austin (later replaced by Thomas Edgar, Abell Chair, Department of Chemical Engineering, UT-Austin); Jim Marston, EDF; and Brewster McCracken.[17] An Executive Committee, a Strategy Integration Team, and several Action Teams, or working groups, were also formed at this time.[18]

AE has and plans to continue to provide staff support for PSP. AE serves approximately 390,000 customers and a population of 1 million. AE has been recognized as one of the leading electric utility companies in marketing clean energy to its customers through its Green Choice® Program and investing in cost and environmental-saving conservation and energy efficiency programs.[19] General Manager Roger Duncan was recognized in 2005 by *Business Week* as one of the Top 20 leaders of the decade in the fight against global warming.[20] Duncan sees PSP as a vehicle to help the utility reinvent the energy system by connecting utilities, businesses, and the transportation industry.[21] The active involvement of AE is critical in the development of PSP as it provides the electric system to integrate clean energy technologies and programs and provides a major source for expertise and funding (through Council approval).[22]

EDF was recruited to bring leadership from the environmental community and help determine the project's direction. EDF was designated as a leader in this project because it provides a public interest perspective that could be replicated nationwide.[23] Staff from EDF's Austin, New York, California, and Washington, D.C. offices are contributing to the project.[24] The Austin Chamber of Commerce is providing support for the project by ensuring that the collaboration among the public and private entities involved will bring economic development to Austin. Dozens of professors, researchers, and students from UT-Austin and Austin Community College are lending their expertise in the identification and evaluation of project ideas and may provide research support for projects identified by PSP.

As a public-private partnership, the participation of private companies from the point of project development will likely bring these companies and others to Austin to develop their clean energy and smart grid technologies. Named partners to date include Applied Materials, Cisco, Dell, GE Energy, Gridpoint, Freescale, IBM, Intel, Microsoft, Oracle, and SEMATECH.[25] These partners will be able to identify the most up-and-coming technologies that can be pilot-tested on the local electric grid once the initial phase of the project is completed. The corporate partners are dedicating 2 to 4 employees at 25 percent of their time for Phase 1 of the project.[26]

On August 6, 2009 Council approved the designation of staff of the City (Council Member Randi Shade and AE General Manager Roger Duncan) as board members of PSP once it is established as a non-profit entity under Section 501(c)(3) of the Internal Revenue Code.[27] Roger Duncan was named President of the Board of Directors. Other members of the board are Jose Beceiro with the Greater Austin Chamber of Commerce, James Marston of EDR, Thomas Edgar with UT-Austin, and Isaac Barchas with the Austin Technology Incubator. PSP will soon file for formal establishment as a non-profit organization.[28] The decision to establish PSP as a non-profit entity met unanimous approval by the Governance Group.[29] The establishment as a non-profit entity will allow PSP to apply for stimulus funding through the American Reinvestment and Recovery Act

(ARRA) and other federal and state funding opportunities. For example, PSP might seek 100 million dollars in federal economic stimulus funds.[30] PSP will have greater flexibility in pursuing projects that may not be cost-effective for AE and each participating entity will have a say in the establishment of goals and pursue of different projects. The structure of PSP will also allow all stakeholders to bring together their broad perspectives by providing a formal forum to discuss the testing, implementation, and promotion of clean energy and advanced energy technologies.[31] The Board of Directors will have an opportunity to develop a clean energy vision for the entire Austin community rather than simply focusing on the vision of one or a few of the partners.[32]

Goals

The overarching mission of the project has been identified as designing and implementing an energy generation and management system that generates a power plant's worth of power from clean sources within the city limits and delivers it over an advanced delivery system that allows for unprecedented customer energy management and conservation.[33] Essentially, the project plans to identify new clean energy technologies and smart grid technologies that can be sited in AE's service territory to account for increased energy demand and displace current power generation from polluting power sources. One goal is to bring 300 MW of distributed generation (which will likely primarily consist of distributed solar photovoltaic module systems) to AE's electric grid by 2020.[34]

The following four initiatives are identified pursuant to the mission of PSP: 1) develop a clean energy public/private research and development consortium for clean energy technologies and distributed generation systems on Austin's electric grid; 2) create an economically sustainable distributed generation system; 3) open AE's electric grid to entrepreneurs and researchers to test prototype technologies in the real world; 4) and implement this model locally and system-wide as a showcase for the rest of the world.[35] While many utilities are implementing smart grid projects and developing clean energy and demand-side management (DSM) programs, PSP aims to move beyond these efforts and attempt to fully integrate all related programs into one networked system. PSP has the potential to stretch the technical and practical limits of the electric utility system to lead to a smarter, cleaner, and more user-friendly electric system.

Phase I

The initial phase of PSP (Phase 1) was launched in October 2008 with over a hundred staff members and representatives from the Governance Group and the private partners being assigned to Action Teams to address specific needs and identify challenges posed by the project. The 12 teams are as follows: 1) distributed generation/renewable energy; 2) low-tech/low-emission options, including solar water heaters, building positioning, shading, etc.; 3) energy efficiency, demand response, and load measurement and control; 4) networked storage; 5) water conservation; 6) transportation; 7) operations and systems integration, including technology and systems modeling; 8) new utility business model and new market entrants; 9) customer interfaces and impacts and behavioral economics; 10) legislative/regulatory requirements and fundraising; 11) economic development and technology commercialization; and 12) workforce training. A strategy and technology analysis team and a communications team were developed to provide support to these 12 project teams.[36]

All project teams were given the task of identifying opportunities (through project idea formulization) and challenges posed by identified opportunities. Some teams (particularly 1 through 6) played the role of identifying technologies and programs that could be implemented to generate cleaner energy, save energy, or shift energy demand to make loads more manageable for the utility. These teams identified the technical potential for short and long-term implementation of different project ideas and designed ways in which to implement these programs. Representatives of the other teams provided support for the development of project ideas by identifying new business model approaches for the utility and identified challenges that these approaches would face. Project ideas developed by these 12 working groups will be discussed in detail in Chapter 2 of this report.

These 12 working groups were further condensed in May 2009 into four core teams to focus on the implementation of project ideas, write final reports, and develop roadmaps for their project ideas. The four core teams are: 1) distributed generation; 2) energy efficiency; 3) transportation and storage; and 4) demand response. Representatives of the remaining working groups were dispersed amongst the four primary groups to provide support to these core teams.

Phase 1 of the project will culminate in a report with technical, financial, and policy recommendations that is planned to be released in the fall of 2009. Questions that will be addressed during Phase 1 of the project include: 1) what changes are needed in pricing, rate design, billing, information technology, and infrastructure to further the testing and implementation of these new distributed technologies; 2) what metering and smart grid systems will best allow customers to manage their own demand and sell distributed power into the AE system; 3) what technology and systems gaps need to be filled by emerging technologies and technologies not yet invented; 4) how should consumers be educated and what incentives will be used to change the public's behavior; and 5) what will a new sustainable business model for AE look like?[37] A specific plan of action for PSP and identification of key barriers to overcome will be outlined in the Phase 1 report.[38]

Phase 2 of the project will consist of implementing the action plan and verifying technologies to move into the stage of implementation. As technologies continue to emerge and be tested they will move through the verification and implementation process in subsequent phases of the project. Incentive approaches to increase customer participation in energy efficiency and demand response programs and increase adoption of distributed generation technologies will likely be developed. Some policies and programs will be ready for immediate implementation while others will be identified for further research or needing to overcome regulatory, policy, or customer acceptance barriers. PSP and AE will identify these barriers to success and attempt to overcome these issues.[39]

Funding

Phase 1 of the project has not required funding from Council or outside sources. Existing AE staff and representatives from the public and private partners of the project have been working together to develop the ideas and recommendations that will initially be proposed. In order to actually implement these projects and support PSP staff, direct funding will be necessary. Details regarding the costs to the City, including potential funding allocated by Council, will be determined in Phase II of the project.[40] AE and its partners are actively engaged in finding government sources of funding as much of the ARRA stimulus bill funding is dedicated to smart grid and clean energy projects.[41] In fact, the announcement of stimulus funding for smart grid and clean energy projects caused PSP to focus on the short term goal of receiving federal funding, rather than its long-term planning.[42] The application process for stimulus funds is currently on-going and AE and PSP hope to receive a significant amount of funding through this process for programs that relate to the success of PSP. While AE's proposal for significant funding under the Smart Grid Investment Grant Program is not directly tied to PSP, many of the program elements of this proposal are directly related to project ideas identified by PSP and will enable PSP project ideas to be implemented. Other funding opportunities should continue to arise for PSP at the local, state, and federal levels.

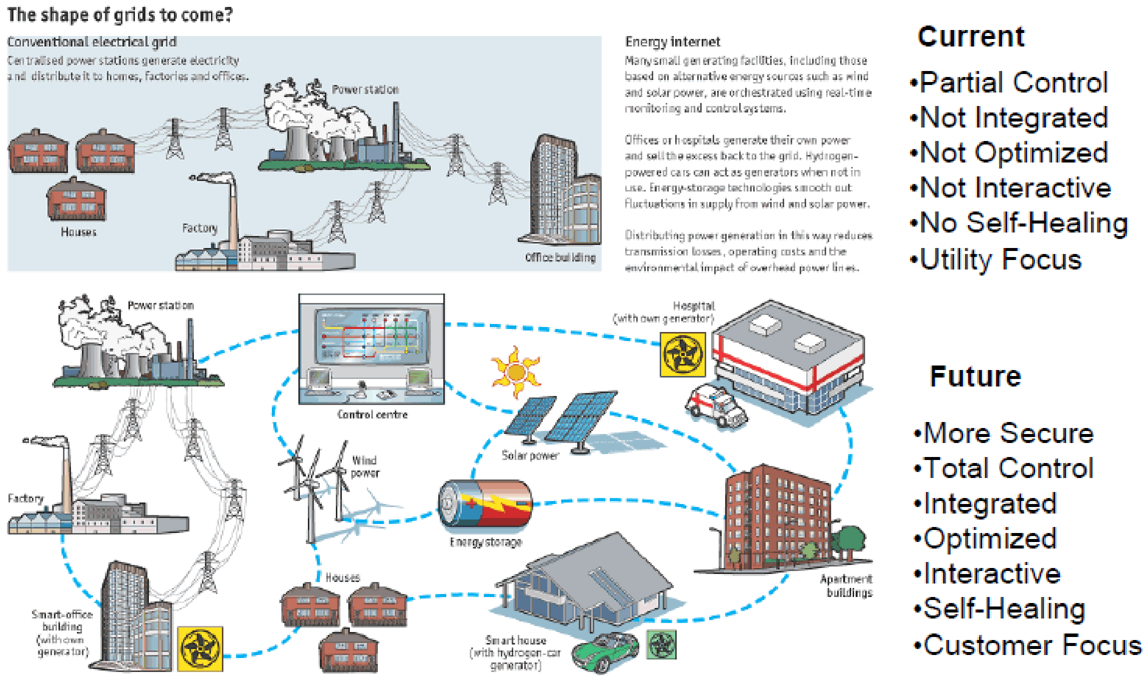
Projects supported for implementation by AE as proposed by PSP will require Council approval for funding if outside sources cannot be obtained. The amount of money that will be necessary to implement different project ideas may be identified in the Phase 1 report with a proposed budget. Many of the project ideas could generate revenue for AE, and subsequently Austin, and have benefits for the utility that outweigh the costs.

Electric Grid of the Future

The development of the smart grid is a systematic approach that has the potential to transform the electric power system. The smart grid generally refers to a broad range of solutions that optimize the energy value chain.[43] There are many definitions of a smart grid and many initiatives that could be classified as smart grid projects due to the wide range of technologies and applications that relate to the smart grid. AE defines the "Smart Grid" as the seamless integration of an electric grid, a communications network, and the necessary software and hardware to monitor, control, and manage the generation, transmission, distribution, storage, and consumption of energy by any customer type.[44] AE's smart grid initiative began as an enterprise operation plan that turned into a redefinition of their business process using service-oriented architecture that allows customers to have greater control over their energy consumption and the type of utility programs she or he participates in.[45] AE is poised to become one of the first utility companies in the US to institute the first steps towards a fully integrated smart grid system. AE began building its smart grid system in 2003 and plans for the system to cover 100 percent of its service territory by August 2009. This system will service almost 410,000 premises (and thus, includes the installation of 410,000 advanced meters), representing about 43,000 businesses and 1 million customers.[46] By August 2009 500,000 devices will be able to be monitored by AE in real-time.[47]

Figure 1.1 compares the conventional electric grid with the capabilities of the smart grid. This figure demonstrates the multitude of new energy technologies that are enabled by a smarter grid. The future grid will hopefully: be more secure; allow for more control by the utility and its customers; have the capability to be fully integrated and optimized to enhance performance; be self-healing; and be customer focused. Many energy companies have been hesitant to invest in the costly infrastructure of a smart grid system, but AE believes that the potential savings created by the smart grid may offset the costs of the system. AE customers will be charged for the costs of implementing the new systems. If the anticipated savings are realized, customers will get lower bills in the future than they would have without making those up front investments. Austin could also benefit economically by being one of the first cities in the US to develop a fully integrated smart grid system. Companies developing smart grid and clean energy technologies may be drawn to Austin as a test market for their products.

Figure 1.1
Conventional Electric Grid Versus a Smart Grid



Source: Lindsay Duran, et al., Austin Technology Incubator, Clean Energy Incubator, The University of Texas at Austin, *CleanTX Analysis on the Smart Grid*, p. 27; and Presentation by Andres Carvallo, Chief Information Officer, Austin Energy, *Austin Energy Smart Grid Program*, Austin, Texas, March 2009, slide 6.

By creating a two-way communication mechanism, both the utility and its consumers have greater control over power consumption. Two-way communication is an enabler of greater control of consumer power consumption. One can envision the electric grid as representing the nervous system of the electric utility; constituting the brain, the communication platform, the wires, and the sensors that allow operators or automation to meet the needs of the system in real time. The smart grid system essentially makes this system more intelligent by allowing for more sophisticated responses to supply and demand fluctuations and personal needs of customers through real-time monitoring.[48]

The smart grid of the future will be distributed, interactive, self-healing, and reach every device that is integrated into the system.[49]

Table 1.1 lists potential benefits of the smart grid system for both AE and its customers. One benefit of the smart grid system is the ability to signal the cost of electricity (based upon supply and demand) in real-time and allow smart devices (including air-conditioning units, vehicles, diesel generators, refrigeration plants, and smart appliances) to operate only at times when electricity costs reach a certain level. This provides a sophisticated mechanism for conserving energy and reducing demand when it is at its peak. Rebate programs will be needed as an incentive for customers to purchase smart appliances. The hope is that customer demand responses will encourage technological developments that utilize smart grid capabilities.[50]

The smart grid is one component of the utility of the future. Smart grid is the union of an advanced distribution infrastructure, distributed energy resources, distributed energy storage, demand response, and the pricing, billing, and financial settlement of transactions between the utility and its customers, as well as among the customers themselves.[51] A smart grid can reduce electricity production and transmission capacity needs, lower fixed and variable costs, and help meet the growing demand for energy in an efficient and sustainable manner. Innovations related to the smart grid include: smart meters that can integrate with smart markets and smart appliances and enable two-way electricity flow; smart appliances that can respond to peak demand and high electricity prices; smart markets that have a price built on supply and demand that will allow prices to vary over time of day and seasonally; smart policies that facilitate innovation and implementation of these technologies and markets; and smart workforce members that can build, design, test, install, maintain, and operate these devices. The electric system will increase from a few hundred thousand users making several decisions each day for millions of appliances, to a system that will also include millions of additional automated decisions with more users operating a greater range of devices.[52]

Table 1.1
Smart Grid Benefits for Austin Energy

Benefits for Austin Energy Customers	Benefits for Austin Energy
Faster notification and restoration times from outages	Reduced operating costs (less truck rolls)
Receive usage information to better understand and manage bills	Improved outage management through ability to quickly determine if power is off or on
Ability to participate in new energy efficiency and demand response programs	Reduced number of delayed and estimated bills
Reduce inconvenience by no longer needing to unlock gates and tie up dogs for meter reads	Reduced energy theft
Improvements in timeliness and accuracy of billing and fewer estimated bills	Lower procurement costs
Remote service turn-on and shut-off	Improved load profiling
Customer can call Utility Customer Service for real-time meter read or via data on in-home display/portal	Improved distribution load management and planning
Customer can manage smart appliances via portal/IHD	Greater historical load and usage data
Ability to participate in other tariff options	Better asset management and maintenance
	Time-of-use pricing, pre-paid, and flat bill programs
	Reduces need for additional generation and transmission capacity
	Supports any market price-responsive tariff requirements

Source: Presentation by Andres Carvallo, Chief Information Officer, Austin Energy, *Austin Energy Smart Grid Program,* Austin, Texas, March 2009, slides 13-14.

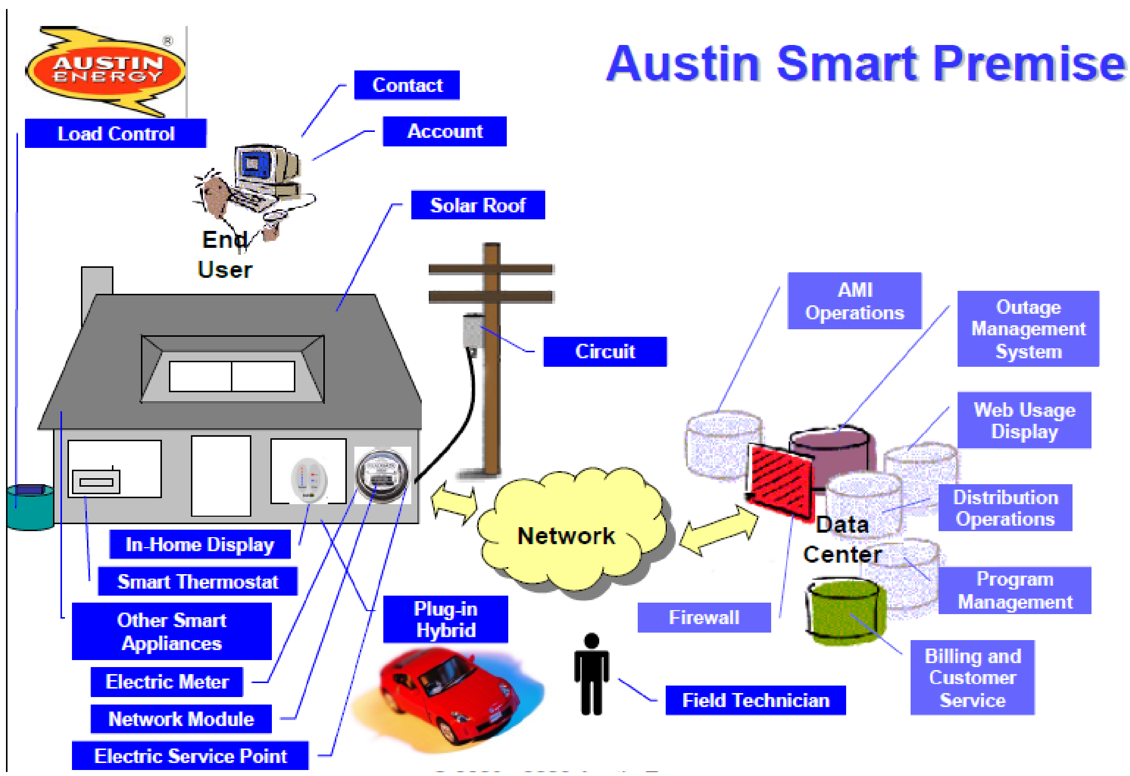
The potential to promote adoption of local renewable energy through distributed generation is a key characteristic of the smart grid. Small-scale renewable energy technologies, primarily solar PV, can connect to the grid, allowing consumers to sell energy back to the grid when personal supply exceeds consumption. As solar energy irradiance is typically highest during peak periods of demand (although the peak energy generation output for solar PV tends to be around noon while peak demand is later in the afternoon), this energy source could help reduce peak demand and potentially reduce GHG emissions and other pollutants for the utility. Other local renewable energy sources that could be tapped into by PSP include landfill gas, waste to energy, waste heat recovery, and small-scale wind turbines and hydropower units.

Energy efficiency and demand response programs enabled by a smarter grid may allow AE to significantly lower demand. For example, consumers may have appliances that turn off when they are not need or when prices are high.[53] Demand response programs implemented over a smart grid could automatically reduce a customer's power consumption to prevent outages and reduce peak demand. Energy management systems may allow the utility or the consumer to control the way in which energy is used. Smart grid technology also allows AE to restructure its billing system to enable dynamic pricing. Under a dynamic pricing scheme electricity rates could be higher when demand is highest, creating an incentive for customers to reduce peak demand.

One other attraction of a smart grid system is the so-called "vehicle-to-grid" system. Vehicle-to-grid can potentially flatten or move demand curves, can provide support for power quality, and can displace petroleum use for transportation purposes. The idea behind the vehicle-to-grid system is that electric vehicles (EVs) and plug-in electric vehicles (PEVs) could serve as temporary storage devices to shift energy from off-peak demand hours to peak-demand hours. Vehicle-to-grid technology could stabilize electrical grids by consuming power when electricity is abundant and selling electricity back to the grid when electricity is in highest demand. Energy storage technologies provide a direct mechanism for the utility to shift loads to off-peak periods, possibly enhancing the use of variable renewable energy sources.

The smart grid is a framework for AE to move from its current state of a static, centrally-controlled, one-way utility to a distributed, self-aware, two-way, dynamic, and sustainable energy system. Figure 1.2 represents the premise of AE's smart grid system and the electric system of the future that can be enabled by its implementation. Again, this figure demonstrates the wide range of technologies that are directly related or enabled by the smart grid. AE is well-positioned to implement a smart grid and move towards the electric system of the future because of its early adoption of smart grid technologies and commitment to an advanced grid.

Figure 1.2
Austin Energy Smart-Grid Enabled Future Electric System



Source: Presentation by Andres Carvallo, Chief Information Officer, Austin Energy, *Austin Energy Smart Grid Program*, Austin, Texas, March 2009, slide 10.

AE's current Smart Grid Program, called Smart Grid 1.0, is focused on the utility side of the grid. This first phase of smart grid deployment focuses on systems integration, communications, safety and reliability of electric operations, better and new services, and improved customer services. Smart Grid 2.0 is planned to be developed through PSP. The purpose of this next level of development is to move beyond the meter and into the premise being served (i.e. home, office, store, mall, building) to integrate back into the utility grid. This stage will manage distributed generation, energy storage, EVs and PEVs, and smart appliances to enable new services for customers and develop a new business model for the utility.[54]

Structure of Report

This report seeks to provide a case study of PSP and identify an analytical approach for evaluating projects, programs, and policies related to emerging technologies such as those identified by PSP. Through my academic and professional involvement with PSP I have been able to follow the process by which PSP evolved and developed its initial recommendations to Council.

This report identifies PSP as an approach to redefining the way electricity is produced and delivered to consumers. As the electric utility industry continues to adapt to changing regulatory and customer demands it is likely that it will need to identify and adopt similar types of technologies and programs as those identified by PSP. It is my intention to detail and define PSP as a model approach for other utilities. While not all technologies, techniques, and tools identified by PSP will be replicable for other utilities due to regional and economic differences, PSP has developed a process by which electric utilities can engage the local community and utilize the resources and expertise that can be provided by local institutes of higher education, the public, and private companies.[55] This process will be summarized at the end of each chapter to demonstrate best practices for similar projects that may be developed nationwide by policymakers and electric utilities.

This report begins by identifying the opportunities (Chapter 2) and challenges (Chapter 3) identified by the PSP working teams and discuses the more than 150 project ideas developed during this process. Chapter 4 discusses the benefits and impacts of the integration of the PSP project ideas to AE, its customers, and the community. Chapter 5 identifies an analytical approach that can be replicated by other entities for categorizing, evaluating, and selecting projects to redefine the way electricity is produced and delivered. A technical analysis of PSP is included in that chapter. Finally, conclusions are drawn, recommendations are made, and policy implications are identified for AE, Austin, policymakers, and other electric utilities in Chapter 6 based on this case study.

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Chapter 2. Identifying Opportunities of the Pecan Street Project

Identifying emerging energy technologies enabled by a smarter grid and opportunities for incorporating clean energy resources into AE's electric grid is the primary component of Phase 1 of PSP. The main opportunities identified by PSP are advancing the electric grid through smart grid technologies, reducing demand through energy efficiency and demand response, increasing the amount of distributed generation, and electrifying the transport sector. This chapter discusses the classification and identification of all opportunities identified during Phase 1 of PSP.

Project Ideas

As detailed in Chapter 1 of this report, 12 working groups were assigned to look at different opportunities and challenges presented by PSP. Working groups were tasked with developing project idea "characterizations" that would capture information about a project idea for comparative purposes. Information provided for each project idea include a background and description of the idea, identification of the critical need met by the idea, identification of implementation timing and dependencies, an overall assessment of the idea, and identification of its potential impacts including financial (cost and revenue), environmental (energy use, carbon, and water use), peak demand reduction, electrical system reliability, economic development, and workforce development.

Through this process, over 150 project idea "characterizations" were developed. The majority of ideas generated by working groups 1-6 sought to affect AE directly through distributed generation, low-tech/low emission options, energy efficiency, demand response/, and load management and control, networked storage and transportation, or water conservation. Project ideas generated by groups 7 and 9 (operations and systems integration and customer interfaces and impacts) identify challenges and potential solutions for integrating emerging technologies into AE's electric grid and developing the electric system of the future. Project ideas generated by groups 8 and 10 (new utility business model and legislative/regulatory issues and funding) identify business model approaches that could be implemented to encourage the successful integration of different project ideas and ways to overcome regulatory and policy barriers to success. Groups 11 and 12 (economic development and technology commercialization and workforce training) evaluate community-wide economic development opportunities and potential workforce training support programs.

Based upon an evaluation of the 150-plus project ideas, I have grouped the characterizations into six categories for discussion and comparative purposes. The categories are as follows:

1) Supply-side resources such as clean, distributed power generation technologies;
2) demand-side programs, including demand response, energy efficiency, and energy storage;
3) transportation programs, including PEV support;
4) research and studies;
5) public awareness and outreach; and
6) economic development and workforce training.

All project ideas developed by the working groups are categorized within these six groups and described in tables included in Appendix A of this report. Information on each project idea provided in these tables includes the name and idea of the project idea as well as its potential impact or cost. Project ideas are referenced by the number assigned during the PSP working group process (the first number denotes the group and the second number denotes the project idea within that group). I have noted project ideas that overlap as well as project ideas that provide support for other ideas. About 25 of the ideas overlap or support other ideas. Therefore, there are about 125 independent project ideas. About half of these ideas have direct impacts on the utility by adding new generation, reducing demand, shifting loads from peak periods to off-peak periods, or encouraging new demand through electrified transportation. The other half of the PSP ideas relate to research, studies, pilot projects, economic development, workforce training, or provide support for PSP through public outreach and awareness. These ideas only have indirect impacts for the utility beyond the potential cost of implementation for the utility. Due to the number of project ideas identified by PSP, this chapter does not include a detailed discussion of every project idea independently, but rather discusses the key opportunities and cumulative potential for each category of project ideas. Chapter 5 of this report provides a technical analysis of all project ideas including an evaluation of the economic, environmental, and system impacts.

Supply-Side Project Ideas

Supply-side project ideas include any proposal for adding new, cleaner power generation to the electric grid or any ideas that supports the adoption and integration of clean power generation technologies to AE's electric grid. Cleaner energy technologies identified for local generation by PSP include combined heat and power, landfill gas to energy, micro-hydropower units, micro-wind turbines, solar PV, and waste heat to energy. These ideas are listed in Table A-1 of Appendix A.

Table 2.1 details AE's current generation mix. Coal, natural gas, combined heat and power, and nuclear resources are owned by AE. Wind and landfill gas resources are purchased power agreements with private companies that operate the facilities. Solar resources are connected to AE's grid, mostly enabled by AE rebates for solar PV. Only 23.7 MW (9 MW of combined heat and power, 11.8 MW from landfill gas, and 2.9 MW from solar) of AE's just over 2,900 MW of power generating capacity is attributed to distributed generation sources.[1] The goal of integrating an additional 300 MW of distributed generation into AE's generation mix by 2020 demonstrates that supply-side project ideas, particularly the integration of solar PV into AE's mix, will be a major component of PSP.

Table 2.1
Austin Energy Resource Portfolio

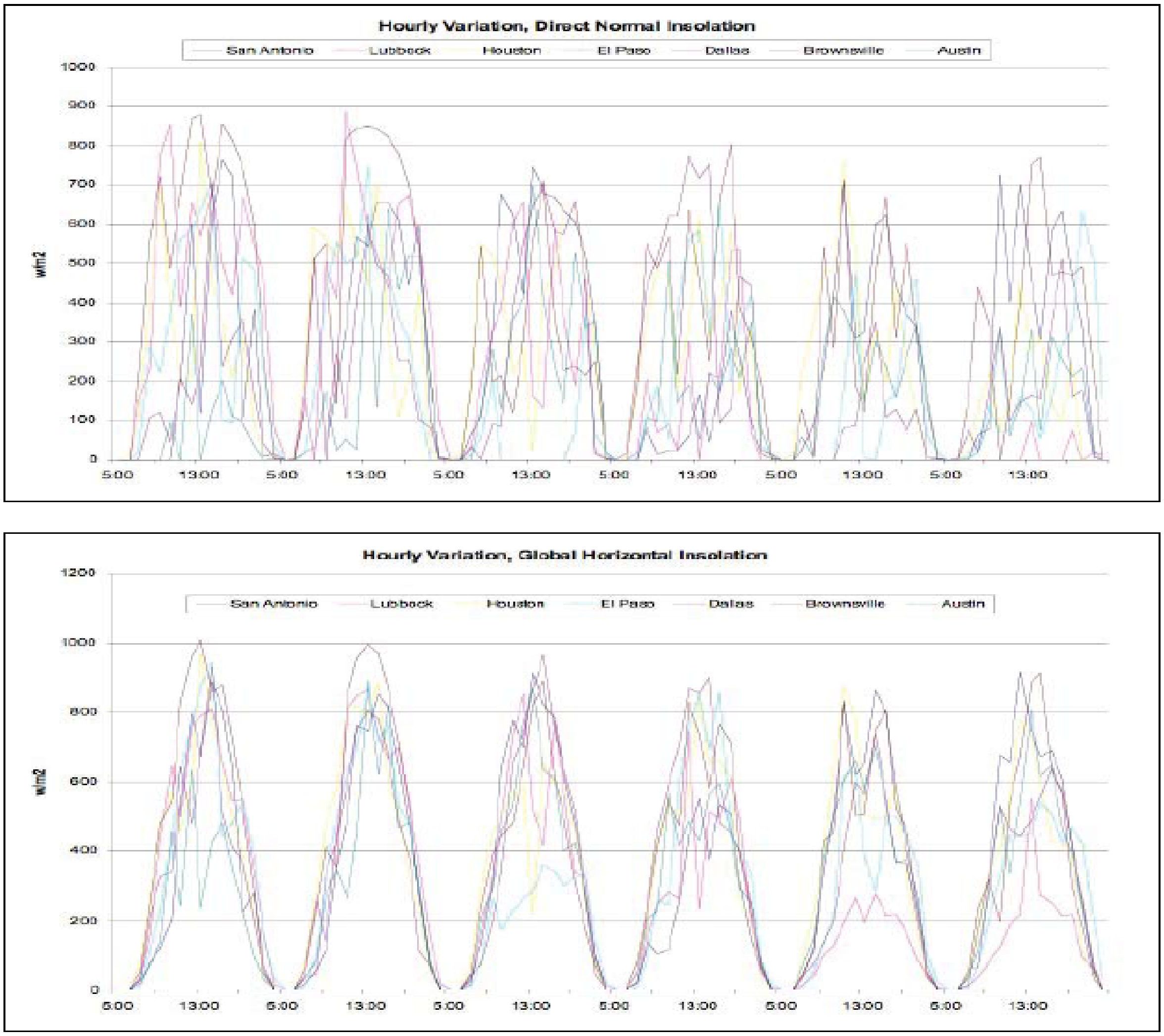
Resource	Capacity (MW)
Coal	607.0
Natural gas	1435.0
Combined heat and power (uses natural gas)	9.0
Nuclear	422.0
Wind	439.7
Landfill Gas	11.8
Solar	2.9
Total	**2927.4**
Summer Peak Purchases	300.0

Source: Austin Energy, *Austin Energy Resource Guide* (October 2008), p. 18. Online. Available: http://www.austinsmartenergy.com/downloads/AustinEnergyResourceGuide.pdf. Accessed: August 1, 2009. Updated with 165 MW wind contract addition in 2009.

The majority of power generation technologies identified by PSP are classified as distributed energy resources. Distributed energy refers to small, modular power generating technologies that are placed at or near the point of energy consumption, rather than traditional central generation units.[2] Distributed energy sources can serve to meet electric load, provide backup power at an electricity consumer's site, or even assist with the management of the electric system. Different distributed generation sources can provide baseload power, peaking power, backup power, remote power, meet power quality needs, and provide cooling and heating services. Integration of distributed resources with electronic interfaces and communication and control devices through the smart grid allow for efficient dispatch and operation of these units. Benefits of distributed energy sources can include congestion mitigation in transmission lines, reducing energy price fluctuations, strengthening energy security, and increasing system reliability.[3]

The variability of solar and wind resources create difficulties for the high penetration of these resources into the electric grid. Wind and solar resources face daily (diurnal), short-term (several days), seasonal, and annual fluctuations. These fluctuations can be predicted reasonably well. As electric utilities have the capacity to carefully plan the dispatch of other resources, ensuring reliability even when a significant portion of a utility's resource portfolio is comprised of variable resources appears manageable. Figure 2.1 shows the daily and short-term fluctuations in solar insolation (direct solar radiation) for a five-day period for seven Texas cities, including Austin, with the night-time hours omitted. Fluctuations are caused by the diurnal (day/night) effect and changing atmospheric conditions, primarily cloud cover.[4] This figure purposely depicts a period of five days with a mixture of clear and non-clear days. Clear days exhibit fairly smooth hourly variations while non-clear days exhibit much more extreme short-term variations ranging from high levels of solar radiation to near-zero levels. These near-zero levels demonstrate the risks of reliance on solar power during peak demand.

Figure 2.1
Daily and Diurnal Variations in Solar Insolation: Texas, Selected Cities

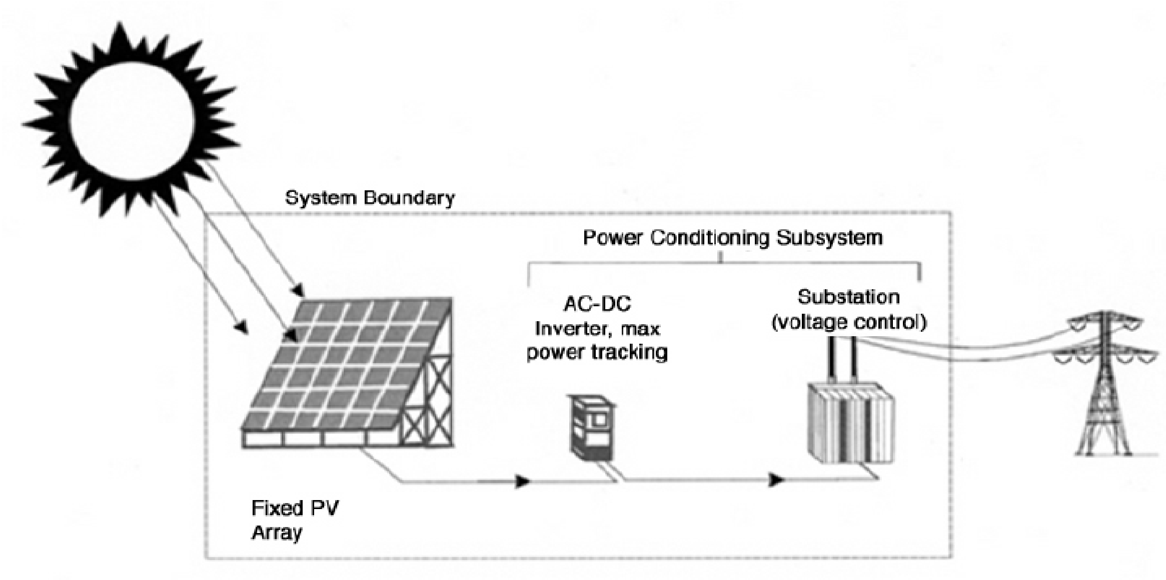


Source: Frontier Associates, LLC, Report for the State Energy Conservation Office of Texas, *Texas Renewable Energy Resource Assessment* (December 2008), pp. 3-14. Online. Available: http://www.seco.cpa.state.tx.us/publications/renewenergy/pdf/renewenergyreport.pdf. Accessed: June 16, 2009.

The distributed generation and renewable energy core team of PSP developed a set of recommendations that seek to deploy a diverse portfolio of renewable technologies by 2020. These recommendations include: 1) deploy solar PV on multiple locations in the near term as well as combined heat and power, waste to energy, and landfill gas to energy; 2) evaluate next-generation solar PV, micro-wind, micro-hydro, geothermal, and other emerging technologies for future deployment; 3) start with the highest energy potential technologies at the lowest cost; 4) couple variable renewable resources with networked storage, beginning with high-congestion areas; 5) take advantage of record low solar PV module prices; 6) create pilots to test and demonstrate emerging technologies; and 7) stage expansion with new, lower-cost energy technologies as they become available.[5] This team also recommends establishing innovative business models and incentives to ensure AE's continued financial stability as it promotes distributed generation and to attract design and manufacturing facilities to Austin.[6] It is recognized that building codes will need to be revised to promote distributed generation development, criteria will need to be assigned to facilitate solar installations, and better permitting mechanisms will be necessary to reach deployment objectives for solar PV.[7]

Due to the economics and limited scale of other sources of distributed energy, PSP ideas are dominated by the integration of solar PV module systems into AE's electric grid. It is estimated that there is technical potential to site about 1,637 MW of solar capacity on rooftops in AE's service territory.[8] There are additional opportunities in Austin for siting ground-mounted solar. Figure 2.2 is a diagram of a PV system connected to the electric grid. Multiple locations for incorporating solar PV into AE's system are identified by PSP including solar arrays on residential homes, commercial buildings, and parking lots as well as ground-mounted solar. Solar PV panels and building-integrated PV are recognized as potential applications of solar PV. Solar PV projects will likely use solar material that is the most cost-effective at the time of implementation. Several ideas are posed by the new utility business model working group and legislative and regulatory requirements group on how to facilitate the incorporation of solar PV into AE's power system while retaining financial stability and system reliability. These ideas are discussed in Chapter 3 of this report. One challenges for incorporating a high amount of solar PV into AE's system is determining ownership and siting as solar PV has traditionally been owned and operated by the customer rather than the utility. The traditional model for promoting solar PV through rebates and incentives would cause significant revenue deterioration and system reliability concerns for AE. However, the cost of a PV system is not currently competitive with traditional power generation resources for the utility. The range of current cost estimates of solar PV are provided in Table 2.2 based on a review of the referenced sources. Traditional power generation sources and wind power range in costs from 3 cents to 10 cents per kilowatt-hour (kWh). AE's average residential electric rates are about 10 cents per kWh.[9] The challenges facing implementation of a high amount of solar PV on AE's electric grid are discussed in more detail in Chapter 3 of this report.

Figure 2.2
Photovoltaic Grid-Connected Power System



Source: National Regulatory Research Institute, *What Generation Mix Suits Your State? Tools for Comparing Fourteen Technologies Across Nine Criteria,* p. 80. Online. Available: www.narucpartnerships.org/Resources/NRRI-GenerationMix.pdf. Accessed: June 24, 2009.

Table 2.2
Photovoltaic System Costs Overview

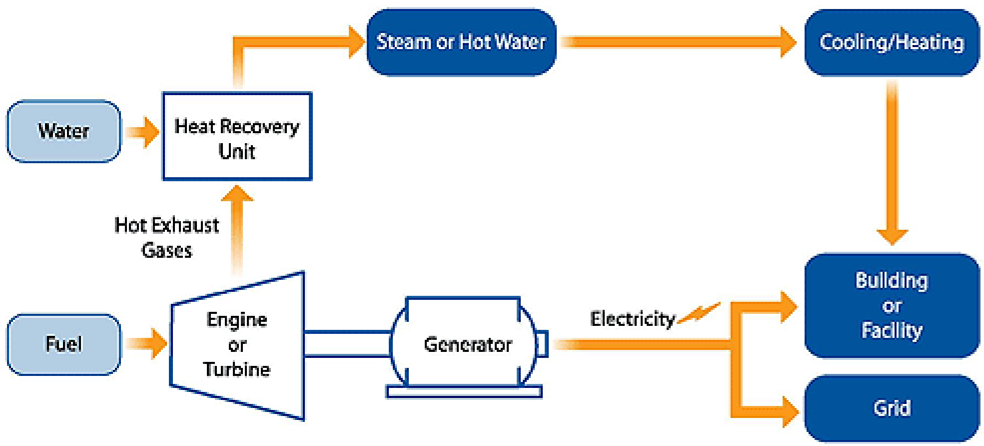
Metric	Cost
Cost of energy ($/kWh)	0.18 – 0.23
Total overnight costs ($/kW)	4,222 - 5,649
Total installed system ($/Wp)	5.20
Variable O&M costs ($/kW)	0.00
Fixed O&M costs ($/kW)	11.37
Total O&M costs ($/kWh):	0.01 – 0.02

Sources: Texas Comptroller of Public Accounts, *The Energy Report* (May 2008), Executive Summary. Online. Available: http://www.window.state.tx.us./specialrpt/energy/exec/solar.html. Accessed: June 24, 2009.; Energy Information Administration, *Assumptions to the Annual Energy Outlook 2008* (June 2008), p. 78. Online. Available: http://tonto.eia.doe.gov/FTPROOT/forecasting/0554 (2008).pdf. Accessed: June 24, 2009.; National Regulatory Research Institute, *What Generation Mix Suits Your State? Tools for Comparing Fourteen Technologies Across Nine Criteria*, p. 19. Online. Available: http://www.narucpartnerships.org/Resources/NRRI-GenerationMix.pdf. Accessed: June 24, 2009.; and National Renewable Energy Laboratory. *Power Technologies Energy Data Book*, *Photovoltaics*, p. 32. Online. Available: http://www.nrel.gov/analysis/power_databook/docs/pdf/db_chapter02_pv.pdf. Accessed: June 24, 2009.

Other sources of distributed generation tend to be limited by resource constraints or siting limitations. Some distributed generation technologies require additional study to determine local potential, operational characteristics, and costs to the utility and its customers. For this reason, feasibility studies are recommended prior to investing in new combined heat and power (CHP) facilities, ground source heat pumps, micro-hydropower generation, and micro-wind turbines.

AE currently operates two CHP facilities. CHP, or cogeneration, is the simultaneous production of electricity and heat from a single fuel source, typically natural gas.[10] If natural gas is used as the fuel source, CHP facilities basically act as highly efficient natural gas facilities by using waste heat to provide local cooling. CHP facilities are typically built to provide heating and cooling services for a micro-grid of users such as a new residential or commercial development or hospital. Figure 2.3 is a diagram of a CHP system that uses a gas turbine or engine with a heat recovery unit.

Figure 2.3
Diagram of Combined Heat and Power Unit



Source: U.S. Environmental Protection Agency, *Combined Heat and Power Partnership: Basic Information*. Online. Available: http://www.epa.gov/chp/basic/index.html. Accessed: July 8, 2009.

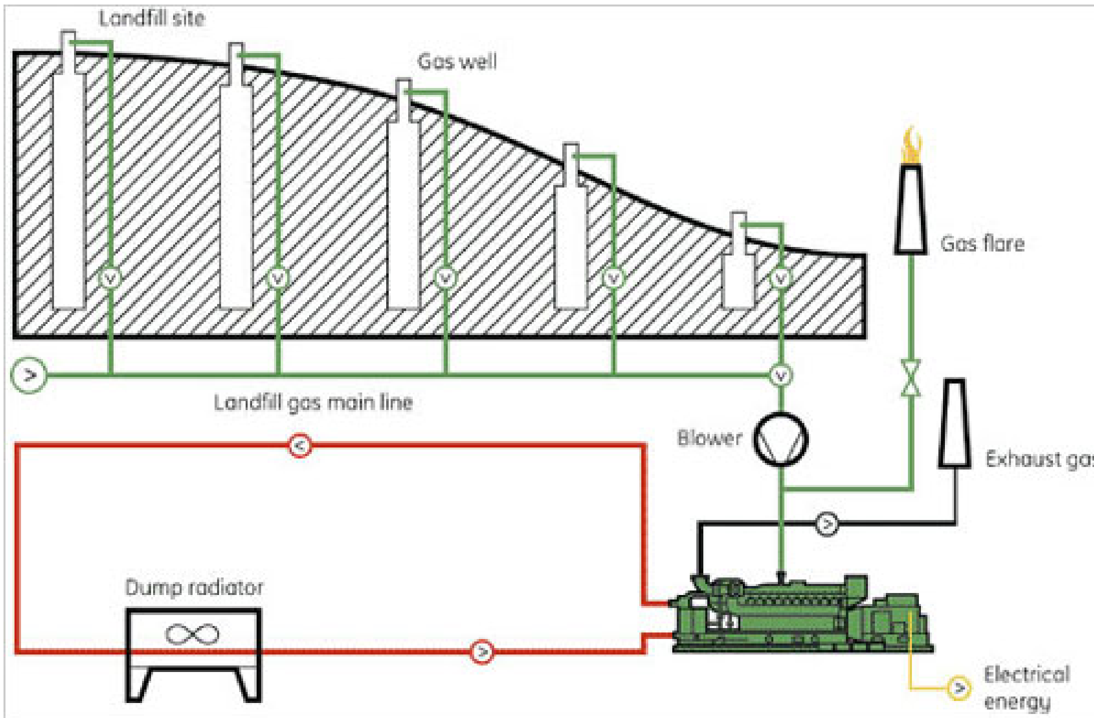
Micro-wind turbines, or small-scale wind turbines, are small wind turbines that could be placed on rooftops or ground surfaces to generate power from wind. Small-scale wind turbines [any turbine that is rated less than 50 kilowatts (kW)], can weigh as little as 35 pounds.[11,12] Figure 2.4 is a picture of a small-scale wind turbine. Small scale wind turbines could provide a complementary resource to solar PV as wind resources tend to generate power predominantly during off-peak periods when the sun is not shining. Small scale wind turbines are not currently economically competitive with larger turbines and would be particularly unattractive for areas with low wind speeds as Austin tends to exhibit. Small-scale wind turbines have a capacity factor of 15 to 20 percent in rural areas and 10 percent in urban areas.[13] Micro-hydro generation units have also not been adopted at a large scale, but are beginning to be evaluated and implemented in some areas of the US. Micro-hydro units typically produce less than 100 kW of power and are most often used in water-rich areas. It is unlikely that such units would have much appeal in the Austin area.

Figure 2.4
Picture of a Small-Scale Wind Turbine

Source: SkyStream Wind Power Generator. *Introducing SkyStream 3.7*. Online. Available: http://www.alpinesurvival.com/Skystream_3.7_Wind-Generator-Turbine.html. Accessed: July 8. 2009.

While AE currently purchases 11.8 MW of power generating capacity from landfill gas to energy facilities, expansion of this resource is limited. The Austin area is limited in landfill gas to energy potential by resource availability, but some generation capacity expansion may become available if a new landfill is constructed in Austin or new resources are identified. Figure 2.5 is a diagram of a landfill gas power plant. The recovery and use of landfill gas as an energy source has multiple benefits as it provides a relatively clean source of energy and offsets the emission of methane, which is a GHG with 21 times the potency of CO_2.[14] Municipal solid waste landfills are the second largest source of human-related methane emissions in the US, accounting for about 23 percent of such emissions in 2007.[15]

Figure 2.5
Diagram of a Landfill Gas Power Plant



Source: General Electric Power. *Images.* Online. Available: http://www.gepower.com/prod_serv/products/ recip_engines/ en/images/landfill_en.jpg. Accessed: July 8, 2009.

Waste to heat is also limited by resource availability, but resources are currently available from City of Austin Solid Waste Services. It is estimated that 200,000 megawatt-hours (MWh) of power generation a year could come from such waste in Austin.[16] A study to evaluate this resource availability in the Austin area is proposed as a project idea.

Demand-Side Management

While investing in new power generation sources is needed to ensure that AE meets future demand, there are options for lowering demand that can be much cheaper than the capital investments required of new generation sources. AE has found that it spends about $350 per kilowatt of peak demand avoided through DSM, which is far below the costs of adding new power generation units.[17] In fact, Council passed a resolution in 1999 that stated "cost-effective conservation programs shall be the first priority in meeting new load growth requirements of AE."[18] Table A-2 of Appendix A lists all PSP ideas related to DSM. Project ideas are distinguished by five sub-categories: demand response, energy efficiency, energy storage, low-tech/low emission, and water conservation.

DSM refers to measures taken by a utility to encourage conservation of electric usage or to reschedule electric usage for more uniform usage. These efforts are intended at minimize the size and number of generating facilities or to design strategic load growth." DSM constitutes a number of ways to reduce annual and peak demand of electric customers to achieve cost and energy savings for the utility. Components of DSM include conservation, energy efficiency, and demand response (with energy storage as a component of demand response). Since 1982, AE has developed and enhanced one of the nation's most extensive and comprehensive DSM programs to reduce about 800 MW of load by 2008.[19] AE commonly touts that these demand savings have prevented construction of a new baseload power plant.[20] AE's practice is to invest in any type of rebate program that they determine can be justified on a cost-benefit basis (determined by the marginal cost of generating such energy) for reducing demand or shifting peak demand.[21]

DSM programs achieve demand savings, energy savings, environmental benefits, and help avoid the need to make costly capital investments in new sources of power generation. In Fiscal Year 2007, AE projected that it saved 65.4 MW of required power-plant peak capacity through its energy efficiency programs.[22] These demand savings (not energy savings) helped to prevent new generation facilities from being developed. AE also projected that its DSM programs equaled 119,000 MWh of energy savings in 2007. The estimated annual power plant emission reductions associated with these savings include 70,000 metric tons of CO_2, 48.8 metric tons of nitrogen oxides (NO_x), 44.1 metric tons of sulfur dioxide (SO_2), 33.9 metric tons of carbon monoxide (CO), 6 metric tons of suspended particulates, and 1.7 metric tons of volatile organic compounds (VOCs).[23] For Fiscal Year 2008, AE projected that it saved 64.1 MW of required power-plant peak capacity and 132,000 MWh of energy savings. The estimated annual power plant emission reductions associated with these savings include 85,500 metric tons of CO_2, 59.6 metric tons of NO_x, 53.9 metric tons of sulfur dioxide SO_2, 41.4 metric tons of CO, 7.3 metric tons of suspended particulates, and 2.1 metric tons of VOCs.[24]In projecting demand and energy savings for a given year, AE takes the expected lifespan savings that a customer will receive through their participation in a particular program at the time of initial participation.

The ACPP set the ambitious goal of achieving an additional 700 MW of demand savings by 2020.[25] AE feels confident that it can achieve these goals even though there remain challenges and uncertainties concerning future demand saving projections, as the development of new technologies and their continued adoption by customers is difficult to predict.[26] Project ideas identified by PSP could help AE meet this 700 MW goal and possibly exceed it.

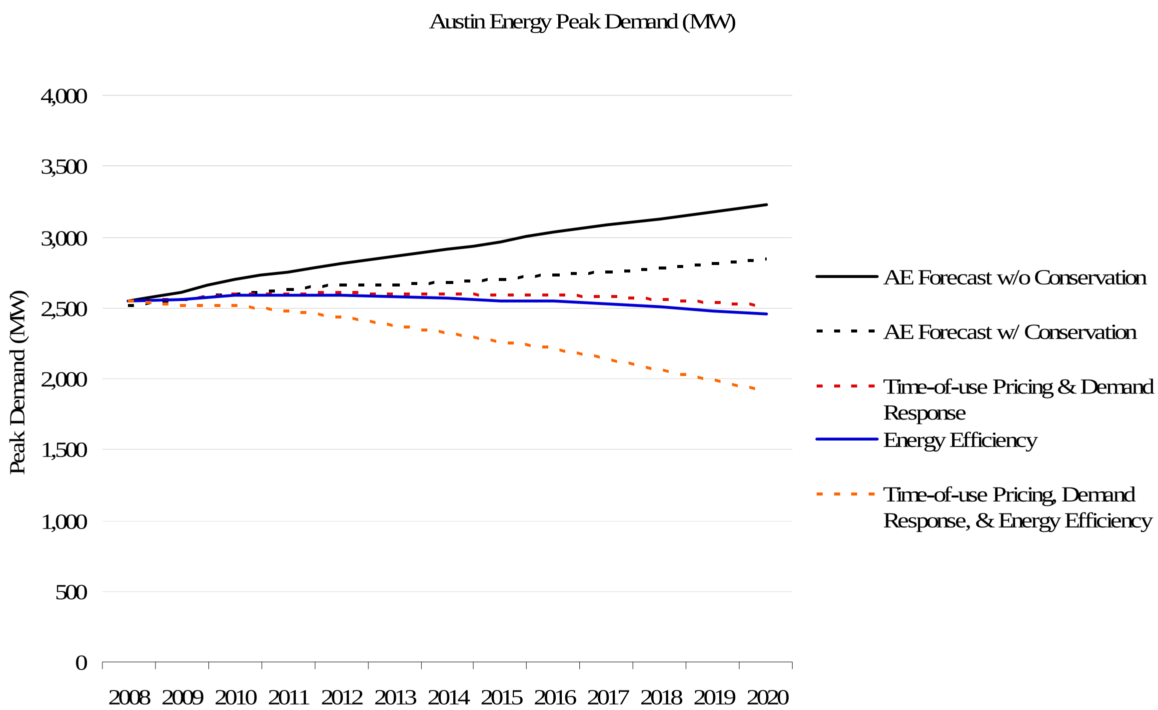
A policy research project conducted during the 2008-2009 school year on future energy options for AE conducted an analysis based on AE's 2008 load forecast on the potential for accelerated energy and demand savings.[27] Based upon an assessment of several utility-scale studies on the potential for energy savings from energy efficiency, time-of-use (TOU) pricing, and demand response, the project determined that AE could theoretically achieve peak demand savings of 40 percent (in MW of peak demand) and overall energy savings of just over 30 percent (in MWh) from baseline energy demand. Under AE's proposed plan, or "strawman proposal" that includes 700 MW of demand savings, AE would reduce both peak demand and overall energy consumption by about 12 percent.

For the following analysis it was assumed that energy efficiency programs could achieve annual energy savings of 24 percent by 2020 and TOU pricing and demand response programs could achieve a combined 22 percent in peak demand savings and about 10 percent in energy savings.[28] In 2004, a report was released that summarized the results of 11 different studies on the technical, economic, and/or achievable potential for energy efficiency in the US.[29] It was determined that there remains a median technical potential ranging from 18 to 36 percent, with a median of 33 percent, for reducing electricity demand through energy efficiency. The median economic potential for electricity efficiency was identified as 20 percent. The achievable potential of energy efficiency for electricity ranged from 10 to 33 percent, with a median of 24 percent. This was applied at an average rate of 1.2 percent per year. A 2004 study by the Berkeley National Laboratory found that real-time pricing programs had achieved 11 to 38 percent demand savings depending on whether the program was obligatory or voluntary.[30]

Figure 2.6 shows the potential peak demand savings from TOU pricing and demand response, energy efficiency, and combined compared to AE's forecast with and without conservation, based on an assumption that these savings can be realized linearly over the years 2009 to 2020. Figure 2.7 shows the potential energy savings from these DSM strategies. Figure 2.8 shows the potential impacts of these DSM strategies on the projected hourly load profile for the peak day in the summer of 2020. Based on these results there is potential for AE to significantly lower its demand through DSM strategies. Dynamic pricing and other demand response strategies can significantly reduce peak demand for the utility, much more so than energy efficiency programs. However, energy efficiency programs can achieve much greater overall energy savings, thus creating much greater environmental benefits such as CO_2 reduction.

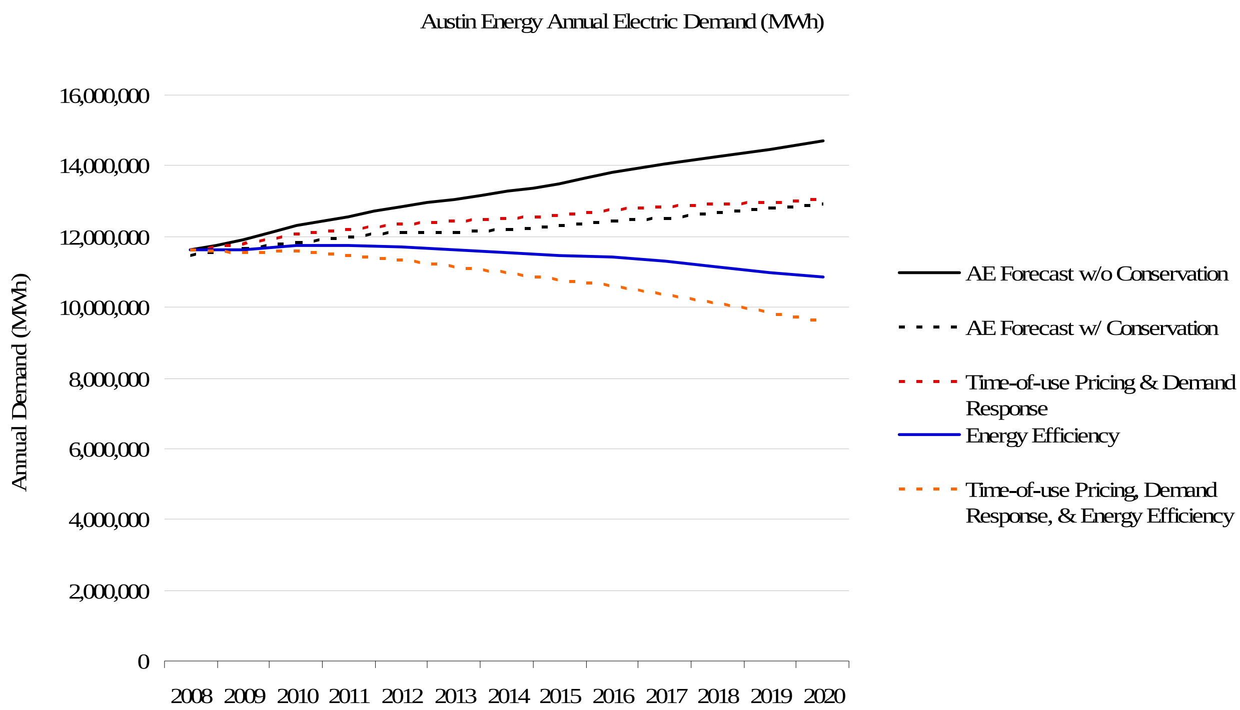
These results provide only a rough estimate of potential demand and energy savings based on a survey of national studies. Since AE has been relatively aggressive historically with its energy efficiency and conservation programs, this potential may be lower for AE. The true potential for DSM must be determined internally by AE through an assessment of technical, economic, and achievable potential. AE's goal for demand savings, currently set at 700 MW, is likely based on expected achievable potential for AE and may demonstrate limitations that AE faces. However, dynamic pricing may be a mechanism by which AE could significantly reduce demand even further. This additional potential will need to be assessed independently if not already included in AE's projections for potential demand savings. While there is significant potential for reducing demand through DSM strategies, the programs identified by PSP may only help AE meet its current demand savings goals, rather than create additional savings. The performance of DSM strategies will need to be consistently evaluated by PSP as the project moves forward and AE should evaluate how this alters, if at all, their demand reduction goals.

Figure 2.6
Peak Demand Profiles for DSM Strategies



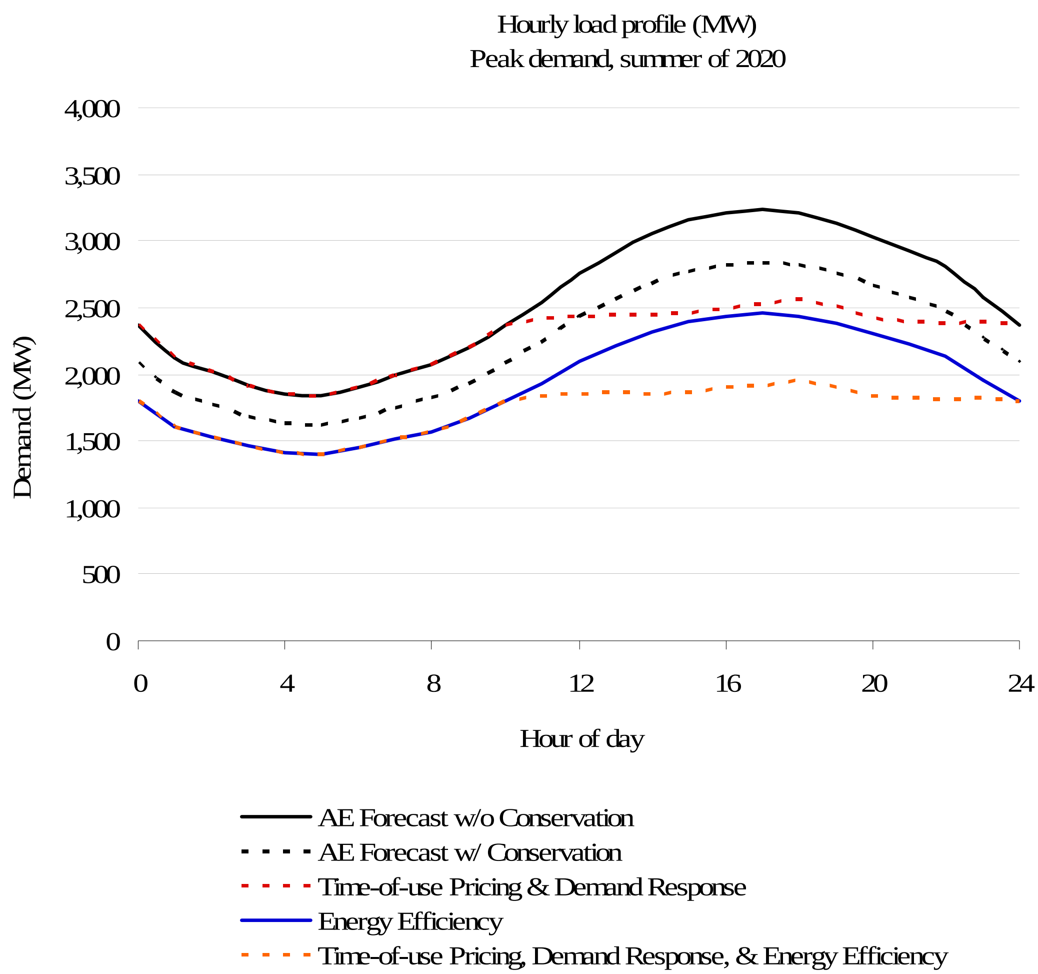
Source: Prepared by Brent Stephens for: Lyndon B. Johnson School of Public Affairs, "Sustainable Energy Options for Austin Energy: Future Resource Portfolio Analysis," Policy Research Project Report Series, no. 166 (Austin, Tex., 2009), Chapter 11 (draft).

Figure 2.7
Annual Electricity Demand Profiles for DSM Strategies



Source: Prepared by Brent Stephens for: Lyndon B. Johnson School of Public Affairs, "Sustainable Energy Options for Austin Energy: Future Resource Portfolio Analysis," Policy Research Project Report Series, no. 166 (Austin, Tex., 2009), Chapter 11 (draft).

Figure 2.8
Peak Day Hourly Profile for DSM Strategies



Source: Prepared by Brent Stephens for: Lyndon B. Johnson School of Public Affairs, "Sustainable Energy Options for Austin Energy: Future Resource Portfolio Analysis," Policy Research Project Report Series, no. 166 (Austin, Tex., 2009), Chapter 11 (draft).

Conservation

Energy conservation refers to decreasing the amount of energy used, primarily by changing the behaviors and habits of consumers of energy or by increasing the energy efficiency of electric-consuming products. PSP ideas related to conservation predominantly relate to the use of water and the energy-water nexus. Several water conservation ideas were identified by the water conservation working group. The treatment of wastewater and outgoing clean water is one of the largest consumers of electricity, accounting for roughly 3 percent of the nation's electricity.[31] Thermal power plants are also major consumers of water. Replacement of energy sources with clean energy sources that require less or no water conserves water, as well as reduces, energy demand from existing resources.

One potentially significant PSP project idea identified by the energy efficiency working team is conserving energy by reducing "vampire" or "phantom" loads. Stand-by appliances and electronic equipment (equipment that is plugged in but not in use) accounts for 5 to 10 percent of home electricity consumption. Called "vampire loads," 75 percent of the electricity used to power home electronics is consumed while the products are not in use.[32] Rebates for smart power strips that would shut down stand-by appliances and electronic equipment when not in use could conserve energy, particularly if paired with educating customers on how their energy use habits at home affect their electric bills and the environment.

The implementation of energy management systems that would allow customers to manage their energy use based on real-time information on usage and costs could promote less energy use and/or the shifting of energy usage patterns (a form of demand response). Pricing mechanisms such as TOU pricing could also lead to energy conservation as well as shifting loads. Pricing mechanisms are discussed in more detail in the section on demand response.

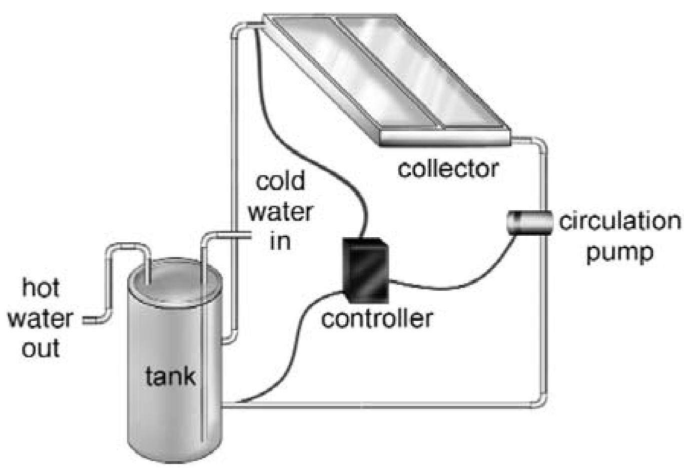
Energy Efficiency

Energy efficiency is typically stated as a percentage calculated by the output of energy released by a process divided by the amount of input through work or energy that was put into that process. Efficient energy use is using less energy to provide the same level of service. In terms of energy efficiency technologies, air conditioning systems and other appliances that run on electricity can be compared based upon their energy efficiency.

The energy efficiency core team provided 10 recommendations for PSP, divided into three categories. The three categories are: strategies to drive energy code transformation in new buildings, strategies to drive new technology development and uptake, and strategies to improve the efficiency of Austin's existing building stock.[33] Recommendations for existing buildings are designed to complement AE's rebate programs. The primary recommendation made for new construction is a shift from prescriptive to performance-based energy codes. Performance-based energy codes are codes that allocate an amount of energy, typically in terms of kWh or kWh equivalent per square foot for each building type to allow discretion in how that level of energy use is achieved.[34] This creates an incentive for better building design strategies rather than just a focus on energy efficiency appliances and other technologies. Another strong recommendation of this team is to plan and construct a zero-net energy demonstration project to showcase the optimal combination of passive and community design strategies.[35] Further discussion of specific technologies and energy efficiency strategies identified by the energy efficiency working group follows.

Solar water heaters and solar absorption cooling are technologies identified as promising energy efficient technologies that can reduce energy use and CO_2 emissions through the use of solar energy. Solar water heating systems come in a wide variety of designs, but are typically composed of a solar collector and a storage tank that use the sun's thermal energy to heat water, replacing traditional hot water heating systems that either use electricity or natural gas.[36] Solar water heater systems can be "active" or "passive," but active systems are more common. Figure 2.9 is a diagram of an active solar water heater. Solar water heating is an effective way of using clean, renewable energy at a residence or larger building. This is a mature technology that has yet to be widely adopted in the US. AE currently provides a rebate of $2,000 per system for existing homes and $1,500 per system for new homes. Customers also can apply for a 0 percent interest loan to help finance the system.[37] AE has not had much success in adoption from customers for this program, only rebating 17 systems in 2008.[38] PSP is looking at increasing awareness of and the amount of the rebate in order to facilitate greater adoption. The goal is to install 500 systems a year, possibly by partnering with a manufacturer willing to implement a pilot program with an enhanced rebate.[39]

Figure 2.9
Active Solar Water Heating Technology



Source: Solar Energy Industry Association, *Solar Thermal Power Factsheet*. Online. Available: http://www.seia.org/galleries/pdf/Solar_Thermal_general_one_pager_Final.pdf. Accessed: July 8, 2008.

Solar absorption cooling systems are typically relatively large in scale, so smaller applications need to be developed for residential use. These systems typically use an absorption chiller to transfer thermal energy from the heat source to the heat sink through an absorbent fluid and refrigerant. Typically, these systems operate off industrial waste heat.[40] Such systems can efficiently cool in the summer and heat water and buildings in the winter, reducing a building's energy use by 20 to 30 percent.[41]

Several project ideas identified by the energy efficiency team relate to the promotion of passive and community design strategies that increase the energy efficiency of residential homes and buildings. Passive design strategies include: maximizing the solar gain of homes based on the orientation and siting of homes and buildings; developing dense, mixed-use, and transit-oriented communities; using shading and weatherization techniques; applying advanced window technology and window placement; and using space heating and thermal mass techniques for energy efficiency gains. Possible ways to promote passive design would be through marketing programs, incentives, and building code standards. The development of zoning regulations would be necessary to make passive design strategies standard.[42] A pilot program to increase market penetration for wireless sensors and lighting controls is also recommended by the energy efficiency core team to increase the efficiency of existing commercial buildings.[43]

Continued enforcement of new green building code standards is a major component of ensuring that continued energy and demand savings are achieved. In 2007, Austin adopted the International Energy Conservation Code with amendments.[44] This was the first step towards reaching zero-energy capable homes through the Zero Energy Homes Initiative passed by Council in 2007. Future building code changes expected for 2012 and 2015 would require new homeowners to build zero-energy capable homes in which reaching zero-net energy usage through the addition of solar technology and other clean energy technologies would be possible.[45] New homes are expected to use 70 percent less energy than before the 2007 code was adopted by 2015 if these codes are enforced as expected.[46] Since green building codes only apply to new homes and buildings, the PSP team also supports the continued enforcement and adoption of building improvement measures for existing homes and buildings. AE already implements a diverse number of such programs that include home energy auditing, weatherization improvements, and rebates for energy star appliances, energy efficient heating and cooling systems, and other energy efficient applications.

Demand Response

Demand response is sometimes referred to as load management, load shaping, or load shifting.[47] Demand response is the ability of a utility to counteract the need for new supply resources by reducing load during a period of relatively high consumption. The ability to change consumption patterns can be induced through price variations over the course of time or incentives designed to induce lower electricity use at times when market prices are high.[48] Demand response programs can have great benefits for the utility because the utility must provide instantaneous supply to meet demand that varies over the course of the day, week, season, and year.

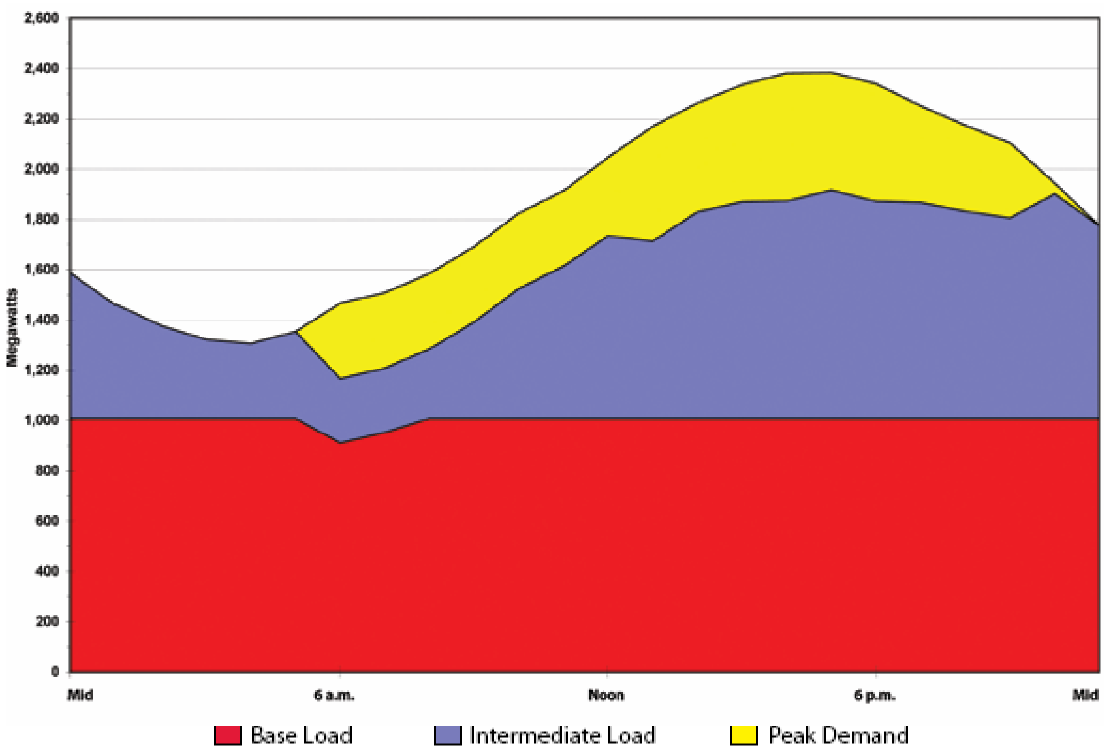
Demand response programs are advantageous for utilities due to the demand, or load, profiles exhibited by utilities. Load profiles demonstrate power requirements over a given period of time, typically represented as daily, weekly, and seasonal patterns. Electric load has a strong correlation with weather due to the relation of weather and electric cooling (air conditioning) and heating systems. Over the course of a typical day, afternoons tend to have the highest peak demand for electricity. Weekdays tend to have higher peak demand than weekends due to business operation schedules. The summer and winter months tend to have the highest demand during a year, with highest annual demand occurring on the hottest day of the summer. Figure 2.10 shows the hourly load shape for AE on a typical hot summer day in August, representing peak demand for the utility. Different resources are used to provide baseload, intermediate, and peak power as demonstrated by this figure. Natural gas tends to meet intermediate and peaking needs for AE, but solar resources can also provide peaking power when it is available. Load varies significantly over the course of the day, with demand peaking in the late afternoon. The cost per unit of energy tends to be higher for plants used to serve intermediate load and higher still for plans serving peak demand.

A load duration curve can be used to illustrate how much power generating capacity is needed at any time over the course of a year. Figure 2.11 shows AE's load duration curve for 2006. This figure demonstrates that the top 100 MW of demand is only used for 43 hours of the year.[49] AE's minimum electricity demand is approximately 1,000

MW at all times over the course of the year as compared to its maximum load requirement of about 2,400 MW. These graphs demonstrate the potential for shifting load on a given day and leveling load over the course of the year.

Figure 2.10
Austin Energy Hourly Load Profile

August Generation by Type



Source: Austin Energy, *Austin Energy Resource Guide* (October 2008), p. 12. Online. Available: http://www.austin smartenergy.com/downloads/AustinEnergyResourceGuide.pdf. Accessed: July 8, 2009.

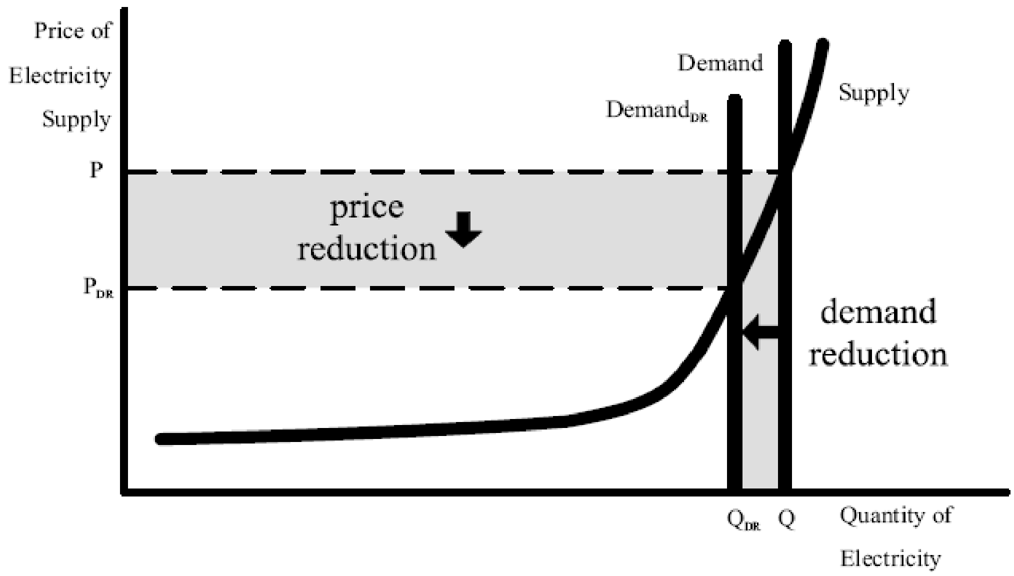
Figure 2.11
Austin Energy's Load Duration Curve, 2006

Source: Class Presentation by Fred Yebra, Manager, Energy Efficiency Services, Austin Energy, "Investing in Energy Efficiency: Assessing the Costs and Benefits," at the Lyndon B. Johnson School of Public Affairs, Austin, Texas, July 8, 2009, slide 12.

Demand response strategies have traditionally been utility-controlled activities, meaning that their application results from a centralized energy control capability to influence how energy is consumed at the end point. As the utility oversees the entire electric system, it can identify when critical peak periods occur and encourage shifting in aggregate energy consumption directly through strategic intervention. Load shifting refers to programs that move electric usage from peak demand hours, such as weekday afternoons, to a time of day that has lower electric demand.[50] In order to shift load, the utility can either control load directly or offer incentives to encourage users to change their energy usage behavior. For instance AE's Power Partner Thermostats program allows the utility to coordinate the "cycling" of a customer's air conditioner during peak demand periods in exchange for a free programmable thermostat plus free installation (valued at $200-280).[51] The demand response core team distinguishes these types of programs as reliability-based demand response. Recommended technologies for reliability-based demand response include energy management systems, building management systems, lighting management systems, and home area networks.[52]

Traditional demand response programs may be expanded by AE, but the focus of PSP for demand response strategies are dynamic pricing mechanisms. Dynamic pricing mechanisms are viewed as having great potential for significantly lowering peak demand and achieving load leveling. TOU pricing, or other incentives, such as pre-pay plans, allow consumers to actively engage in the electricity market. Figure 2.12 demonstrates the typical demand-supply relationship for electricity consumption. The demand for electricity is commonly represented as fully inelastic, but studies have shown significant substitution elasticity based on pricing alone (see Table 2.3). When combined with smart metering and usage information displays, the energy value gained from either shifting from peak to off-peak or eliminating consumption altogether can be much higher.[53] AE could provide its customers the price signals they need to make such substitutions.

Figure 2.12
Electricity Pricing Supply and Demand Curves



Source: U.S. Department of Energy, *Benefits of Demand Response in Electricity Markets and Recommendations for Achieving Them*, Report to the U.S. Congress Pursuant to Section 1252 of the Energy Policy Act of 2005 TT(Washington D.C., February 2006), pp. v–viii. Online. Available: www.oe.energy.gov/DocumentsandMedia/congress_1252d.pdf. Accessed: July 3, 2008.

Dynamic pricing provides a mechanism for utilities to pass on the true marginal costs of generating electricity to the consumer. AE could incorporate TOU, real-time, or critical peak pricing tariffs at all customer levels, with a focus on the residential customer class, to reduce peak demand and energy consumption as a whole. It is important to note that price signals depend upon the costs of producing electricity unique to the utility. Therefore, AE must evaluate the variance in the costs of electricity for different periods of the day and over the course of the year to determine the potential impacts of dynamic pricing.

AE currently charges a fixed rate for connection to the distribution network, a steeply inclined block rate for its base energy charge, and a constant fuel charge for all energy purchased.[54] While the block rate may capture the differences between baseload and peaking plant operations cost, the fuel price is simply an average of the many different fuel costs used in AE's power generation mix. Under such a system, a consumer has no incentive to reduce peak load and, therefore lower total cost, because electric rates do not vary by the time of day.

A basic TOU rate structure attempts to partition the day into time-based price blocks, where the cost for a specific block reflects the utility's costs of service at that time.[55] For example, the costs of delivering electricity during the daytime peak demand period is typically higher than the costs of electricity during the night or off-peak hours. TOU rates have the potential to lower system demand, particularly at peak periods, if a sufficient price signal is applied appropriately to each time block. While TOU pricing more accurately allocates cost than a constant price, the costs within a time block are still averaged and do not necessarily provide a real-time price signal. TOU pricing has been implemented by some utilities in the US with large commercial and industrial customers that have been outfitted with advanced meters that can record differentiated consumption within the time block.[56]

Real-time pricing is a structure that applies actual cost of service in small measured increments, such as hourly consumption. Some tariffs may pass through the market-clearing price in the wholesale electricity market, while others may be based on the utility's actual marginal cost for that hour (system lambda). Customers can be made aware of the prices ahead of time, with the method of communication being crucial to the success of the program.[57]

Energy prices are currently driven by the most expensive power plant deployed at a given time. Power generation in the Electric Reliability Council of Texas (ERCOT) market is priced at the wholesale level on the marginal cost to serve the next unit demanded. At times of very high demand, or critical peak, the price to serve the next MWh can be extremely high. At times of extreme power shortage, ERCOT spot market prices may be capped but may reach fifty times larger than the incremental cost of AE's baseload plants.[58] A critical peak pricing program is an event-driven hybrid of TOU and real-time pricing. When a "critical peak" occurs, the normal peak time period in a TOU rate structure is replaced by a very high price that reflects the marginal cost of supply during that event. The designation of critical peak days is usually limited for a given year. Critical peak pricing could help AE defer some of its wholesale market risk in the ERCOT market. If AE were to lose some power generation capacity during a shortage event, they might be exposed to such high market pricing which would be very costly. The ability to avoid such "critical peak" costs could be very valuable to AE.[59]

A price-based demand response pricing structure will require restructuring AE's billing system.[60] AE already plans to upgrade its billing system to take advantage of its smart grid system. This process for upgrading the billing system began in May 2009, but will not be completed until 2011.[61] Advanced meters will also be necessary to enable dynamic pricing. A presentation by Mark Dreyfus, Director of Government and Regulatory Affairs at AE, in July 2009 discussed the utility's current efforts to analyze the potential for dynamic pricing. It was discussed that the utility was currently doing market research on all dynamic pricing programs that have been tested and implemented in the US. Drefyus stated that AE would need to first establish policy objectives for TOU pricing, perform piloting, and determine the potential rate structure through a rate case prior to full deployment of dynamic pricing.[62] The challenges for implementing dynamic pricing are many, but the benefits to the utility and its customers could be significant. AE will need to carefully determine the structure and identify the potential ramifications before any formal pricing scheme is fully implemented.

The demand response team recognizes the challenges posed by implementing dynamic pricing. It is recommended that AE launch pilot projects to test dynamic pricing for different customer classes. It is also recommended that AE include a vision for dynamic pricing in its implementation of the next customer billing system and seek regulatory approval for such pricing mechanisms.[63]

Energy Storage

Energy storage is the storing of some form of energy that can be used at a later time to perform an operation. The widespread ability to store energy at utility-scale for long periods of time has yet to be accomplished. However, advancements in grid energy storage technologies could allow for the temporary storage of electricity to shift loads by generating electricity during off-peak hours that can be used during peak demand hours. This could help meet supply and demand needs over 24 hour increments of time. By temporarily storing energy, load curves can be flattened so that there would be less need for intermediate plants and peaking plants that are seldom used and are thus expensive to build and operate per MWh of energy produced. Energy storage can also be used by the utility to ensure that electricity comes from an uninterruptible source (improving the reliability of variable resources such as solar and wind), to provide grid support, and to help manage load. Advancements have been made in the area of grid energy storage primarily for the purpose of better utilizing distributed generation.[64] Potential energy storage technologies are listed in Table 2.4 and grouped based upon their development status as either commercially available, pre-commercial, demonstration, or developmental. AE will most likely look at commercially available technologies for immediate implementation while waiting on pre-commercial technologies for additional research. AE already has plans to evaluate and potentially add compressed air energy storage to its resource mix, both aboveground and underground. Underground systems are likely to be larger in scale (around 300 MW) and be located in conjunction with a wind farm in West Texas. However, smaller systems (around 15 MW) could be located on the local grid at a substation. The focus of PSP is on local, smaller-scale energy storage technologies.

Table 2.3
Energy Storage Technologies

Commercial	Pre-commercial	Demonstration phase	Developmental
Pumped hydro	Flywheel	Electrochemical capacitor	Lithium ion (grid applications)
Flywheels (local power quality)	Flywheel (grid device)	Hydrogen loop	Super-magnetic energy storage applications
Compressed air energy storage (CAES)	Zinc-bromine battery		
Lead acid battery	Vanadium redox battery		
Ni-Cd battery			
Sodium sulphur battery			

Source: Jon Slowe, "Emerging Electricity Storage Technologies," *Cogeneration and On-Site Power Production*, Sep.-Oct. (2008), p. 71. Online. Available: http://www.smartgridcentral.com/artman/publish/Generation_Storage/Emerging_Electricity_Storage_Technologies-1597.html. Accessed: July 8, 2009.

Thermal storage, neighborhood electric storage, and other grid-support storage innovations are identified by the PSP team as applications of energy storage technologies that could support local distributed generation. Thermal energy storage is a method of temporarily storing energy collected by solar towers, thus reducing the variability of solar power. The two main thermal storage applications are tank-based systems and molten salt storage systems. Each system type takes advantage of heat transfer fluids to store heat and drive a steam turbine hours after the energy is produced. Molten salt can be used as a heat store while ice can be made from water, stored until the next day, and then used to cool either the air in a large building during peak demand or the intake air of a gas turbine generator.[65]

Batteries in electric vehicles could also be used as temporary energy storage devices. By plugging in vehicles at night when electricity is relatively cheap and demand is low and selling back energy during the day when demand is high and electricity is most expensive, a utility can price accordingly to create an incentive for consumers to shift energy demand periods. Although electric vehicles would increase overall energy demand for the utility, the need to invest in new sources of generation could potentially be avoided through such load leveling techniques. Additional discussion of the application of EVs and PEVs as an energy storage mechanism is discussed below.

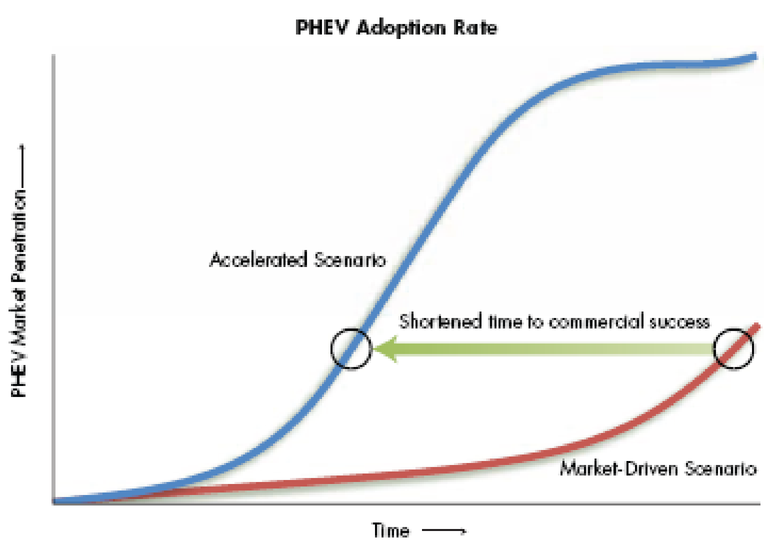
Transportation

EVs and PEVs present an opportunity to increase energy security and lower overall emissions (but increase emissions for the utility) by shifting vehicles from using oil to using electricity. While EVs and PEVs may increase electric demand, creating problems for management of the electric grid, opportunities for utilities to actually reduce the costs of electricity with EVs and PEVs exist. This concept has been termed the vehicle-to-grid system. The idea behind the vehicle-to-grid system is that EVs and PEVs could serve as temporary storage devices to shift energy from off-peak demand periods to peak-demand periods. AE is one of the main proponents of this concept and has already begun to test its potential. In January 2008, AE announced that it would partner with V2Green's Connectivity Module to test its automation equipment with two PEVs.[66] The idea behind this technology is that the vehicle-to-grid system can control the timing and the extent to which the vehicles are charged and when energy is sold back onto the grid. By charging a vehicle at night, when demand is low, and selling back energy when the vehicle is plugged-in during the day, when demand is at its peak, plug-in customers can make money from the electricity produced while the utility can effectively shift demand from off-peak to on-peak hours. This process would effectively store energy for the utility to reduce peak demand.

The amount of emissions related to a PEV is dependent upon the utility's generation mix or the generation technology linked to a particular PEV. If a person were to plug-in their vehicle to a solar energy source, emissions attributed to the vehicle would be much lower than if the electricity used was attributed to the utility's overall power generation mix. For instance, wind energy tends to be abundant during the early morning hours (2 to 6 am) when supply could be greater than demand. Prices for such energy could be very cheap for plug-in customers and provide clean energy for the powering of their vehicles. If this energy is sold back onto the grid later, clean energy will have been stored for the electric utility by the vehicle's battery storage component.

PEVs need to be able to significantly penetrate the market for this type of technology to make a sizeable difference. Several automakers are developing EVs and PEVs and plan on bringing vehicles to market between 2009 and 2012. Figure 2.13 demonstrates a general representation of the likely prospects of plug-in hybrid electric vehicle (PHEV) market penetration. Initial costs of purchasing EVs and PEVs will likely be high and subsidies may be needed as an incentive to purchase such vehicles. Incentives could be provided by the government and/or by AE through agreements that the customer will provide a certain amount of electricity back to the utility during certain hours of the day when demand is the highest. This figure demonstrates that PHEVs will take several years to make a sizeable impact on the electric grid as market penetration of new automobile technologies tends to grow slowly because of high initial cost and risks of early adoption.[67] The provision of incentives by the government and the utility along with consumer education will likely determine the rate of adoption.

Figure 2.13
PEV Market Penetration Projections



Source: Electric Power Research Institute, "Plug-in Hybrids on the Horizon: Building a Business Case," *EPRI Journal* (Spring 2008), p. 13. Online. Available: http://mydocs.epri.com/docs/CorporateDocuments/EPRI_Journal/2008-Spring/1016422_PHEV.pdf. Accessed: July 8, 2009.

PSP aims to be a leader in the adoption of PEVs by providing incentives to purchase vehicles and facilitate the selling of energy to the utility, supporting charging stations, and increasing consumer confidence and awareness of the benefits of owning and using a PEV. Table A-3 of Appendix A lists different project ideas related to transportation. These ideas focus on the electrification of road vehicles. Additional ideas include the electrification of non-road vehicles, especially city-owned vehicles, and electrified mass transit. The transportation core team believes that through incentive and support programs it can enable the deployment of approximately 190,000 PEVs in Austin by 2020, capturing 30 to 40 percent of all need car purchases.[68] AE anticipates that by the end of 2010 95 PEV vehicles will be deployed for testing.[69] The core team recommends a pilot project to develop the support necessary for PEV deployment through charging and communication infrastructure development. AE has been active in applying for stimulus funding directly for smart charging and partnering with vehicle manufacturers to test and implement PEVs on AE's grid. A second pilot project is recommended to develop a business model and approach to using transportation and battery storage to shift loads.[70]

Research and Studies

As one of the goals of PSP is to develop Austin into a test bed for emerging clean energy and smart grid-related technologies, many project ideas relate to the development of research initiatives, pilot projects, and studies prior to the implementation of new technologies. Many new technologies identified through the PSP process are still in the developmental stage or are not yet cost-effective for the utility. Therefore, it is necessary for PSP and AE to first gather data and information to determine if implementation is appropriate for later project phases. Research projects and studies are intended to gather information in order to assess the potential impacts and benefits of different technologies and energy programs to determine the value of implementation. Table A-4 of Appendix A lists the research ideas, studies, and pilot projects identified by PSP.

Technologies that are identified as requiring additional study prior to implementation include micro-wind turbines, micro-hydro turbines, waste-to-heat resources, thermal storage, ground source heat pumps, CHP, and energy storage technologies. Other technologies are identified for demonstration projects prior to mass implementation such as EVs and PEVs. Demonstration projects are recommended to test the technical potential and associated impacts of smart grid technologies, TOU pricing and other dynamic pricing schemes, zero-energy capable homes, advanced DSM residential homes and commercial buildings, and energy storage technologies. Tools for identifying and evaluating new technologies are recommended to increase the amount of information and improve the business decisions made by AE and PSP. Tools identified include a cost modeling tool for renewable energy technologies, a database of renewable energy technology companies, market research sessions on PEVs with AE customers, investment modeling for energy storage, surveying of smart grid leaders and monitoring of smart grid projects, developing a carbon impact model, and studying the renewable energy credit market.

One of the major initiatives of PSP is to develop a clean energy park similar to SEMATECH. Such a facility would help facilitate the testing of new technologies, particularly smart grid technologies, and would allow PSP partners to establish operations for testing purposes in Austin. AE does not have authority, as a City Department, to maintain a research and development budget, limiting its ability to independently test and research emerging technologies. Such a facility is critical to the success of PSP and is one of the major initiatives being evaluated and promoted by PSP founders. PSP is also interested in promoting the establishment of a National Renewable Energy Laboratory in Austin.

Public Awareness and Outreach

The customer interfaces and impacts and behavioral choice economics working group was primarily tasked with identifying methods to increase public awareness of PSP and promote the success and adoption of PSP programs through outreach methods. The ideas generated by this working group predominantly relate to either providing information to AE customers to increase participation in PSP related programs or promoting local, regional, and national recognition and prominence of PSP through the design of public demonstrations and other methods. Table A-5 of Appendix A lists the public outreach and support ideas identified by PSP. These ideas will be essential to ensuring the success of PSP. It is yet to be determined the extent that AE will be able to provide staff support for the project or how much funding PSP itself will receive. Staff support will be essential in developing the programs identified by this working group. It should not be overlooked that the successful development and implementation of the project ideas identified by other working groups will be heavily dependent on the success of these support programs.

Programs related to providing information to customers include marketing and awareness programs, designing a PC energy portal or website for PSP and developing a PSP reference manual, home energy reporting/auditing, multi-player information gaming, online resources and communication, public school curriculum, work-based education programs, informational booths, a customer acceptance program, and facilitation of community input and participation. Information campaigns are expected to increase participation and customer satisfaction with PSP and related programs implemented by AE. Confidence campaigns are identified as a method to encourage participants to encourage participation from others in the community. Contests and challenges and a national competition are methods that could increase local and national recognition. A fixed or mobile public demonstration project is identified as a way to convey the vision and value of applying a smart grid system and implementing PSP programs.

Economic Development and Workforce Training

One of the primary purposes of PSP is to develop Austin into the clean energy capital of the world and bring emerging clean energy technology companies to Austin. Most PSP ideas have some implications for economic development in the Austin region. By integrating new technologies into AE’s electric grid and promoting new technologies PSP hopes to bring new companies to base operations in Austin and bring new jobs to the City and region. While all project ideas have direct or indirect impacts on economic development, an economic development working group was tasked with identifying opportunities for the promotion of economic development through PSP and to identify barriers to success. A workforce training working group was tasked to identify programs that could help facilitate new job opportunities and encourage the success of PSP.

The ideas identified by the economic development and workforce training groups are listed in Table A-6 of Appendix A. Ideas proposed by the economic development group focus on creating funding opportunities for companies that participate in PSP programs, supporting the development and success of these companies, and identifying legislative and regulatory barriers that could impact the success of such companies. The workforce training working group identified two opportunities: developing a smart grid education program through UT-Austin and training solar installation technicians and developing trade skills for those entering markets identified by PSP. These working groups further evaluated project ideas from other working groups to assist in the determination of potential economic impacts.

Policy Implications

The process used by PSP to identify opportunities for redesigning the electric utility system can serve as an example for policymakers and other electric utilities. PSP gathered a diverse group of perspectives for project idea formulization by recruiting private company partners, local energy experts, and community volunteers to join PSP and participate in working groups and later core teams for project idea formulation and evaluation. Working groups consisted of five to 20 members with backgrounds and experience ranging from electric utility staff, City staff, University professors, researchers and students, and private company representatives. This approach to mobilizing local and national resources to ensure project success and create relationships that can be used for later project development and implementation is replicable across the US. Policymakers and electric utilities should use a similar approach as projects to dramatically redefine a community or utility’s energy system are proposed.

Notes

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Chapter 3. Identifying Challenges for the Pecan Street Project

PSP seeks to turn Austin into America's clean energy laboratory by opening up AE's electric grid to test and implement new energy technologies. This potential transformation presents a host of major challenges to the utility. The capabilities of a smarter grid, increasing penetration of distributed generation technologies, new opportunities for DSM, energy storage technologies, and the penetration of EVs and PEVs could all lead to major changes in the structure of the electric power system. Being a first adopter of a collection of new, innovative energy technologies puts AE at risk for several factors including high costs, revenue erosion, and jeopardizing the integrity and reliability of the electric system. It is uncertain how these risks will affect AE because of the immaturity of the technologies that will be tested and the uncertain rate of penetration with which AE can and will integrate these technologies into its system. PSP working groups were tasked with identifying the challenges associated with PSP and recommending approaches to mitigate these problems and ease the transition to the electric system of the future.

This chapter identifies the major challenges posed by PSP and discusses potential solutions to these challenges. Challenges facing the utility include redefining the utility business model to ensure the utility's continued financial stability, successfully operating and managing the smart grid and emerging clean energy technologies, ensuring electric system stability and reliability, managing the high costs related to the testing and implementation of these technologies, ensuring customer satisfaction, and overcoming regulatory and other implementation hurdles. This chapter begins with a discussion of the impacts of high penetration of solar PV (assumed to be 300 MW by 2020) under AE's current business model approach to solar PV to demonstrate the challenges that PSP will face as it seeks to develop the electric system of the future.

Challenges to Utility of High Penetration of Solar PV

A primary component of PSP is to integrate distributed solar PV into AE's power generation and distribution system. The goal of achieving 300 MW of distributed power generation by 2020 has been stated by project founders.[1] The majority of such generation would most likely come from PV installed on residential, commercial, and industrial roof space. Although AE has supported PV through its solar rebate program, distributed solar only accounts for roughly 2.9 MW of AE's over 2,900 MW generation mix.[2] At such a relatively small-scale, the impact of PV upon AE's revenues and power system is minor. As the amount of solar PV connected to the electric grid increases, it is likely that AE will need to take an active approach in the placement, operation, and control of these systems by developing new business models to ensure reliable service and their own financial stability.

Costs of Solar Distributed PV

While the penetration rate of solar PV has risen as system costs have decreased, mass penetration of solar PV in the US continues to be hindered by the relatively high cost of electricity per kWh of energy produced.[3] The majority of the cost of a solar PV system comes from the initial capital requirement. AE estimates that a 1 kW system currently costs between $6,250 and $9,375 to install, tending to decline in cost as size increases.[4] The size of a typical residential solar PV system ranges from 1 to 9 kW.[5] A 3 kW system (assumed to be the average size for the purpose of this analysis) will cost about $22,000 to install prior to any incentives being applied. The AE Solar Rebate Program offers customers a rebate of $3.75 per Watt installed.[6] For a 3 kW system this would amount to $11,250. The federal government offers an additional tax credit of 30 percent of the costs of a solar PV system, up to $2,000.[7] Assuming full application of the credit, an AE customer pays roughly $9,750 for the installation of a solar PV system.

If market penetration of solar PV grows exponentially, as expected, solar PV system costs will likely continue to decline and reach economies of scale making solar cost-competitive with traditional power generation technologies per unit of energy produced.[8] Capacity-weighted average installed costs of solar PV declined from $10,500 per kW in 1998 to $7,600 per kW in 2007, an average annual reduction of $300 per kW, or 3.5 percent a year in real dollars.[9] This figure may be misleading as costs remained fairly stable between 2005 and 2007. The actual cost of electricity generated from distributed solar PV systems averaged between 18 and 23 cents per kWh produced in 2006.[10] The US Department of Energy (DOE) projects that this cost will decline to between 11 and 18 cents per kWh by 2010 and 5 to 10 cents per kWh by 2015.[11]

For the purposes of this analysis, I assume that solar costs will gradually decline at a rate of 5 percent a year.[12] Capital costs for solar PV would need to drop to about $4,000 per kW in order to reach an average cost of electricity of 7.5 cents (the median point of DOE's 2015 projections).[13] If cost reduction trends continue, such a rate could almost be achieved by 2020.

Modeling the Impacts of Solar PV

To model the impact of solar PV penetration on AE, I used a theoretical penetration rate that mimics the projections of the DOE and Berkeley National Lab. I then analyzed the potential costs and revenue impacts of adding 300 MW of customer-owned solar PV to AE's system.

If AE were to continue to provide its current rebate to achieve 300 MW of residential PV by 2020 it would cost about $1.1 billion.[14] Because it is unlikely that AE could sustain such high costs, the number of solar rebates they provide each year is capped. This alone indicates the necessity for AE to own and operate a significant portion of the solar PV attached to its grid at high penetration levels. As solar costs decline, AE could adjust or eliminate its solar rebate program accordingly. Figure 3.1 demonstrates the projected costs of a 3 kW PV system for an AE customer by year through 2020 as installation costs decline and penetration rates increase with a steady reduction in AE's solar rebate of $250 a year beginning in 2010.

The following assumptions were made:

- Annual cost of PV installations to customers and AE as identified in Figure 3.1;

- AE's residential billing rate structure (taken as an average of the summer and winter month rate structure) remains unchanged;
- Electric bill (in $) = 6 + 0.0355 (first 500 kWh) + 0.0692 (kWh after 500) + 3.563 (total kWh);[15]
- Distributed generation renewable resources rider ($3.50/month) remains unchanged; [16]
- Average residential electricity use of 12,000 kWh per year;[17]
- Solar capacity factor of 17 percent;[18]
- No monthly or seasonal variations in electric use or solar availability;
- Commercial PV installation costs and impacts reflect the impacts for residential PV; and
- AE does not incur any support system costs.

Figure 3.1
Cost Assumptions for Solar PV Impact Analysis

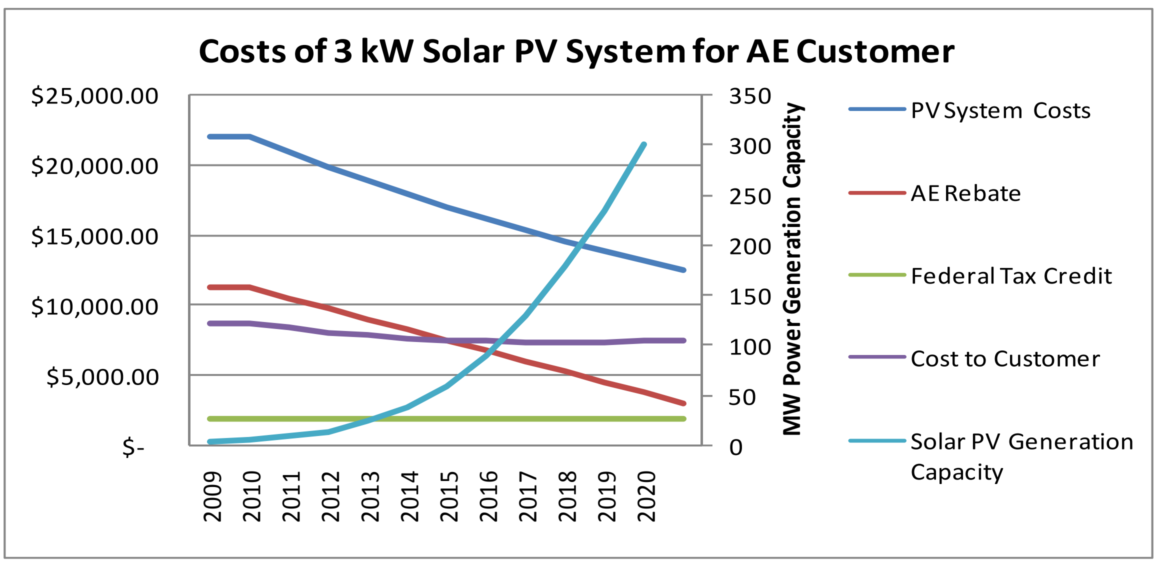
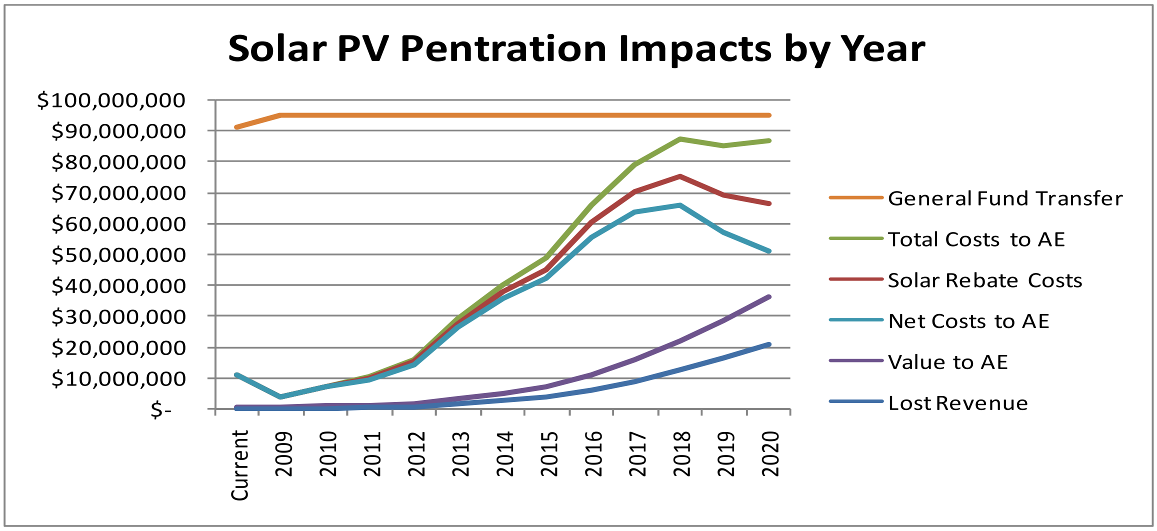


Figure 3.2 demonstrates the revenue and cost impacts of gradually achieving 300 MW of solar PV on AE's power system by 2020. In 2006, AE solicited a study to determine the value of solar electric generation to AE. This study determined that at a

100 MW penetration rate solar PV was worth 10.7 cents per kWh due to cost savings from energy production, avoided new generation capacity, transmission and distribution capacity deferrals, reduced transformer and line losses, reactive power control, environmental savings, natural gas price hedging, and disaster recovery.[19] For the purpose of this analysis, I valued solar PV at a constant rate of 10 cents per kWh produced.

Figure 3.2
Impacts of Solar PV Penetration



Given these assumptions, projected lost revenue for AE would actually be less than the value of solar PV to AE. Total lost revenue through 2020 is about $74.9 million. Total value of solar PV through 2020 is about $130.2 million. While lost revenue may be offset by the value of solar PV, solar rebates are still very costly for AE even after implementing an annual reduction to the current rebate of $250. The total cost of providing solar rebates through 2020 is about $485.35 million. The solar rebate reduction structure proposed herein would save about $630 million. The total net cost to AE (solar rebate costs + lost revenue – value of solar) through 2020 is about $430 million.

It appears that the impact on revenue erosion can be offset somewhat by the benefits of solar PV. This theoretical value of solar PV is based upon many cost saving assumptions that may become questionable at a penetration of 300 MW. Therefore, AE should re-evaluate the value of solar PV for 300 MW installed based upon its most recent load forecast through 2020.

A New Business Model Approach

The potential impacts on AE's finances along with other uncertainties related to the operation of wide-scale solar PV systems that rely on a variable energy source indicate the necessity for AE to develop a new business model approach to solar PV integration. AE currently supports solar PV integration by providing purchase incentives for systems connected to the grid (allowing AE operational capacity), but AE does not own these systems. AE does not earn a return on its rebate investment because it does not own the system. Thus, AE currently operates a business model in which revenue is lost at the added expense of the cost of the rebate.

As proposed by the PSP working groups, AE should move towards a new business model in which it becomes a part or whole owner in a large portion of solar PV systems connected to the grid. While it may be difficult to convince homeowners to purchase a solar PV system, even when providing a reasonable rebate, AE understands the value of solar PV and has the capacity to incur high capital costs through low financing rates. Because of the value of solar to AE, customers could still receive reduced electric rates or earn a cash incentive if they agree to have the system installed on their home or property. If lower electric rates are provided, this would add value to the property. Concern that a utility would have an unfair advantage in providing value-added customer services through solar PV systems has created some regulatory resistance to allowing utilities to own and operate these systems.[20] AE would need to evaluate regulatory issues that may prevent such a business model approach.

AE could also explore other innovative business model approaches to integrating high penetration of solar PV on its system. San Diego Gas & Electric has designed a program that allows it to "lease" roof space (and effectively own and operate) on commercial entities through the provision of cash incentives.[21] Southern Edison has proposed a solar PV program that has the goal of achieving 250 MW of customer-sited and utility-owned PV through cash incentives that focus on commercial customers with space for a 1 to 2 MW system.[22] Another innovative approach is to build small PV systems in a community park and allow customers to pay into the program at a different rate similar to AE's GreenChoice® program.

While the risks and uncertainties posed by high solar PV penetration rates for electric utilities are many, so are the opportunities. AE and other electric utilities must evaluate new business model approaches to meet new renewable energy goals through solar PV while ensuring financial stability.

Redefining the Utility Business Model

New business model approaches will be necessary to ensure that AE remains financially stable and that reliable, affordable electric service for customers is retained. The above example regarding the potential impacts of high penetration of solar PV demonstrates the necessity for developing new business model approaches to ensure AE maximizes the benefits of solar PV while ensuring continued operational stability, both in a financial and systems sense.

The new utility business model team aimed to answer two primary questions: 1) how can the utility maintain a revenue stream sufficient to cover its costs of operation as increasing penetration of distributed energy resources undermines traditional recovery mechanisms and 2) how can the utility create new revenue streams off the growth of distributed energy resource technologies.[23] AE is obligated to finance its capital investments, ensure a strong credit rating, and serve as Austin's largest general fund revenue source. For these reasons, AE, like other utilities, is pressured to minimize risks and act as a proven technology adopter rather than a technology creator or early adopter. Ideas generated by the utility business model team are summarized in Table A-7 of Appendix A.

The traditional utility business model is based upon earning a negotiated return on the utility's capital investments while providing reliable electric service for customers.[24]

AE uses a largely volumetric approach (with the exception of a $7 monthly customer charge) to recover costs by aligning energy use with customer payments to the utility. However, much of a utility's costs are fixed (costs related to generation assets, transmission, distribution, other operations and maintenance costs, retail services, and overhead costs) and do not vary with the volume of energy sold. Historically, volumetric pricing has been effective since the majority of customers use electricity supplied from the same mix of resources and DSM has not been a significant driver of demand. The utility could simply calculate the revenue necessary to recover its costs and use that to develop its electric rates.[25] The goals of PSP could seriously disrupt the utility's financial status if this volumetric approach continues to be used. As distributed generation, energy efficiency, and demand response technologies and programs reduce the net consumption of energy by consumers, the ability for traditional utility payments to maintain the revenue requirement necessary for the utility's financial soundness is threatened. Non-solar customers and customers who adopt DSM strategies would not pay an equal share for maintaining the grid, shifting costs to other customers.[26] This questions the rate design fairness, as solar customers will still require backup power support from the grid due to the variable nature of this resource.

In order to address these issues, the utility business model team recommends that AE unbundle its rates and develop a new rate structure to align cost drivers with cost recovery as and when it is appropriate to do so.[27] A rate case can take several years to implement, but AE is already recommending this to Council, independent of PSP. AE is well-positioned to unbundle its rates as it has already purchased a new customer information system that is expected to be online by April 2011 to enable such a rate design and a fully integrated two-way automated meter infrastructure is expected to be in place by 2012 as well.[28] AE's rates are currently bundled, meaning that all business activities necessary to deliver electric service to customer are recovered in the same fashion.[29] The concept of unbundling rates would allow the utility to itemize separate charges and rates for electric supply and delivery services. Unbundling rates would not entirely overcome the issue of fully recovering fixed costs for the utility. Decoupling revenue is recommended as an additional goal of AE's new rate design.[30] Decoupling is defined as, "a rate adjustment mechanism that separates (decouples) an electric or gas utility's fixed cost recovery from the amount of electricity or gas it sells."[31] This approach provides an additional tool to decouple cost recovery from volumetric energy sales. The utility business model team does not recommend a specific decoupled rate design, recognizing that there are several different approaches that need to be carefully considered so that all objectives are met without adverse consequences. Ensuring that a decoupled rate design creates incentives for customers to adopt DSM strategies is a crucial requirement for successful adoption.[32]

As AE determines a new rate design, dynamic pricing is recognized as an opportunity to reflect in rates the varying costs to generate energy over the course of the day. TOU pricing, real-time pricing, and critical-peak pricing are potential dynamic pricing models that are explained in more detail in Chapter 2 of this report. The challenge for the utility in designing dynamic pricing rates is to ensure that customers see savings in their electric bills without affecting the utility's profits.[33] This can only be achieved by charging rates that adequately affect consumer energy usage patterns. Challenges that must be overcome are ensuring that behavior changes occur as expected and that customers who have little ability to respond to price signals, such as low-income seniors who stay at home during the day, are not adversely affected. As a smarter grid enables greater automation of energy-use applications in the household, there is much greater potential for the utility and customers to determine the use of energy through automated principles.

There are other potential rate designs that the utility business model team identified that could contribute to successful future cost recovery under a high penetration of distributed energy resources scenario. Demand charges can be applied that relate to the peak demand of a customer rather than their overall energy usage since this determines the necessity for capital investments in new sources of power generation. Fixed charges for transmission and distribution, which can account for about 30 percent of a utility's overall cost of service, can also more accurately reflect the true costs of differentiated electric services.[34] Solar customers could be recognized as a distinct customer class, allowing for the true cost of retaining backup power to be applied to these customers.[35] A feed-in-tariff that allows solar customers to receive a higher rate for energy produced could create an incentive for greater adoption of solar PV. However, these costs are ultimately borne by all of the utility's customers, creating an equity issue.[36]

A secondary task of the utility business model team was to identify business models and opportunities for the utility to maximize the potential of emerging clean energy and smart grid technologies. This team worked with the four core teams to determine the most attractive business opportunities. The overall conclusion of this process is that AE needs to develop a clear, integrated strategy for encouraging and enabling distributed energy resources before establishing new business models based on those technologies.[37]

Mechanisms to encourage rapid deployment of customer-owned distributed generation were identified such as financing assistance, new types of rates such as TOU pricing and feed-in tariffs, and continued or increased incentives. Distributed generation is seen as a promising resource for the utility, but it is acknowledged that the utility needs to determine the true value of different types of distributed energy resources and set clear policy goals for investing in these resources to help guide business decisions.[38] One business opportunity for expanding the amount of distributed generation in AE's service territory is the packaging of rates for distributed generation with low-carbon central station generation rates similar to the Green Choice® program. This would allow the high costs of solar PV to be offset somewhat by low-cost central station generation units (presumably fueled by natural gas). Service or warranty plans could also be provided to customers who own distributed generation resources to create incentives beyond a rebate.

Energy efficiency opportunities are classified by the utility business model team as either non-revenue activities or potential revenue opportunities. Revenue opportunities are created by technologies that have a potential revenue stream through leasing equipment or a "sell the business" function. "Selling the business function" means that rather than encouraging the adoption of a technology by customers through rebates and other incentives, the utility or a third party owns the technology and sells the output.[39] Other business opportunities for energy efficiency include expanding incentives for energy efficient technologies, changing building and land development codes, and developing rates that encourage energy efficiency.[40] Zero-energy capable homes are considered an energy efficiency model that could significantly reduce demand for the utility. Zero-energy capable homes could be promoted through energy modeling services provided to developers as well as through the development of a demonstration project.

Demand response strategies are classified into two categories by the utility business model team; reliability and price-based. Both policy objectives are considered promising for reducing peak demand for the utility. It is recognized that new rate structures, particularly if dynamic pricing is instituted, could create major benefits for demand response. Energy management systems are also viewed as a promising technology to help customers engage in their energy consumption and provide incentives for customers to shift energy usage patterns to off-peak. Demand response technologies, particularly energy management systems, have great potential for third-party companies to market energy services to customers and aggregate load management to AE.[41]

Electrification of the transportation sector is recognized by the utility business model team as an area of significant uncertainty. This creates a potential revenue opportunity for utilities, but also a significant load management challenge. It will be important for AE ensure that vehicles are charged off-peak, when possible. One challenge identified is that customers may not be willing to allow a third-party, such as the utility, to manage and control the charging of a vehicle.[42]

Operations and Systems Integration

The operations and systems integration team evaluated the challenges of implementing a smarter grid, handling high levels of distributed energy resources, utilizing energy storage technologies to the advantage of the utility, and supporting PEVs through the electric grid. One goal of PSP is to provide a roadmap for incorporated distributed energy resources into the utility's operations and systems, while mitigating and managing its disruptive effect.[43] The Smart Grid 2.0 concept envisioned by AE and described in Chapter 1 of this report would implement the necessary set of technologies needed to integrate the next generation of clean energy technologies. New paradigms of technology use will need to be developed in order to maximize the potential of this system. This team looked at every possibility for future scenarios of technology advancements and penetration rates. It was determined that distributed generation and electrified vehicle technologies have the greatest potential to disrupt the stable operations of the utility due to their ability to heavily concentrate. Storage was recognized as having the greatest potential to help the utility manage these new technologies.[44] While there are clear benefits to promoting the growth of these technologies there are significant challenges to their integration. It must be ensured that AE balances the components of its mission: promoting reliable, clean energy at affordable rates with excellent customer service.[45]

In order for AE to successfully integrate distributed energy resources it will need to successfully model the impacts, with special emphasis on the use of baseline data in controlled studies.[46] Real-time systems will be necessary to determine the impact of distributed generation, particularly on power factor and other system performance measures, and manage the varied availability of solar power. There will likely be increased costs to ensure electrical stability and instantaneous balancing of load and generation. These costs may need to be accounted for through distributed generation surcharges.[47]

The success of new DSM strategies will likely be dependent on the ability of a smarter grid to further enable energy efficiency and demand response program adoption. Customers will need to be recruited to new programs that use energy management systems, distributed automation, and communication to intelligent endpoint devices (i.e. smart appliances). The utility will need to successfully control such a system. Research will need to be done by the utility to ensure that systems operation, control, architecture, and component design is successfully managed to maximize system benefits. This will require hardware needs and heavy utility involvement with customers.[48] Workforces will also need to be developed to provide support to this new type of system and ensure reliable service is maintained.

The improvement of system reliability has been touted as one of the many benefits of a smarter grid. Nonetheless, the technical aspect of managing a new, automated system does create challenges and potential threats to the reliability of the electric grid. The lack of interface codes and standards creates uncertainty with the way in which this system is integrated to manage transmission and distribution networks.[49] Ensuring that AE's smart grid system meets future standards and ensures the highest level of interoperability and security is key to the success of PSP. AE has identified that several benefits of a smarter grid will enhance system reliability including remote outage detection, remote asset management tracking, mobile mapping, better distribution planning, and automated controls.[50] While these benefits seem likely, the high penetration of emerging distributed generation technologies, particularly solar PV, and other immature energy technologies, such as energy storage and PEVs, creates reliability concerns for AE.

The thereat of cyber attacks has become a concern for an advanced electric grid, as all components connected to internet technology are vulnerable to infiltration. Smart meters, sensors, and advanced communications networks all must be integrated and managed by establishing practices to prevent security breaches and third-party control of the electric grid. While security issues have risen to the top of concerns regarding the smart grid, increased security has also been cited as a benefit of the smart grid. A smarter grid could allow for greater identification of threats and vulnerabilities, functions for protecting the network, and inclusion of security risk in system planning.[51]

Costs

The costs of implementing emerging clean energy and smart grid technologies into AE's system are likely to be high as these technologies are immature and have yet to reach economies of scale. The discussion in this chapter on the potential impacts of high penetration of solar PV demonstrates the cost uncertainty that emerging technologies tend to face. Funding mechanisms for PSP have yet to be identified, but will likely come through a combination of City of Austin funding for specific projects managed by AE, state and federal grants, and funding provided by corporate partners. PSP project managers and AE will need to come up with innovative and cost-effective business model approaches to increase adoption of energy efficiency and demand response programs. Dynamic pricing may hold the greatest value in overall peak demand savings, but will come at the cost of upgrading the billing system and re-configuring its meters. However, this is a cost that AE is already willing to incur independent of PSP. Energy storage and solar PV projects that will be managed by the utility will likely come at the highest costs as these technologies have yet to penetrate the market at sufficient scale.

As an early adopter of new energy technologies, high capital costs will likely be incurred by PSP and AE. The return on investment will need to be calculated to assess whether the benefits outweigh these costs. PSP ideas reduce peak demand, save energy, and/or promote clean energy technologies. Therefore, these ideas should be evaluated based upon the potential societal and external benefits they create including: environmental benefits, avoided new generation, fuel cost hedging, and customer satisfaction. High costs for the implementation of new technologies developed and produced by partner companies will likely be accepted by those companies so they can test their technologies to validate their success. By creating a public-private partnership PSP has developed opportunities to offset the high costs of project ideas.

Customer Satisfaction

Traditionally, customers have primarily cared about the reliability and cost of electricity, rather than its source. Increasing concern for the environment, particularly regarding the emission of CO_2 and other GHGs into the atmosphere, has created new environmental demands for utilities. Solar and other clean energy resources are likely to be welcomed by the majority of AE customers, but only if the addition of these resources comes at a competitive marginal cost to customers. AE must provide transparent and detailed information on the potential increased cost of electricity that will be incurred by

AE residential, commercial, and industrial customers prior to approving any PSP programs.

A smarter grid will likely be embraced by customers as it promises more efficient use of resources and maximization of quality of service. However, these benefits will need to be expressed and felt by customers for them to embrace the transformation of these services. Project ideas that promote public awareness and outreach will need to communicate to the public the benefits of the smart grid and actively engage customers in their participation. Energy efficiency and demand response programs should be encouraged to all customer classes and across economic levels. Any significant changes to billing and the way services are provided should be piloted first to survey acceptability and satisfaction of a diverse range of customers.

Regulatory and Legal Challenges

Although the electric utility sector is a highly regulated industry, its legislation and rules have not kept up with technological advances, creating barriers for the implementation of PSP ideas. The legislative and regulatory requirements team was tasked with identifying these challenges and proposing solutions. Table A-8 of Appendix A lists the issues identified by this team.

AE has several advantages in developing emerging technologies and redefining its electric grid because it is a municipally-owned utility that does not have to meet regulatory approval from the Federal Energy Regulatory Commission because Texas' electric grid is sited solely within Texas. Both the Public Utility Commission of Texas (PUC) and ERCOT have some regulatory authority over AE's facilities and activities. The PUC regulates all electric utilities in Texas, provides oversight to ERCOT, and adopts and enforces rules related to retail electric competition. PUC has jurisdiction over rates and quality of service of transmission and distribution utilities, sets wholesale transmission rates, and oversees wholesale and retail competitive markets.[52]

In September 2003, the PUC ordered ERCOT to transition from a zonal to a nodal market, which as of August 2009 has yet to be implemented.[53] The purpose of the switch was to improve price signals, improve dispatch efficiency, and assign congestion costs to market participants responsible for the congestion.[54] The nodal market is expected to consist of more than 4,000 nodes, replacing the current congestion management zones of the zonal market.[55] Although the nodal market will not affect all of ERCOT's current processes and systems, several major components will be added: day-ahead markets; reliability unit commitment; real-time or security constrained economic dispatch; and congestion revenue rights.[56] The nodal market may cause AE to lose some control over the dispatch and operation of its power generation facilities, creating some potential challenges for AE and PSP.

The switch to a nodal market will affect AE's future resource planning as only 5 to 10 percent of AE's annual power generation is currently traded through the ERCOT market.[57] Under the nodal market, all power will be bid into and purchased out of the market. Under the zonal market, AE contracts to buy or sell power from other parties through bilateral contracts. With the switch to the nodal market, these bilateral true supply contracts will become ERCOT instruments that provide guaranteed prices.[58] Besides a significant change in the way power transactions are completed, AE will have to ensure its infrastructure is able to perform in the nodal market.[59]

The federal government has supported the development of a smarter grid by devoting a large amount of stimulus funding to smart grid projects. The DOE is encouraging smart grid development through provisions of the Energy Policy Act of 2005 and Energy Independence and Security Act of 2007. Because the PUC and the federal government appear to support the development of the smart grid, the regulatory team did not identify any specific state regulations that would preclude or limit integration of a smart grid. However, the current lack of interoperability standards and security concerns are challenges for early implementation of a smart grid system. The National Institute of Standards and Technology (NIST) has been tasked through ARRA to develop a comprehensive framework for a nationwide, interoperable smart grid.[60] What these standards will look like and when the final standards will be implemented is still undetermined, but NIST hopes to develop initial standards in 2009.[61] The Institute of

Electrical and Electronics Engineers is also in the process of developing guidelines for interoperability of the smart grid.[62] Given the constraints created by the current lack of standards, the development of a smart grid fast-track committee is proposed to maximize the timeline by which AE implements its fully integrated smart grid system. AE could also implement a system to track smart grid projects nationally to ensure that it takes advantages of all available cost-effective technologies in a consistent fashion.

The regulatory working group identified several local challenges to promoting the successful integration of solar PV into AE's system. One issue is the revision of building codes to promote solar PV development. By making new developments "PV-friendly" state and federal incentives that lower the costs of solar PV systems or allow for low-rate financing for consumers may increase penetration rates. It should be noted that one market prohibition for the expansion of solar PV in AE's service territory is that under Texas' utility deregulation law, AE cannot allow any other entity to provide retail electric service in its territory. Therefore, any third-party attempts to provide electric service from distributed generation could run the risk of entering AE into full retail competition.[63]

Policy Implications

The process used by PSP to identify challenges for redesigning the electric utility system can serve as an example for policymakers and other electric utilities as does the process developed to identify opportunities. Again, PSP gathered a diverse group of perspectives to identify these challenges by recruiting private company partners, local energy experts, and community volunteers to join PSP and participate in working groups and later core teams. Successfully combining the expertise of the utility and those outside the utility is critical to successful project development of this magnitude. The new utility business model team consisted of top-level executives with AE, including General Manager Roger Duncan. The operations and systems integration team consisted of over 40 members, including AE's Chief Information Officer Andres Carvallo who has led AE's efforts to develop a fully integrated smart grid system. Bringing together the utility's information technology group with private companies that are developing support technologies for the smart grid and enabled clean energy technologies allows the utility to identify the current and expected available technologies and determine how these technologies can be successfully integrated and monitored by the utility. While the promise of these emerging technologies is high in terms of environmental and other community benefits, it is important that policymakers advocating for projects similar to scope as PSP recognize the serious challenges and potential limitations imposed by new technology integration. Utilities must be prepared for these challenges and recognize the true costs to the utility associated with these technologies.

Notes

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Chapter 4. Benefits and Impacts of the Pecan Street Project

The Pecan Street Project aims to identify and implement opportunities for advancing the efficiency and capabilities of the electric grid, significantly reducing demand through energy efficiency and demand response programs, and increasing the amount of local, clean, distributed energy resources. The systematic approach behind the project is the smart grid. The smart grid is commonly misperceived as a specific technology. A smarter grid is created through the incremental deployment and integration of intelligent operating systems. The upgrade of the electric grid to a smarter grid refers to a modernized electricity network that delivers electricity from suppliers to consumers (and vice versa) using digital technology. This system enables new applications to be deployed by the utility and adopted by customers that allow the utility and customers to have greater control over the way in which electricity is provided and used. New applications enabled by smart grid technologies may allow customers to monitor their electricity usage and respond to price signals in order to lower electric bills. The smart grid builds upon technologies already in use by electric utilities by increasing the communication and control capabilities of the utility and its customers. The smart grid is well-positioned to take advantage of new technologies such as smart metering, smart appliances, distribution automation, lighting management systems, energy storage technologies, PEVs, and various forms of distributed generation, particularly solar PV systems.[1] This chapter discusses the benefits and impacts of PSP through a smarter grid and technologies and programs identified for potential implementation by PSP.

This chapter identifies the major, general benefits and impacts of development of a smarter grid and deployment of technologies and programs that benefit from this advanced electric system. Specific impacts and benefits of project ideas identified in Chapter 2 of this report and summarized in Appendix A are identified in the technical analysis of this report, Chapter 5 and Appendix B.

Improved Electric Grid

An improved electric grid, enabled through the smart grid, would add monitoring, analysis, control, and communication capabilities to the electric delivery system to allow utilities to increase the efficiency of the system and reduce energy consumption.[2] Benefits of a smarter grid include reduce energy use and cost, increased reliability, and greater transparency. Such a system will bring a new interactive approach to electricity service between customers and energy markets. The system will become more optimized to use resources and equipment to the best of their abilities and will allow for the integration of a variety of new power generation options that allow the customer to become an electricity consumer and producer. This system will be integrated to merge all critical information that allows for the electric system to be operated most efficiently.[3]

AE is positioned to demonstrate the full range of benefits of a smart grid system for a large and diverse customer base in the short term as it has exhibited strong leadership in smart grid development. AE has been constructing an interactive, self-healing smart grid over the past several years that will allow customers to have greater control over their energy consumption. PSP is a complementary initiative to AE's independent efforts in developing the smart grid as it brings together private companies, University researchers, and other outside experts into the development of advanced smart grid technologies and programs. PSP has the ability to redefine the way electricity is delivered and used by creating programs that will maximize the benefits of a smarter grid.

Improved Service and Increased Reliability

Electric delivery is a service that is highly valued in modern culture yet is also taken for granted. When a failure occurs in the electric system, business and residential life can be disrupted. Thus, it is the electric service provider's primary goal to ensure reliable service at the lowest cost possible. Improved service and increased reliability are two of the greatest benefits of a smarter grid. Customers will become more engaged with the way in which they use electricity. The system will be self-healing and adaptive to correct problems to prevent emergencies from occurring and ensure the lowest number of customers for the least period of time are without power.[4]

Service to customers is improved by the ability to implement a diverse set of DSM programs. Demand response programs can allow customers to opt-in to energy and cost saving programs that will allow the utility to control the way air conditioning and heating systems, electrical devices, household appliances, and other consumers of electricity are used to optimize operation in the least disruptive way. Smarter technologies will be able to "learn" the way in which energy is used by a household or business and adapt to those demands in the most efficient manner.

An example of the potential for self-healing technologies demonstrates the way in which a smarter grid can increase the reliability of the electric system. Under the traditional electric grid system, when a tree limb falls on a power line, causing a feeder outage, customers must alert the Operations Center so that the utility can dispatch a field technician to inspect and fix the outage. TXU, an investor-owned electric provider in Texas estimates that such a process averages 40 minutes.[5] Under a smarter grid, automated switches can reconfigure the system to restore service to a majority of customers within one minute. The disruption location can be pinpointed and service restored remotely within 24 minutes. Such automation technology can eliminate sustained interruptions for two-thirds of the customers and reduce restoration time up to 40 percent for the remaining one-third of customers.[6]

Cost Savings

Cost savings can be achieved by both the utility and the customer through a smarter grid and smart grid-enabled technology and program development. While the initial investment in an advanced metering infrastructure costs millions to billions of dollars depending on the number of customers, this investment can payback itself in several ways. Cost savings are achieved by: 1) reducing the need to build new generation units and transmission lines; 2) improving the efficiency of generation usage; 3) better management and maintenance of assets; 4) improved management of outages; 5) reduced number of delayed and estimated bills; 6) lower procurement costs; 7) reduced energy theft; and 8) reduced costs associated with meter reading, field visits, and customer calls, among other operating costs.[7] While the rate of return on investment for each utility will vary, AE has calculated that, ultimately, the benefits outweigh the costs of investing in advanced metering infrastructure and thus have not yet directly increased customer electric bills as a result of their deployment of advanced meters for all customers.

Once AE achieves its return on investment, additional cost savings may be passed on to customers, as AE does not operate for profit. Customers will have greater control over the way they manage their electricity usage, creating the potential for additional individual cost savings. By adopting distributed generation and energy storage systems customers can become producers as well as consumers of energy through net metering of their energy production and usage, thus lowering electric bills. Customers with solar PV and other distributed generation systems could be compensated for the power generated at or above the market rate, known as a feed-in tariff. This is discussed in more detail in Chapter 3 of this report. New demand response and other DSM programs will allow AE customers to adopt cost saving approaches to lower electric bills. Because demand fluctuates during the course of the day, the cost of producing electricity for the utility also fluctuates over the course of the day. Thus, AE has an incentive to credit customers for limiting their energy use during peak demand periods (the hours of highest energy demand during the course of the day, typically in the late afternoon hours) and buying smart appliances that can cycle up and down in response to the cost of electricity.[8] TOU pricing or other dynamic pricing signals could be enabled by the smart grid system when a new billing system is created to provide energy price information to customers. Customers can then make behavioral choices of when and how they use electricity that influences their electric bills. Under the current AE billing system, all energy is priced at the same amount for a particular billing period up to a certain amount of usage at which customers than pay a higher price for all energy consumed beyond that amount for the billing period.

While customers and the utility can benefit from cost savings enabled by the smart grid and programs enabled by a smarter grid, there is potential for revenue erosion that could negatively impact the financial stability of the utility. As the addition of distributed energy resources owned by customers and participation in DSM programs takes revenue away from AE new business model approaches will need to be developed to offset lost revenue. This is discussed in more detail in Chapter 3 of this report.

Environmental Benefits

The ability for the smarter grid to improve delivery and consumption of energy also creates external environmental benefits. Environmental benefits can be achieved by increasing the efficiency of the system, reducing demand, and using cleaner energy technologies to generate electricity. Any efficiency gains created by a smarter system equate to less energy use and, therefore, environmental savings. The greatest environmental benefits come from replacing the use of traditional fossil-fuel burning power plants with clean energy technologies.

DSM programs that have high energy savings are also cost-effective measures to reduce the environmental impacts of generating electricity. Energy efficiency, demand response, and other DSM programs prevent the need to build new power plants. AE has been recognized nationally for its DSM program and since 1982 has estimated that this program has cumulatively reduced energy use by the equivalent of the annual output of a 700 MW power plant.[9] AE has developed an analytical approach to measure the environmental benefits of its DSM programs. These metrics will be applied in the technical analysis of PSP (included in Chapter 5 of this report) to evaluate the environmental benefits of PSP project ideas.

The promotion of cleaner energy distributed generation technologies, particularly solar PV, has many environmental benefits when used to replace fossil fuels. Distributed solar and wind technologies are carbon-free sources of energy. These energy sources do not emit GHG emissions into the atmosphere as do fossil fuel power sources. These energy sources also do not emit other pollutants such as ash, carbon monoxide, mercury, particulate matter, sulfur and nitrogen oxides, and volatile organic compounds. These pollutants can have local, regional, national, and even global negative health and environmental impacts. The specific health and environmental benefits of carbon dioxide, sulfur dioxide, nitrogen oxides, and particulate matter are discussed in more detail below.

Burning fossil fuels emits large quantities of CO_2, the most widely dissipated human-induced GHG. Many scientists agree that human-induced GHG emissions are a cause of global temperature increases.[10] In 2007, the Intergovernmental Panel on Climate Change released their fourth assessment report on climate change stating that, "warming of the climate change system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea levels."[11] This rise in temperatures, termed global warming, could change the world's climate system and potentially affect the well-being of humans and other species. The electric utility sector has been targeted as a major potential source of reducing CO_2 emissions, as 47 percent of total GHG emissions in the US were attributed to the generation of electricity and heat in 2005.[12]

SO_2 and NO_x react with other substances in the air to form acids that then fall to the earth through precipitation. Termed, "acid rain," the negative impact of this reaction to water and land quality as well as human health has led to federal regulation of these pollutants. SO_2 also creates breathing problems for people with asthma or other high-risk groups and can create respiratory illness and aggravate existing heart disease. SO_2 also contributes to reduce visibility and decay of building materials and paints.[13]

NO_x emissions are regulated by the federal government through the US Environmental Protection Agency's National Ambient Air Quality Standards. NO_x emissions contribute to the formation of ground-level ozone and fine level particular matter.[14] NO_x emissions contribute to respiratory problems due to the formation of ozone. Ozone is formed when NO_x and volatile organic compounds react with heat and sunlight. NO_x emissions are relatively high at natural gas facilities.[15] The local operation of natural gas facilities for AE has created regulatory difficulties for Austin as it is close to achieving non-attainment status. It is likely that Austin will attain such status is 2009.[16]

Solar PV and other distributed energy resources as well as demand response programs that reduce peak demand can reduce the level of operation of local natural gas facilities in Austin and thereby lower ozone levels.

Particulate matter consist s of extremely small particles that include acids, organic chemicals, metals, and soil or dust particles. The small size of these particles allows them to be passed through the throat and nose and enter the lungs of an individual, creating serious heart and lung health problems. Particulate matter is also regulated by the federal government and is classified as either fine particles or inhalable coarse materials.[17]

Renewable energy also sources do not require the extraction of fossil fuels that can disrupt ecosystems or risk the health and safety of workers. Wind and solar resources do not generate hazardous waste nor require the extraction of fuels, the transportation of fuels, or substantial amounts of water to generate electricity. Although wind and solar resources tend to use relatively large amounts of land, dual uses of the land can be implemented.

Economic Development

One of the primary purposes of PSP is to spur economic growth for Austin. For this reason, a working group was entirely devoted to analyzing the economic development potential for PSP opportunities. By becoming not only an early technology adopter, but also opening up its electric grid for the purpose of testing pilot projects prior to reaching the market, AE and Austin is creating an incentive for clean energy technology companies, software and communications companies involved with the development of the smart grid, smart appliance manufacturers, entrepreneurs, and investors to bring their operations to Austin to participate in PSP. PSP has already partnered with 11 companies. Many of the companies involved are some of the largest software and communications companies in the US, including several Fortune 500 companies.[18] Bringing these companies to Austin would create jobs and bring in tax revenue.

Clean energy technology companies may want to base operations in Austin as opportunities arise for research and development, including the testing of their products on AE's electric grid. Manufacturing and design jobs can be created through these enterprises. Large-scale deployment of solar PV in and around Austin could specifically influence solar manufacturing companies to bring operations to the Austin as well.

Model for Policymakers and Other Electric Utilities

One of the identified initiatives of PSP is to create a model for other utilities to follow in developing the future electric system. As a model utility, AE may have opportunities to take financial advantage of the information it obtains as a testing facility for new technologies. AE could potentially become a consultant and work with other utilities in the development of clean energy and smart grid technologies. These opportunities are being evaluated by AE, but may be prevented by regulatory barriers since AE is a municipally-owned utility. Regardless of financial gain, AE will be developing knowledge and know-how for developing a reliable, cleaner electric utility system. The information it attains will allow other utilities to follow in AE's footsteps and create larger gains for efficiency and environmental benefits to be shared by all.

This report identifies PSP as a model approach for other utilities and policymakers to use for identifying the unique resources and potential capabilities of the local electric grid and clean energy economy. While not all technologies or programs will derive the same level of benefits for other localities or regions of the US, PSP has identified a process by which electric utilities can engage the local community and partner with private companies to revolutionize the way energy is used and delivered to customers while achieving economic development benefits. Recommendations for policymakers and other electric utilities based on the case study of PSP are provided in Chapter 6 of this report.

Policy Implications

This assessment of the general benefits and impacts of projects identified by PSP demonstrates that multiple benefits for the utility and the consumer are generated through the adoption of clean energy and smart grid technologies. Policymakers should evaluate the costs and benefits of these types of technologies and determine policy mechanisms for supporting these technologies and programs as appropriate. Benefits include improved system efficiency, environmental improvements, and economic development. It is clear from this assessment that there is major potential for improving the way society uses and delivers energy by developing the conceptual electric utility system of the future.

TTNotes

[1] National Electrical Manufacturers Association, *What is Smart Grid and Why is it Important?* Online. Available: http://www.nema.org/gov/energy/smartgrid/whatIsSmartGrid.cfm. Accessed: June 22, 2009.

[2] Ibid.

[3] Presentation by Don Von Dollen, Electric Power Research Institute, "Enabling Energy Efficiency-IntelliGrid," 2006 NARUC Summer Meeting, San Francisco, July 30, 2006, slide 4.

[4] Ibid.

[5] Ibid., slide 7.

[6] Ibid.

[7] Lindsay Duran, et al., Austin Technology Incubator, Clean Energy Incubator, The University of Texas at Austin, *CleanTX Analysis on the Smart Grid*, p. 23.

[8] Ibid., p. 13.

[9] Austin Energy, *Annual Report: 2006*, p. 22. Online. Available: http://www.austinenergy.com/About%20Us /Newsroom/Reports/annualReport.pdf. Accessed: June 30, 2006.

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Chapter 5. Pecan Street Project Technical Analysis

The purpose of Phase 1 of PSP is to develop technical, financial, and policy recommendations to be delivered to Council.[1] A process was developed by which working groups and core teams were tasked with the identification of projects and programs for implementation, challenges associated with implementation, and new business model approaches for the utility. This process is described in the preceding chapters of this report. A strategy and technology analysis team led by EDF was created to provide support for the PSP working groups and later the four core teams by developing an analytical approach for the evaluation of project ideas to determine the potential costs, benefits, and impacts of these policies and programs on the environment, the economy, and the electric grid.

As a member of the strategy and technology analysis team I assisted in the development of this analytical approach. The analysis that follows aligns similarly with that developed and used by the PSP analytical support team. However, this analysis was completed independently and prior to the final reporting of the analytical team and thus may differ in some respects. The discussion and interpretation of these findings should not be considered representative of the opinions and conclusions of the analytical support team, but rather represent my independent perspective. The data provided in Appendix B of this report and the discussion that follows based on this data should not be construed as representative of the thoughts and opinions of AE or PSP.

The analytical approach identified in this chapter provides data on the costs and impacts of PSP ideas and analyze the relative value of those ideas to AE, its customers, and society for the purpose of prioritizing project idea implementation. This analysis also develops evaluation metrics and a process for evaluating emerging clean energy technologies and energy programs that can be replicated by other electric utilities and policymakers who are or will be developing projects similar in scope to PSP.

Developing an Analytical Approach

The first step in evaluating PSP ideas was to identify the unique impacts of different ideas and determine the potential for cross-comparison of those ideas. In Chapter 2 of this report I identified six distinguishing project idea categories: supply-side resources; demand-side management; transportation; research and studies; public awareness and outreach; and economic development. Projects and programs that fall within each of these categories exhibit distinct differences in how they affect the utility and its customers. For the purpose of this analysis, these six categories are further distinguished based on whether the project ideas contained therein have direct or indirect impacts.

Three of these categories have direct energy use and environmental impacts: supply-side, demand-side, and transportation. However, within these three categories the types of evaluation metrics that can be used vary. Supply-side resources add additional or replace existing power generation capacity while DSM technologies and programs reduce the necessity to use existing power generation or build new power generation capacity. Demand-side projects save energy and/or lower demand at peak periods. New power generation resources supply cleaner sources of energy to the electric grid without necessarily affecting demand (although the addition of customer-owned distributed generation would lower demand for the utility). Transportation project ideas have unique environmental impacts because traditional gasoline-burning vehicles are substituted by electrified vehicles, thus lowering overall emissions. Electrifying transportation also increases demand for the utility.

The three remaining categories (research and studies, public awareness and outreach, and economic development) do not have direct energy use and environmental impacts. However, these types of projects are necessary for the success of PSP and its project components, the identification of projects for implementation in later phases of PSP, and ensuring the growth of the local economy. Implementation of these projects all come at a cost, but the impacts of these ideas are indirect. All project ideas that support the development and success of PSP are evaluated based upon the expected costs relative to the dependency of the idea for PSP's success. Economic development project ideas are also assessed based on the potential for job creation and economic stimulation.

This chapter first identifies and discusses metrics that can be used to evaluate project ideas with direct and indirect impacts. Appendix B provides tables that contain available data and information gathered from the Phase 1 process of project idea identification and assessment. Project ideas with direct impacts are assessed separately from those ideas with solely indirect impacts. This chapter concludes with an evaluation of these results and a discussion of the relative value of these project ideas. This cross-comparison of project ideas is conducted because it is assumed that PSP will be constrained in the number of projects and programs it can implement based on its budget and staff resources.

Assessing Direct and Indirect Impacts

Emerging clean energy and smart grid enabled technologies and programs have numerous direct and indirect impacts on the utility, its customers, and society. Electric utilities have traditionally valued system reliability and affordable service above all other concerns. New societal and regulatory obligations have increased the complexity of valuing new technologies and programs for the utility.[2] Environmental concerns continue to increase in importance to policymakers, particularly the impact of GHG emissions on global climate change. It appears likely that federal regulation will soon adopt a regulatory scheme that will place an economic "value" on these emissions through an allowance market for CO_2 and other GHG emissions designed to cap and gradually lower emissions. Facing regulatory uncertainty, electric utilities and policymakers must assess the potential for new technologies and programs to lower emissions and reduce other environmental impacts.

Measuring the direct and indirect impacts of different project ideas allows one to assess the relative value of adopting different energy technologies and programs that affect the way utility customers consume and produce energy. Many measurements can be used to assess direct and indirect impacts on the utility, its customers, and the environment. A multitude of metrics are identified within this chapter for the purpose of evaluating different categories of impacts. Some measurements can be quantified based on estimated penetration of new technologies or program adoption by utility customers. Other measurements are assessed using ordinal variables.

Direct impacts can be grouped into four categories: costs and revenues; energy use; environmental impacts; and system reliability and customer satisfaction. Metrics are also identified to evaluate the feasibility of project ideas to determine the appropriate timing, if any, for implementation. Costs to the utility and customer and impacts on utility revenues, energy use, and environmental impacts can be assessed quantitatively. System reliability and customer service are predominantly assessed by using an ordinal scale of low, medium, to high expected impacts (distinguished as positive or negative when necessary).

Indirect impacts are grouped into two categories: potential impacts and inter-dependencies. Indirect impacts can sometimes be assessed quantitatively, but ordinal variables tend to be used due to the difficulty of directly linking a measurement to a project or program. Potential measurements assess the relationship of a supporting project or program to project ideas with direct impacts by determining the anticipated level of impact of the related idea or ideas. Most ideas that exhibit solely indirect impacts propose some form of research be conducted, either through a pilot project or a research study, or the development of public awareness and outreach programs to ensure the success of PSP. These ideas contribute to the overall success of PSP as well as specific project ideas with direct impacts. Thus, inter-dependencies exist between project ideas that increase adoption of clean energy technologies and programs or set goals for the implementation of these technologies and programs. These support projects can enhance customer satisfaction with PSP and acquire information necessary to assess the costs, benefits, and potential of different resources and programs for implementation during subsequent phases of PSP.

Metrics for assessing direct and indirect impacts of project ideas are presented in this chapter for each category of project ideas. Some of these measurements were applied to the technical analysis presented in Appendix B of this report. The most appropriate measurements given the data and information available for this study were selected for inclusion in the tables provided in Appendix B. The metrics that are included in this chapter are intended to serve as a resource for policymakers and other electric utilities who develop projects similar in scope to PSP.

Data Limitations

One of the key challenges to providing a complete, thorough analysis of PSP was accumulating all of the necessary data for each and every idea. As the nature of this project is to identify emerging energy technologies, little to no data exists internally within AE, and often externally, on the potential impacts of these technologies and programs. Working groups and core team leads were tasked with accumulating several data points for the purposes of evaluating project ideas. Despite their best efforts and the assistance of the analytical support team, many data gaps could not be filled. Due to the number of data gaps, a complete analysis for the purpose of prioritizing project ideas became difficult. For this reason, general recommendations are provided at the end of this chapter based on this analysis rather than conclusive results. The information contained in Appendix B is a combination of data gathered from PSP working group project idea characterizations and core team final reports, external studies, and subjective ordinal variables determined by myself. Data and ordinal variables drawn from PSP documents are indicated with an asterisk, "*." Data drawn from external reports or determined by the author of this report are indicated with a "^." If a project idea has an "*" next to the title all metrics within that row not identified by a "^" came from internal PSP documents.

These data gaps can serve a valuable purpose for evaluating project ideas. Limited information indicates that additional information, either through research or a pilot project, may be necessary prior to the implementation of a project idea. Thus, the level of information on the potential impacts of a technology or program can help determine the most appropriate stage of development and formulate the necessary steps to be taken prior to implementation. The data included in the PSP technical analysis provided in Appendix B, albeit incomplete, should provide some guidance for PSP, AE, and the City of Austin for determining which ideas should be implemented as a Phase II component of PSP and which ideas require additional research and study. Data that do not apply to a specific project idea are marked in Appendix B as not applicable, "n/a." Data that were not found are marked as unavailable, "-." When a specific measurement was not available for a given data point, but an ordinal variable could be applied, this variable was provided.

Assumptions

In order to conduct a technical analysis of PSP, several assumptions were made due to limited data and information on potential project idea impacts. The following major assumptions were made:

- Environmental impacts are constant for all supply-side and demand-side project impacts based upon weighted averages calculated for 2007 AE DSM programs.
- Current cost estimates (in 2009 dollars) are applied regardless of the point of implementation.
- All new sources of generation will be located in AE's service territory.

Assumptions specific to a project idea may have been made by PSP working groups, but this information is not provided in this chapter or the results in Appendix B. It is assumed that information provided by PSP working groups is the best source of information and only when information was not available did I provide an estimate. Ordinal variables that are applied to different impact metrics are intended to provide a general estimate. These values are not evaluated on a scale more specific than low, medium, and high. Set values or a range of values for these variables was not determined for or by PSP working groups or by myself.

Evaluation of Project Ideas with Direct Impacts

While it is not the intent of this report to capture all of the potential costs and benefits of technologies and programs identified by PSP, this analytical approach attempts to identify the most important measurements for the purpose of evaluation and comparative analysis. PSP project ideas with direct impacts on the utility are grouped into supply-side, demand-side, and transportation categories. The same types of impacts apply to all of these categories. However, the measurements used to identify these impacts vary as some ideas relate to supplying electricity and others aim to reduce the use of electricity. Table 5.1, Table 5.5, and Table 5.6 detail metrics that can be used to evaluate the direct and indirect impacts of different electric utility project ideas. A discussion of these metrics and best practices for gathering this information follows each category. A methodology for measuring the direct impacts for each category (i.e. energy use, environmental, etc.) is included and measurements that vary by project idea category are discussed.

Supply-Side Analytical Approach

PSP supply-side project ideas propose additions of cleaner energy resources to AE's power generation mix. These ideas are evaluated as power generation resources for the utility with direct impacts to the utility, customers, and the environment. Table 5.1 identifies metrics that can be used to assess the impact of adding new supply-side resources to a utility's power generation mix. Utilities must evaluate the availability and performance of different resources unique to their service territory and determine the metrics appropriate for the unique goals of their project.

Supply-side resource project ideas tend to have relatively reliable and available data compared to other PSP ideas as the impact of generation resources tends to be predictable and the potential of different resources has typically been assessed. The majority of PSP supply-side ideas are related to the integration of large amounts of solar PV to the electric grid. Project ideas are distinguished based upon the type of solar PV application and/or potential site for implementation. The potential location of the resource determines if AE would need to lease the land or building on which the solar PV is sited.

Table 5.1
Supply-Side Project Idea Evaluation Metrics

Impact	Metric
Costs and Revenues	
Capital Cost	Dollars per kW of power generation capacity and total costs (represented as an overnight cost) for ownership, lease (annual), and/or rebate (per kW)
Impact on Utility Revenues	Annual dollars generated or reduced per kWh of energy generated and total
Cost to Utility (Levelized Costs)	Dollars per kWh of energy generated
Cost to Consumer	Impact (as a percentage increase or decrease) on electric utility bills for each customer class
Economic Development	Number of expected jobs created or displaced and other economic stimulation measurements
Fuel Cost Hedge	Cost of fuel avoided with a range of future cost risk
Cost of Reducing Carbon Emissions	Pounds of CO_2 emissions avoided for each dollar spent
Energy Use	
Power Generation Capacity	MW of power generation capacity (practical potential at full implementation)
Energy Generated	Amount of energy generated annually (MWh)
Peak Demand Potential	Average amount of energy that can be generated at peak hour (capacity factor at 5 pm) in MW
Impact on Daily Load Shape	Qualitative explanation and/or graph
Environmental Impacts	
Carbon Dioxide	Metric tons of carbon dioxide emissions avoided annually
Sulfur Dioxide	Pounds of sulfur dioxide emissions avoided annually
Nitrogen Oxides	Pounds of nitrogen oxide emissions avoided annually
Volatile Organic Compounds	Pounds of volatile organic compound emissions avoided annually
Total Suspended Particulates	Pounds of total suspended particulates avoided annually
Carbon Monoxide	Pounds of carbon monoxide avoided annually
Mercury	Milograms of mercury emissions avoided annually
Cadmium	Milograms of cadmium emissions avoided annually
Lead	Milograms of lead emissions avoided annually
Land Use	Acres of land required per MW of capacity (noting if dual use is applicable)
Water	Gallons of water conserved annually
System Reliability and Customer Satisfaction	
Impact on system reliability	Ordinal scale
Level of Customer Satisfaction	Ordinal scale
Lower Transmission & Distribution Losses	Reduction in transmission and distribution losses
Lower Operations and Maintenance Costs	Reduced operations and maintenance costs and

	lower equipment failure
Greater Transmission Capability	Increased transfer capability without the need to build new transmission capacity (ordinal scale)
Reduced Power Interruptions	Reduction in number and length of power outages
Better Power Quality	Reductions in momentary outages and severe sags and swells and lower harmonic distortion
Transmission Congestion Costs	Change in transmission congestion costs ($)
Feasibility	
Time-Frame	Months/years for full implementation
Difficulty of Implementation	Ordinal scale
Cost Uncertainty	Range of capital cost requirements ($/kW)
Resource Availability	Ordinal scale

Costs and Revenues

The first group of impacts is costs and revenues. Costs should be calculated both to the utility and to the customer. Costs to the utility depend upon the business model approach of the project idea. For generation resources that AE plans to own or lease, costs are incurred solely by the utility and include the projected installed cost ($/kWh and $/kW installed capacity in 2009 dollars) as well as the projected cost to lease (assumed to be $0.01 per MWh). Capital costs are presented in this analysis as overnight costs (in dollars per kW) for the purpose of comparison of project ideas. However, it should be recognized that projects will be financed over a period of time that will affect the cost and value of the project. If AE owns or leases a generation resource, all or a portion of the costs may be passed on to the customer. Since many of these resources have a “value” to the utility, determining the actual cost to the customer requires detailed analysis by the utility. PSP project teams were limited in providing this information. The cost to the customer will be dependent upon the rate structure and operating costs of a particular utility as well as how the resource is “valued” by the utility. Some project ideas propose that AE provide a rebate to customers as an incentive for adoption. Rebates are traditionally evaluated by AE through a cost-benefit analysis. For the purposes of this analysis, costs to the utility for rebates are presented as dollars per kW of capacity. Under a rebate approach, costs may not be passed on to the customer if the costs equal or outweigh the benefits. For this reason, such analysis should attempt to include the cost to the customer after the rebate or other incentives are applied. This analysis includes the cost per kWh and the cost per kW of installed capacity when available. For some categories the cost per unit of a technology or the rebate cost is included.

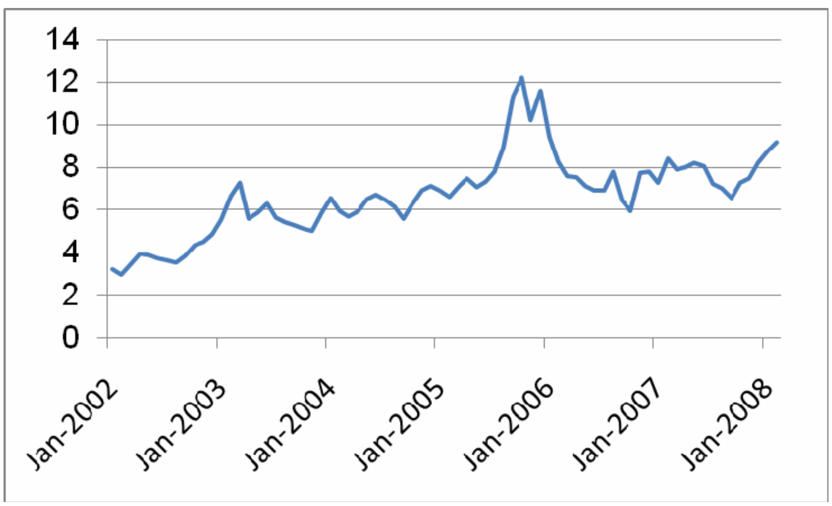
Supply-side resources may have an impact on revenues depending on whether AE owns or provides a rebate for that generation technology. Thus, supply-side project ideas may be revenue-neutral, revenue-generating, or revenue-depleting. This should be represented as annual dollars generated or reduced per kWh of energy generated as well as total revenues generated. In this analysis, potential revenue losses are noted under the cost per kWh column. No specific values are provided.

For electric utilities, particularly those that are municipally-owned, assessing impacts on economic development can be particularly important for garnering support from the community and the local government. Total jobs created and total economic stimulation can be used to determine the relative economic impacts of different project ideas. Total number of jobs created when available or an ordinal scale of jobs created is used in this analysis to indicate the impact on economic development. Economic stimulation measurements are not included in this analysis as project managers were not asked to supply this information. For future analysis, the IMPLAN software program, or a similar economic development software program, could be used to determine job creation and other economic impacts, such as total value added to the region or county analyzed.[3] IMPLAN is an input-output program which uses county-level historic industry averages to project the impact of large investments on local economies. IMPLAN is limited in its modeling capabilities for emerging technologies.

Other economic impacts related to the addition of new power generation sources include local production of materials, installation and/or construction of new power generation, the addition of new companies to the region, or the expansion of existing companies. New jobs can be created and new companies may add new tax revenue for the locality. This could spur economic growth in other sectors due to population growth and increased demand imposed on existing businesses and products.

One value induced by clean energy technologies replacing fossil fuel-based power generation is fuel cost savings (and a reduction in the risks of fuel price volatility). For this reason, fuel cost savings (based on the traditional generation source replaced) should be presented with an identified range of those costs reflecting price volatility. For example, the spot price for natural gas electricity generators, which historically receive the most competitive pricing, has fluctuated from less than $3/MMBtu in 2002 to a peak of over $12/MMBtu in 2005. Prices have averaged well over $6/MMBtu since 2004.[4] Figure 5.1 demonstrates the changing natural gas spot prices for electrical generators from 2002 to 2008. The value of different supply-side resources and DSM programs as a fuel cost hedge is not included in this analysis due to data limitations.

Figure 5.1
Natural Gas Spot Prices for Electrical Generators
(dollars per metric cubic foot)



Source: Adapted from Energy Information Administration, *U.S. Natural Gas Electric Power Price*. Online. Available: http://tonto.eia.doe.gov/dnav/ng/hist/n3045us3m.htm. Accessed: July 8, 2009.

The final metric included under costs and revenue impacts is the cost of reducing CO_2 emissions, or the carbon return on investment (CROI), represented as CO_2 emissions removed from the atmosphere. This can be calculated as carbon dioxide-equivalent emissions removed to capture all GHG emissions for each dollar spent.[5] AE currently uses a CROI calculation to determine the cost per ton of CO_2 per displaced dollar spent for DSM and renewable energy programs. A simple version of the CROI calculation is: [6]

$$(x-y) / k \qquad \text{Equation 1}$$

Where:	x	=	current amount of carbon actually being produced from a certain fuel or technology;
	y	=	carbon expected to be produced from a certain fuel or technology; and
	k	=	cost of the energy project

This equation would not take into account the carbon balance (life-cycle carbon emissions) or distinguish between the marginal cost of the new technology and what it is replacing. These aspects could be applied. For this analysis, the average rate of reduction in CO_2 emissions for AE's DSM programs in 2007 is used to calculate the projected amount of avoided CO_2 emissions. This calculation is discussed in greater detail in the section on "environmental impacts." As carbon emission reductions are of high priority for PSP and the development of future electric utility systems, this metric is a useful term for comparing project ideas.

Energy Use

Impacts on energy use are determined by the expected penetration or adoption of a project idea. The potential scale of a project idea determines its environmental, economic, and system reliability impacts. Project ideas may vary in the time they take to reach full potential. The timeframe necessary to reach the identified potential in capacity and energy use is identified in the "Timeframe" column of the tables provided in Appendix B. Supply-side resources are evaluated based on practical feasibility through 2020. Because the operational requirements of the utility vary over the course of the day and certain project ideas focus on the reduction of peak demand, the overall power generation potential for a project idea as well as the impact on peak demand should be evaluated. Measurements of impacts on energy use are included for power generation capacity (in MW), annual energy generated (in MWh), peak demand potential (the amount of energy that can be generated at 5 pm in the afternoon), and a qualitative assessment of the impact of the generation resource at its proposed scale on the daily load (demand) shape. In this analysis all of these measurements are included other than the impact on the daily load shape. Impacts on energy use vary considerably for DSM and transportation project ideas. Some of these differences are discussed below.

Environmental Impacts

Clean energy technologies that replace, avoid, or reduce the use of traditional fossil fuel-burning power generation units can provide environmental benefits. These environmental benefits appear to be increasing in terms of overall societal value and are a reason for the move towards a new electric utility system. Environmental impacts for supply-side resources can be calculated based upon the amount of energy generated by that resource and the type of resource(s) that the generation displaces or avoids.

This analysis looks at 11 environmental impacts, including nine impacts related to the release of air pollutants and toxic metals into the atmosphere. The impact of project ideas on the emissions of the following pollutants is provided: carbon dioxide, sulfur dioxide, nitrogen oxides, volatile organic compounds, total suspended particulates, carbon monoxide, mercury, cadmium, and lead. AE has developed a pollution calculator that is updated annually to determine the environmental savings from its DSM programs. Calculations for avoided emissions of these nine air pollutants and toxic metals as well as water conservation savings are included in the latest AE pollution calculator designed to evaluate the impacts of DSM programs in 2007. Figure 5.2 shows the results of AE's pollution calculator for 1,000 kW of energy savings. This calculator was used to determine a baseline for the potential environmental savings of PSP ideas.

The AE pollution calculator evaluates the load shapes and program adoption for each DSM program for a given year to determine the generation units that are displaced by the program based on an hourly dispatch model of AE's facilities. The cumulative impacts of all of AE's DSM programs are used to determine the average impact of a kWh of energy savings. It is assumed that each type of DSM program will avoid the same amount of emissions per kWh of energy saved. This may be misleading as different DSM programs displace different generation units (with different emission and water usage factors) based upon impact on load shape. Since the majority of AE's intermediate generation comes from natural gas-burning units, these impacts among different resource additions and DSM programs should be fairly similar. It must be acknowledged that this calculator is intended to evaluate demand-side savings rather than the generation of electricity from cleaner resources. Solar PV is likely to act similar to DSM programs in reducing the use of AE's different generation units. An internal analysis by AE using an hourly dispatch model determined that adding 10 MW of solar PV to AE's resource mix would result in an annual reduction of about 14,129 metric tons of CO_2. The impact of 10 MW of solar PV (assumed to run at a capacity factor of 26 percent) analyzed by AE's pollution calculator results in an annual reduction of 13,438 metric tons of CO_2. AE's internal analysis of 300 MW of solar PV resulted in an annual reduction of 429,467 metrics of CO_2. When this same scenario is run with AE's pollution calculator it results in an annual reduction of 403,135 million metric tons of CO_2. These results demonstrate that the AE pollution calculator is fairly accurate for predicting the environmental benefits of adding small and large amounts of solar PV to AE's generation mix. Generation resources such as landfill gas that can act as a baseload source could contribute to a greater reduction of baseload coal usage which would have greater environmental savings. Table 5.2 lists the assumed environmental savings for the nine air and toxic metal pollutants as well as water conservation based upon the calculations generated by AE's most recent pollution calculator.

Figure 5.2
Austin Energy Pollution Calculator (2007)

Energy Efficiency Projects **1,000** annual kWh savings

Air Pollution	**Saved this much Carbon Dioxide (CO_2) from being emitted:**	**588**	Kg. or	**1,294**	pounds	or	**0.6**	tons
	Saved this much Sulfur Dioxide (SO_2) from being emitted:	**0**	Kg. or	**1**	pounds	or	**0.00**	tons
	Saved this much Nitrogen Oxides (NOX) from being emitted:	**0**	Kg. or	**1**	pounds	or	**0.00**	tons
	Saved this much Volatile Organic Compounds (VOC) from being emitted:	**0.01**	Kg. or	**0.03**	pounds			
	Saved this much Total Suspended Particulants (TSP) from being emitted:	**0.1**	Kg. or	**0.1**	pounds			
	Saved this much Carbon Monoxide (CO) from being emitted:	**0**	Kg. or	**1**	pounds	or	**0.00**	tons
	Total	**589**		**1,296**			**0.6**	
Toxic Metals Pollution	**Saved this much Mercury (Hg) from being emitted:**	**7.9**	mg. or	**0.00**	pounds	or	**0.0003**	ounces of Hg
	Saved this much Cadmium (Cd) from being emitted:	**0.4**	mg. or	**0.00**	pounds	or	**0.00001**	ounces of Cd
	Saved this much Lead (Pb) from being emitted:	**11.7**	mg. or	**0.00**	pounds	or	**0.0004**	ounces of Pb

These projects effectively planted  **22** **trees or** **1.1** **acres of forest in Austin's parks.**

These projects effectively removed **1,136** **Vehicle Miles or** **0.1** **cars from Austin's busy roadways.**

These projects effectively provided electricity to **0.1** **average homes in Austin for a year.**

Source of Emissions data: "Delta Emissions", a combined effort of Lauer, Muraya, and Breeze (rev.1/18/07).
Source of Metals, trees, vehicles and homes data: "Pollutant Emission Rates for the City of Austin Electric Utility" (rev. 02/20/03)."

Water conservation at generation power plant (evaporation only)	450	**Gallons**	
Water conservation if air conditioned and cooling tower exists	782	**Gallons costing**	$ 8

Source of water conservation data: Bill Hoffman City of Austin Water and Waste Water Utility (rev. 06/20/07).

Source: Austin Energy, “Pollution Calculator,” 2008.

Table 5.2
Avoided Emissions and Water Conservation Calculations

Environmental Criteria	Emissions Avoided or Water Conserved
Carbon dioxide	0.59 metric tons per MWh
Sulfur dioxide	0.82 pounds per MWh
Nitrogen oxides	0.90 pounds per MWh
Volatile organic compounds	0.03 pounds per MWh
Total suspended particulates	0.11 pounds per MWh
Carbon monoxide	0.63 pounds per MWh
Mercury	7.89 milograms per MWh
Cadmium	0.36 milograms per MWh
Lead	11.68 milograms per MWh
Water	450 Gallons per MWh

Source: Austin Energy, "Pollution Calculator," 2008.

In order to accurately evaluate the environmental impacts of resource additions, subtractions, and DSM programs, an electric utility must consider its unique power generation mix. For example "avoided emissions" can be calculated based upon an assumed displacement of a particular generation unit or set of generation units or a more intricate and accurate analysis can be conduced based upon the utility's dispatch scheduling. Using an hourly dispatch model allows computation of marginal impacts of different project ideas. Creating an hourly dispatch model can be complex and costly and often contains confidential data for a utility. The environmental calculations used for this analysis assume the DSM average savings per kWh calculated based upon all of AE's DSM programs for 2007. If one were to wish to look at the environmental savings of displacing a particular generation unit or units one would need data on the emissions from those particular units. Unit specific air pollutant data for AE's polluting power generation units (coal and natural gas) is provided in Table 5.3 and unit specific data for water use is provided in Table 5.4.

Table 5.3
Austin Energy Generation Unit Emission Rates

AE Facility	Sulfur Dioxide (lbs/MWh)	Nitrogen Oxides (lbs/MWh)	Carbon Dioxide (lbs/MWh)	Carbon Monoxide (lbs/MWh)	Total Solid Particulates (lbs/MWh)	Volatile Organic Compounds (lbs/MWh)	Mercury (lbs/MWh)
Fayette Power Project (coal)	7.2	1	2179	2.1	0.56	0.039	0.0000485
SHEC-CC (gas combined-cycle)	0.0040	0.1	785	0.04	0.02	0.002	-
SHEC-CT (gas combustion units)	0.006	0.335	1163.5	0.6	0.2	0.003	-
Decker Steam (gas)	0.0066	0.8905	1228.5	0.025	0.033	0.0365	-
Decker-CT (gas combustion units)	0.004	2.21	1732	7.76	0.136	0.5684	-

Source: Austin Energy, “Unit Emission Rates,” November 13, 2007.

Table 5.4
Austin Energy Generation Facility Water Withdrawal

	Water Usage		FY07 MWh	
Facility	**Acre-Feet**	**1000 Gallons**	**Production**	**Gallons/kWh**
Decker (gas)	3,500	1,140,650	1,416,523	0.81
Sand Hill (gas)	1,978	644,733	1,941,859	0.33
FPP (coal)	6,450	2,102,055	4,150,178	0.51
STP (nuclear)	6,700	2,183,530	3,326,727	0.66
Total	18,628	6,070,968	10,835,287	0.56

Source: Austin Energy, "Plant Water Use," 2008.

Land use impacts can also be evaluated as an environmental concern. For the purposes of this analysis, land use impacts are only evaluated for solar PV additions. Other power generation sources may also require the use of land. Some generation sources use land for multiple purposes such as solar PV on rooftops and landfill gas for energy. These dual uses should be noted where appropriate. The calculation used for land use for solar PV is 4.6 acres per MW of capacity which is based on the calculation used in the Texas Interactive Power Simulator.[7]

System Reliability and Customer Satisfaction

The addition of new power generation sources, especially at high levels, to the electric grid can create new challenges for the utility in handling load and ensuring system stability and reliability. These generation sources can also present opportunities for improving system reliability and increasing customer satisfaction. As the majority of the technologies proposed for implementation by PSP working groups are emerging technologies, the impact of high penetration of these technologies on the utility is uncertain. Chapter 3 of this report identifies some of the system reliability challenges related to the integration of clean energy and smart grid technologies. This analysis is limited in using ordinal variables to demonstrate the relative expected impacts on system reliability and customer satisfaction. Impacts could be positive or negative and for many project ideas this impact is uncertain. Such uncertainty is noted when applicable.

A utility could use quantifiable metrics to determine impacts on system reliability and customer satisfaction. Table 5.1, Table 5.5 and Table 5.6 identify metrics that could be used to evaluate these impacts in a more rigorous, quantifiable fashion. Identified metrics include: reduced transmission and distribution losses (predominantly caused by locating generation closer to its end-use); reductions in operations and maintenance costs; reduction in equipment failure; increased transfer capability without the need to build new transmission capacity; reduction in number and length of power outages; reductions in momentary power outages, sags and swells, and harmonic distortion; and reductions in transmission congestion costs. Some of these metrics relate solely to the reliability of the system and savings to the utility while others are measurable impacts on customer perception of system reliability based on direct impacts (power outages).

Customer satisfaction can be measured directly through polling of customers on their opinions of new energy sources and support programs or by annually evaluating customer satisfaction. It is likely that customers will have mixed perceptions on new sources of clean energy and new programs related to DSM and the smart grid, depending upon the personal value that is placed on the environment and other social benefits relative to increased electric bills and ease of service. The number of power outages also tends to correlate with the level of satisfaction of customers and could be used as a metric for assessing customer satisfaction.

Feasibility

Several metrics have been identified to determine the feasibility of different project ideas. As many of the technologies identified by PSP are emerging technologies, the feasibility of implementation in the near future for many of these ideas may be difficult. Risks and uncertainties exist for many of these project ideas in terms of costs, impacts on the electric system, and ability to implement.

Four metrics are presented that relate to the feasibility of the project. The first metric is the time-frame in which the full potential of the project idea can be achieved. The second metric looks at the availability of a resource or technology. Some technologies are limited in availability in terms of the actual resource or through technological capabilities. For example, landfill gas or waste-to-heat are limited resources and wind and solar are variable resources. Technological maturity can be based on anticipated advancements or future availability based on an actual assessment of the physical amount of the resource available to the utility conducting the analysis. Difficulty of implementation can be assessed on an ordinal scale that considers implementation limitations, siting difficulties, legal or regulatory hurdles, and other identified factors. Cost uncertainty can be measured by determining the range of potential costs over the course of the project for that technology or program. For this analysis, only the timeframe and difficulty of implementation metrics are evaluated.

Demand-Side Analytical Approach

DSM programs and technologies should be evaluated distinctly from power generation sources because DSM aims to reduce demand, sometimes with a focus on peak periods, rather than adding new electric generation sources. However, many of the same metrics used for evaluating the impact of new supply-side resources can be used to evaluate DSM programs and technologies. PSP ideas that reduce demand on the utility are categorized into three types for measuring and comparing impacts: demand response, energy efficiency, and energy storage. Energy storage can be used as a demand response technique, but its operational characteristics are distinct from other types of DSM projects. Table 5.5 identifies the impacts and associated metrics for DSM project ideas.

Table 5.5
Demand-Side Project Idea Evaluation Metrics

Impact	Metric
Costs and Revenues	
Costs to Utility	Dollars per unit, rebate amount (in dollars), dollars spent per kWh energy saved, dollars spent per MW peak demand savings, and total costs
Impact on Utility Revenues	Annual dollars generated or reduced per kWh of energy savings and total revenues
Cost to Consumer	Impact (as a percentage increase or decrease) on electric utility bills for all customer classes and cost

	to customer of participation or product (if applicable)
Economic Development	Number of expected jobs created or displaced and other economic stimulation measurements
Fuel Cost Hedge	Cost of fuel avoided with a range of future cost risk
Cost of Reducing Carbon Emissions	Pounds of CO_2 emissions avoided for each dollar spent
Energy Use	
Energy Savings	Amount of energy savings annually (in MWhs)
Demand Savings	Annual peak demand savings (at 5 pm) in MW
Impact on Daily Load Shape	Qualitative explanation and/or graph
Environmental Impacts	
Carbon Dioxide	Metric tons of carbon dioxide emissions avoided annually
Sulfur Dioxide	Pounds of sulfur dioxide emissions avoided annually
Nitrogen Oxides	Pounds of nitrogen oxide emissions avoided annually
Volatile Organic Compounds	Pounds of volatile organic compound emissions avoided annually
Total Suspended Particulates	Pounds of total suspended particulates avoided annually
Carbon Monoxide	Pounds of carbon monoxide avoided annually
Mercury	Milograms of mercury emissions avoided annually
Cadmium	Milograms of cadmium emissions avoided annually
Lead	Milograms of lead emissions avoided annually
Land Use	Acres of land avoided for new generation
Water	Gallons of water conserved annually
System Reliability and Customer Satisfaction	
Impact on system reliability	Ordinal scale
Level of Customer Satisfaction	Ordinal scale
Lower Transmission & Distribution Losses	Reduction in transmission and distribution losses
Lower Operations and Maintenance Costs	Reduced operations and maintenance costs and lower equipment failure
Greater Transmission Capability	Increased transfer capability without the need to build new transmission capacity (ordinal scale)
Reduced Power Interruptions	Reduction in number of power outages and reduction in length of power outages
Better Power Quality	Reductions in momentary outages and severe sags and swells and lower harmonic distortion
Transmission Congestion Costs	Change in transmission congestion costs ($)
Feasibility	
Time-Frame	Months/years for full implementation
Difficulty of Implementation	Ordinal scale
Cost Uncertainty	Range of capital cost requirements ($/kW)
Resource Availability	Ordinal scale

DSM programs and technologies create energy and peak demand savings for the utility. Annual energy savings (in MWh) and peak demand savings (based on the savings achieved in MW at 5 pm in the afternoon during the day of the year with the highest energy demand) can be calculated for each program or technology. Peak demand may vary by utility and should be evaluated based on the utility's specific peak demand expectations. Another metric can be a detailed qualitative explanation of the impact on the daily load shape, including an actual projected load shape of the DSM program when possible, allows the utility to fully evaluate projected energy savings and peak savings to determine the unique value of the particular DSM program. Energy savings allow the utility to avoid the dispatch of existing generation units while peak savings allow the utility to avoid the need to build new power generation capacity, as utilities must invest in new power generation units to ensure the ability to meet peak demand. As power market prices and costs for generating electricity for the utility vary over a day, a utility can evaluate the historical costs associated with generating electricity at a particular time of day and weigh the value of demand savings achieved by the hour or even the minute. For this analysis, annual energy saved and peak demand savings are provided as available. A discussion of the specific impact on the load shape is not provided due to data limitations. Where specific information was not available from PSP core teams, an ordinal variable is provided.

Costs to the utility and customer and the impact on revenues can be calculated based upon the amount of energy and demand savings achieved. Multiple metrics to demonstrate the costs to the utility can be used. For DSM programs that require the adoption by customers of some type of technology, costs can be expressed as dollars per unit with total cost based upon expected deployment of that resource (assuming the utility pays the full amount for the technology). If the utility provides a rebate to the customer to encourage participation in a DSM program or adoption of a particular technology, a unit cost savings can be multiplied by expected adoption. Dollars spent per kWh of energy saved and dollars spent per MW of peak demand savings is an appropriate value to the utility. Costs to the consumer include the remaining costs for adoption of a program or technology (total costs minus the amount of the rebate provided by the utility and any other cost incentives) and the impact on the costs of electricity for the customer. For AE, current DSM programs do not impact the cost of electricity negatively because the utility sets rebates and adopts programs that are revenue-neutral or revenue-saving for the utility. Because DSM programs prevent the necessity to build new power generation capacity and incur those capital costs, these programs can be revenue-neutral in relation to how much revenue is generated and how much revenue is required to meet the utility's operating costs and debt. Calculations of any potential impacts on the utility's revenue balance can also be included. Since most new power generation capacity for meeting peak demand uses natural gas as the fuel source, DSM programs and technologies can provide a hedge against high natural gas prices. The impact on hedging fuel prices was not included in this analysis. The cost of reducing CO_2 emissions (discussed in the supply-side project ideas section) can be used to compare project ideas. The lack of information on the cost of achieving each kWh of energy saved limited the ability of this analysis to calculate a value of CO_2 emission reductions for DSM programs and technologies.

Many DSM programs create new jobs and stimulate the economy because they require technical assessments or installment of new technologies, require program supervision by the utility, or require the production of new technologies. The number of jobs created from such programs or technologies and the amount of economic stimulation can be estimated or calculated based upon an ordinal scale or some type of economic impact analysis tool.

Environmental impacts for DSM programs and technologies can be calculated in the same way as is discussed above for supply-side resources. In fact, the AE pollution calculator was designed to account for demand-side energy savings rather than the impacts of new generation. It is important to note that some demand response programs, depending on the utility's generation mix, could shift energy demand to sources that emit higher levels of pollutants. An hourly dispatch model would capture this result.

DSM programs often have positive benefits on system reliability and customer satisfaction by decreasing peak demand and leveling loads. By reducing or leveling loads the utility's infrastructure (transmission and distribution assets) faces much less variance and is less at risk of failure. This can decrease the number of outages and thereby increase customer satisfaction. DSM programs also have benefits for customer satisfaction as these programs create savings on electric bills and allow the customer to have greater interaction with the utility and her or his energy use. The same metrics for determining system reliability and customer satisfaction that are applied to supply-side resources are applied for DSM programs.

The same feasibility metrics identified for supply-side resources can also be applied to demand-side programs, with a greater emphasis on the assessment of the difficulty of implementation. While DSM programs may be relatively easy to implement it is often difficult to achieve high levels of adoption by customers. The availability of technologies necessary for implementation of a DSM program should be evaluated along with the difficulty of achieving adoption. The willingness of customers to participate in a program may be based on the attractiveness of the program (based on potential energy savings and return on investment), the appeal of the program, and the capacity for the utility to increase awareness and encourage adoption. Some programs may take several years to implement. For example, to develop dynamic pricing a utility might have to conduct a rate case and re-structure its billing system which can take several years to complete. This analysis includes the level of difficulty to achieve adoption goals as a metric to assess the difficulty of implementation.

Transportation Analytical Approach

Transportation programs sponsored by the utility focus on incentives to increase the penetration rate of the electrification of vehicles and mass transit and ensure the utility has some control over its implementation. For transportation project ideas, impacts are many for the utility, including significant environmental impacts and energy security benefits created by switching to lower-emitting fuels and reducing dependence on oil.

Table 5.6 identifies the impacts and associated metrics for evaluating transportation project ideas.

Table 5.6
Transportation Project Idea Evaluation Metrics

Impact	Metric
Costs and Revenues	
Costs to Utility	Dollars per unit, rebate amount (in dollars), and total cost
Impact on Revenues	Annual dollars generated or reduced per kWh and total
Cost to Consumer	Impact (as a percentage increase or decrease) on electric utility bills for average residential customer and cost to customer of participation or product (if applicable)
Economic Development	Number of expected jobs created or displaced and other economic stimulation measurements
Cost of Reducing Carbon Emissions	Pounds of carbon dioxide emissions avoided for each dollar spent
Energy Use	
Increased Demand	Increased demand in annual MWh and peak demand in MW
Peak Demand Reduction Potential	Annual potential peak demand savings (capacity factor at 5 pm) in MW
Impact on Daily Load Shape	Qualitative explanation and/or graph
Environmental Impacts	
Carbon Dioxide	Metric tons of carbon dioxide emissions avoided annually
Sulfur Dioxide	Pounds of sulfur dioxide emissions avoided annually
Nitrogen Oxides	Pounds of nitrogen oxide emissions avoided annually
Volatile Organic Compounds	Pounds of volatile organic compound emissions avoided annually
Total Suspended Particulates	Pounds of total suspended particulates avoided annually
Carbon Monoxide	Pounds of carbon monoxide avoided annually
Mercury	Milograms of mercury emissions avoided annually
Cadmium	Milograms of cadmium emissions avoided annually
Lead	Milograms of lead emissions avoided annually
Land Use	Acres of land required per kW of capacity
Water	Gallons of water conserved annually
Energy Security	
Reduced Oil Consumption	Annual reduced oil consumption in barrels
System Reliability and Customer Satisfaction	
Impact on system reliability	Ordinal scale

Level of Customer Satisfaction	Ordinal scale
Lower Transmission & Distribution Losses	Reduction in transmission and distribution losses
Lower Operations and Maintenance Costs	Reduced operations and maintenance costs and lower equipment failure
Greater Transmission Capability	Increased transfer capability without the need to build new transmission capacity (ordinal scale)
Reduced Power Interruptions	Reduction in number of power outages and reduction in length of power outages
Better Power Quality	Reductions in momentary outages and severe sags and swells and lower harmonic distortion
Transmission Congestion Costs	Change in transmission congestion costs ($)
Feasability	
Time-Frame	Months/years for full implementation
Difficulty of Implementation	Ordinal scale
Cost Uncertainty	Range of capital cost requirements ($/kW)
Resource Availability	Ordinal scale

Energy use impacts should first be calculated. Since transport is not currently supported by the electric utility industry, these projects will likely increase electricity demand both annually and at the peak. The impact on daily load shape is particularly important for electric vehicles because the time of day at which cars will require electricity (based upon when the vehicle is plugged into the grid to charge) and when they could potentially supply electricity to the grid will impact the necessity to add new generation. Increased demand should be calculated both annually and at peak (5 pm in the afternoon). If there is potential to reduce peak demand through incentives for customers to plug-in during peak periods, these savings should be calculated as well.

By increasing demand, new generating resources or increased use of existing generation resources may be required. This could come at a cost to the utility, but these costs could be averted through incentives for how and when electrified vehicles are charged and supply electricity to the grid. Costs to the utility for a transportation program may include total program costs, cost per unit, or rebate amount. Costs to the consumer for such programs may include the cost to purchase an electric vehicle after rebates and incentives, the cost for other services designated by the program, or the impact on electric utility bills. The impact on electric utility bills could reflect a utility's ability to meet increased demand and the costs of producing the electricity needed to meet this new demand. However, these costs could be averted through incentives to supply power to the grid for the utility to use at times electricity prices are relatively high. The cost of reducing CO_2 emissions can again be calculated based upon the calculation of metric tons of CO_2 emissions avoided for each dollar spent by the utility and/or consumer.

Calculating the environmental impacts of transportation project ideas is complicated. Although electrified vehicles increase demand on the utility and, thus require the increased use of existing or the building of new power generating units, these impacts may be offset by the environmental savings created by avoiding emissions from higher polluting traditional gasoline-burning vehicles. Calculations for emission savings should be based upon the average emission factors for the utility's current generation mix, compared to the annual emissions created by the average gasoline-powered vehicle (based on the same average usage). Land and water use impacts are likely to be significant with transportation projects because there are no direct land use and water use impacts of using traditional-fueled vehicles. Increased demand from electrified vehicles may require new generation to be added to the utility's generation mix that will have land use and water impacts. Land and water use impacts can be based on the average characteristics of the utility's power generation mix weighted by its annual energy use. For this analysis, the impact of the addition of 192,000 electrified vehicles to AE's electric grid by 2020 is used to determine potential environmental impacts. Calculations for CO_2 and nitrogen oxide savings in this analysis are based upon average emission reductions calculated in a report conducted by AE and the Electric Power Research Institute on the impact of 100,000 electric vehicles on AE's electric grid.[8] Calculations to determine the impact on other air pollutants and toxic metals was not available. Impacts on demand are calculated based upon the analysis conducted by Pace Consulting of 400,000 electrified vehicles added to AE's electric grid.[9]

By opening up new opportunities for manufacturing and sales of electrified vehicles, economic stimulation could be spurred through transportation projects. Job creation and economic stimulation could be calculated based on similar metrics devised for supply-side resource and demand-side program impacts. This analysis provides ordinal variables for the level of economic development impacts.

Increased demand on the electric utility and integration requirements for electrified transportation may augment system reliability concerns. Several metrics are again provided to assess the impacts on system reliability and customer satisfaction. The ability for the utility to successfully integrate the transition to electrified vehicles by successfully managing the charging requirements of these vehicles is a new factor for ensuring customer satisfaction with a utility whose potential impacts can be assessed accordingly.

Reducing the consumption of oil through transportation projects hedges against oil price risks and provides energy security benefits for the region, state, and nation. By measuring the reduced consumption of oil (in annual barrels) one can estimate the impact on energy security concerns. This analysis uses data from the US Environmental Protection Agency on average passenger vehicle fuel economy (20.3 miles per gallon) and average use of passenger vehicles (12,000 miles per year) to calculate reduced oil consumption.[10] It is assumed that 44 gallons of gasoline constitutes a barrel of crude oil.[11]

Feasibility metrics identified for other project ideas should also be applied to transportation project ideas. The market for electrified vehicles is uncertain. Therefore, the feasibility to implement each transportation project idea in a timely fashion and the level of difficulty in achieving anticipated results will likely be high.

Evaluation of Project Ideas with Indirect Impacts

The PSP technical analysis provided as Appendix B of this report is grouped into projects with direct impacts and projects with primarily indirect impacts. Project ideas related to conducting research, studying the potential for new technologies and their implementation, pilot projects, public outreach, and promoting awareness and adoption of PSP programs are recognized as project ideas with primarily indirect impacts. These project ideas are evaluated for costs and dependencies on project ideas with direct impacts and the overall success of PSP.

Research and Studies and Public Awareness and Outreach Analytical Approach

Research and studies provide a vital component to utility projects that are evaluating emerging technologies. As such projects are likely to have a long timeframe with multiple phases, research projects and studies on feasibility and implementation can have many indirect impacts on the utility. Benefits for the utility include the ability to more successfully and cost-effectively implement a program based on the information obtained. Research can be used by the utility to increase revenues through the potential selling of the knowledge. Table 5.7 identifies the evaluation metrics that can be used for research, studies, public awareness, and outreach project ideas.

Table 5.7
Research, Studies, Public Awareness, and Outreach Project Idea Evaluation Metrics

Impact	Metric
Costs and Revenues	
Cost	Cost of pilot project, public outreach program, or other costs in dollars
Potential Impacts	
New Power Generation Capacity	Ordinal scale
Energy Savings	Ordinal scale
Demand Savings	Ordinal scale
Environmental Benefits	Ordinal scale
Economic Development	Ordinal scale
System Reliability Benefits	Ordinal scale
Customer Satisfaction Benefits	Ordinal scale
Information and Dependencies	Ordinal scale
Value of Information/Data	Ordinal scale
Level of Dependencies with PSP Ideas with Direct Impacts	Ordinal scale
Level of Dependency on Overall Success of Project	Ordinal scale
Feasability	
Time-Frame	Months/years to conduct study
Difficulty of Implementation	Ordinal scale

Since research and studies do not have direct impacts for the utility (unless revenue can be generated through the selling of this knowledge), this analysis evaluates project support ideas based upon the level of importance to the overall success of PSP and other project ideas. The costs of a research project or study can be compared to the level of potential impacts (measured on an ordinal scale) for the development of new power generation capacity, energy savings, demand savings, environmental benefits, economic development, system reliability, customer satisfaction, value of information and data, and level of dependencies with other project ideas that have direct impacts. These different categories of potential impacts can be weighted for evaluation or assessed generally. An assessment of the feasibility of the research or study proposed should also be provided.

The purpose of increasing public awareness and outreach is to increase the satisfaction of customers involved in the project, generate support, and increase the adoption of project components. Therefore, there are both direct and indirect impacts. Direct impacts may include the potential for increased adoption in different programs that have measurable direct impacts. Indirect impacts occur with increased support and success of the program in general. These impacts are assessed based upon their potential (ordinal scale) in the same manner as was done for research and studies. Some programs have multiple dependencies with other project ideas and the success of the project as a whole. The value of information generated by the outreach program and the dependencies with project components should be evaluated using an ordinal scale. The feasibility of implementation should also be evaluated. An assessment of the necessity of the project idea to the success of the project can be used to compare these project ideas. These impacts and the necessity of the project should be evaluated based upon the relative costs of the pilot project, public outreach program, or other costs.

Economic Development Analytical Approach

While economic development impacts are evaluated for all supply-side, demand-side, and transportation project ideas economic development ideas may be additionally generated to provide support for economic development. This analysis evaluates economic development project ideas by looking at potential costs, economic development impacts, and relation to success of PSP and other project ideas. Table 5.8 identifies the evaluation metrics that can be used for economic development project ideas.

Table 5.8
Economic Development Project Idea Evaluation Metrics

Impact	Metric
Costs and Revenues	
Costs to Utility	Cost of program or action to utility in dollars
Economic Development	
Job Impacts	Number of jobs created or displaced
Economic stimulation	Annual dollars of economic stimulation
Information and Dependencies	Ordinal scale
Value of Information/Data	Ordinal scale
Level of Dependencies with PSP Ideas with Direct Impacts	Ordinal scale
Level of Dependency on Overall Success of Project	Ordinal scale
Feasability	
Time-Frame	Months/years to conduct study
Difficulty of Implementation	Ordinal scale

Conclusions of Pecan Street Project Technical Analysis

Appendix B of this report provides data and analysis on the potential impacts of PSP ideas identified by working groups and core teams. This information can assist in determining the value of different investments PSP and/or AE can make in emerging technologies, applications of technologies and programs enabled by a smarter grid, and supporting policies and programs to ensure the overall success of PSP. Project ideas are divided into those that have direct and indirect impacts to distinguish between projects that will have direct impacts on energy use and environmental impacts and projects that merely support the successful integration of these projects and the overall success of PSP. Table 5.9 summarizes the conclusions of the PSP technical analysis.

Table 5.9
Summary of Conclusions of PSP Technical Analysis

• Identified projects that have limited data on potential impacts should be assessed through a preliminary study or pilot project in Phase IIof PSP.
• Clean energy sources other than solar PV provide the greatest reductions in emissions, particularly CO_2 per dollar spent, but are limited in availability.
• In order to meet the solar PV goal of installed capacity by 2020 several different business model approaches will need to be utilized and timing of different approaches will need to be assessed based on least cost.
• The most appropriate mechanism for increasing adoption and achieving the greatest energy and peak demand savings should be identified for each energy efficiency project idea prior to implementation.
• Electrifying transportation has great positive environmental benefits for the community, despite increasing emissions for the utility.
• Cost estimates for all research, studies, and pilot projects are necessary to compare the costs and benefits of these ideas.
• Public awareness and outreach programs that have a high level of dependency with other PSP project ideas and overall success of the project should move forward with implementation, but should be combined as appropriate to reduce costs.
• More complete data and information on the potential impacts of different project ideas would allow for a more rigorous approach to comparing project ideas to be applied. This would allow project ideas to be prioritized given future budget constraints.

The following conclusions are based upon an overview of these results:

Identified projects that have limited data on potential impacts should be assessed through a preliminary study or pilot project in Phase II of PSP. The absence of information on a project idea indicates that the technology or program is too immature or a lack of information on resource availability limits immediate implementation. Thus, assessment of the potential impacts is necessary prior to implementation. Project ideas that may require preliminary study are pricing mechanisms such as TOU pricing, solar farms on flood plain land, building integrated solar PV, energy storage technologies, water conservation strategies, and electrified non-road vehicles and mass transit.

Clean energy sources other than solar PV provide the greatest reductions in emissions, particularly CO_2 per dollar spent, but are limited in availability. While landfill gas, waste to energy, and combined heat and power technologies provide the greatest reductions in emissions per dollar spent, total potential capacity additions for these resources by 2020 is only about 30-35 MW. It should be noted that these resources could potentially replace baseload generation (coal) and achieve even greater emission reductions than projected.

In order to meet the solar PV goal of installed capacity by 2020 several different business model approaches will need to be utilized and timing of different approaches will need to be assessed based on least cost. Based upon the potential for generation capacity of different applications and sites for solar PV, all identified project ideas for solar PV will need to be implemented. The value of CO_2 reductions per dollar spent on different solar PV applications should be used to determine the priority of different solar PV applications. Potential future costs of solar PV should be assessed and used to determine the most appropriate timing for the implementation of different solar PV applications.

The most appropriate mechanism for increasing adoption and achieving the greatest energy and peak demand savings should be identified for each energy efficiency project idea prior to implementation. It is unclear how much different energy efficiency programs and related technologies will cost the utility and customer. The relative impacts of providing incentives, implementing a program, developing a demonstration project, or developing a policy should be evaluated to determine priorities for reducing demand through different energy efficiency measures.

Electrifying transportation has great positive environmental benefits for the community, despite increasing emissions for the utility. As a community-oriented project, PSP has the opportunity to lower overall emissions by supporting and providing incentives for citizens to switch from gasoline-fueled vehicles to electrified vehicles. Electrifying the transportation sector can have major benefits in terms of energy security and reduced emissions. As more of AE’s power generation mix is composed of renewable energy sources, these benefits will increase.

Cost estimates for all research, studies, and pilot projects are necessary to compare the costs and benefits of these ideas. It is likely that PSP will be limited in the amount of spending on research, studies, and pilot projects. Projects with a relatively low cost and potential high impact on the success of PSP, AE customer satisfaction, and economic development should be prioritized for initial implementation. Projects that have a high dependency on the success of PSP project ideas with direct impacts, such as advanced residential and commercial DSM pilots, a TOU pilot, a PSP lab, and a zero net energy demo project hold a relatively higher value than assessment studies that may have a low potential for impacts in subsequent phases.

Public awareness and outreach programs that have a high level of dependency with other PSP project ideas and overall success of the project should move forward with implementation, but should be combined as appropriate to reduce costs. Increasing awareness and ensuring customer satisfaction will be key to the success of PSP. Programs identified to have a high impact on the overall success of PSP and a high level of dependency on the success of PSP project ideas with direct impacts should be implemented in the most cost-effective fashion. Many of the ideas generated for support of PSP can be combined into objectives of a staff support group for PSP public awareness and outreach.

More complete data and information on the potential impacts of different project ideas would allow for a more rigorous approach to comparing project ideas to be applied. This would allow project ideas to be prioritized given future budget constraints. This PSP technical analysis was limited in its ability to rigorously evaluate project ideas due to data limitations. AE could conduct more accurate analysis by modeling impacts with an hourly dispatch model. Additional information on project ideas with limited data on impacts should be conducted prior to moving forward with these project ideas.

Notes

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[4] Energy Information Administration (EIA), *U.S. Natural Gas Electric Power Price*. Online. Available: http://tonto.eia.doe.gov/dnav/ng/hist/n3045us3m.htm. Accessed: July 8, 2009.

[5] Roger Duncan, *Clean Energy Project Exchange*. Online. Available: http://www.austinenergy.com/About%20Us/Newsroom/Reports/cleanEnergyProjectExchange.pdf. Accessed: July 17, 2009.

[6] Ibid.

[7] Melissa C. Lott, Cary W. King, and Michael E. Webber, "Analyzing Tradeoffs in Electricity Choices Using the Texas Interactive Power Simulator" (paper presented at the 3rd Annual International Conference on Sustainability, San Francisco, California, July 19-23, 2009).

[8] Austin Energy, et al. "Testing of Charge-Management Solutions for Vehicle Interaction with the Austin Energy Electric Grid," February 20, 2009.

[9] Presentation by Pace Consulting, "Austin Energy Scenario Review," Austin, Texas, June 29, 2009, slide 12. Online. Available: http://www.austinsmartenergy.com/. Accessed: July 28, 2009.

[10] U.S. Environmental Protection Agency, *Emission Facts: Greenhouse Gas Emissions from a Typical Passenger Vehicle.* Online. Available: http://www.epa.gov/OMS/climate/420f05004.htm. Accessed: July 28, 2009.

[11] EIA, *What Fuels Are Made From Crude Oil*. Online. Available: http://www.eia.doe.gov/kids/energyfacts/sources/non-renewable/oil.html. Accessed: July 28, 2009.

Chapter 6. Conclusions, Recommendations, and Policy Implications

Conclusions

PSP is an ambitious project that will face many challenges for implementation. Carefully defining the objectives of PSP, the role of different partners and AE, and the criteria for selecting technologies and programs that will constitute the project are initial challenges that project founders, particularly AE, now face. PSP has identified a vast number of emerging technologies that may transform the way people use energy and the way electric utilities interact with consumers to deliver that energy. Local policymakers and project participants will soon determine the direction in which PSP goes.

Phase 1 of the project will culminate in early Fall 2009 with a presentation of recommendations to Council, the community, and other electric utilities. Council will determine the involvement of the utility in PSP and the level of funding the City is willing to contribute to its actions. The community will play a strong role in its support or rejection of these recommendations. The establishment of PSP as a non-profit entity will allow PSP to define a clean energy vision for the City of Austin. As a non-profit entity, PSP can independently advance its goals and obtain funding from a multitude of sources.

PSP has the opportunity to accelerate the advancement of clean energy technologies and smart-grid related technologies and turn Austin into the clean energy capital of the US. Electric utilities across the nation will follow this project, as its findings will have implications for the entire electric utility industry.

Since PSP is still in the development stage, this chapter attempts to provide conclusions and recommendations based solely on the content contained within this report. The recommendations that follow are not intended to promote the implementation of specific project ideas, but rather recommend how the project can successfully move forward. Policy implications are identified for those entities that will be affected by PSP.

Policy implications are provided for the following audiences: AE and the City of Austin, other electric utilities, and other policymakers.

Recommendations to the Pecan Street Project

During the process of writing this report PSP members were formulating formal recommendations to Council and drafting an initial report and action plan to conclude Phase I of the project. The recommendations that follow will likely identify several issues that will be addressed in these deliverables. The purpose of these recommendations is to identify major issues that I have identified by following the project and assessing its potential impacts. Table 6.1 summarizes these recommendations. My recommendations may vary with those submitted by PSP and do not reflect the views or opinions of PSP or AE.

Table 6.1
Summary of Recommendations

• PSP should formally define its scope and set specific goals in its initial deliverables to Council, PSP partners, and the public.
• Funding should be actively pursued through a multitude of sources and a budget should be constructed as soon as possible.
• Research and the development of emerging clean energy technologies followed by implementation and demonstration of these technologies should be the main priority of PSP.
• Project ideas should reflect potential benefits and risks. Ideas should be planned for implementation based on expected availability and current and future cost projections.
• Technologies and programs that require additional information for successful implementation should be allocated funding to conduct research as an initial step towards implementation.

PSP should formally define its scope and set specific goals in its initial deliverables to Council, PSP partners, and the public. As discussed in Chapter 1 of this report, project founders have announced general goals and initiatives of PSP. While these goals have provided a foundation for Phase I of the project, it is necessary for PSP to formally define its scope and set specific goals for Phase II of the project. Carefully defining the scope of the project and developing areas and processes for research and development will be necessary for the continued success of the project. Setting specific goals that can be immediately implemented will allow project founders to determine initial budget requirements, develop processes for implementation, and set standards to measure initial success of the project.

Funding should be actively pursued through a multitude of sources and a budget should be constructed as soon as possible. The establishment of PSP as a non-profit entity allows PSP to seek funds from multiply sources to support its activities. The number and nature of the projects identified during Phase I of PSP indicates that substantial funding will be necessary. An initial budget should be developed and approved as soon as possible so that project ideas can be grouped within budget constraints. Potential sources of funds include economic stimulus funding and other government grant programs, Council appropriations to AE or PSP directly for PSP projects, project partner contributions, partnerships with other electric utilities, and outside philanthropic sources.

Research and the development of emerging clean energy technologies followed by implementation and demonstration of these technologies should be the main priority of PSP. AE, as a municipally-owned utility, cannot retain funds solely for research and development. PSP, as a separate entity, presents an opportunity for a progressive utility such as AE to use PSP as an outlet for research and development of emerging technologies to increase the penetration, and thus lower the costs, of these technologies. Once research is completed these technologies should be implemented to demonstrate successful integration into AE's electric grid. Research, implementation, and demonstration of emerging technologies should be the primary priorities of PSP along with the establishment of some type of research facility, whether independently operated or operated by the federal government and supported by PSP.

Project ideas should reflect potential benefits and risks. Ideas should be planned for implementation based on expected availability and current and future cost projections. This report attempts to provide a basic technical analysis of the potential impacts of project ideas identified in Phase I of this project. Using costs, benefits, and other metrics to compare these impacts across project idea grouping (such as metric ton of CO_2 avoided per MWh of energy generated or avoided or MW of energy generated or avoided at peak), a multi-objective benefit analysis could be extended to include environmental, system reliability, and economic development impacts, among others. These results can then be interpreted based upon the timeframe in which projects could be implemented, the availability of necessary technologies and supporting system requirements, the scale at which those project should be implemented based upon current and future cost projections, and budget constraints. This analysis will need to be on-going and separated into project phases as the project proceeds.

Technologies and programs that require additional information for successful implementation should be allocated funding to conduct research as an initial step towards implementation. As one of the first major undertakings of its kind, PSP faces much uncertainty and lack of data. As evidenced by the technical analysis contained herein, many data gaps exist that create difficulties for assessing the costs and impacts of different project ideas. Project ideas lacking in data should not be implemented until this information is obtained. Many project ideas are proposed that will require the acquisition of data through pilot projects, studies, and other forms of research. Any idea identified as facing significant data limitations should be evaluated for additional study and be approved for funding based on the potential benefits of acquiring that information.

Policy Implications

The following policy implications are identified by this report to acknowledge the potential that PSP and its findings as on influencing local, state, and national energy policy. Policy implications are summarized in Table 6.2.

Table 6.2
Summary of Policy Implications

Austin Energy and the City of Austin
• Austin Energy will need to evaluate all PSP ideas that require connection to the electric grid based on the marginal and cumulative impact on its system, customers, and the Austin community.
• Austin Energy will likely have to provide substantial staff support for the implementation and monitoring of all projects implemented under PSP.
• The Austin City Council will need to consider whether to support PSP based upon an assessment of its potential impacts and determine whether or not to approve costs incurred for project support and implementation.
• Austin Energy and the City of Austin will need to consider the costs and impacts upon the electric system, the environment, economic development, and electric rates to customers for all projects that relate to PSP that require Council approval for implementation and/or funding.
Other Electric Utilities
• Other electric utilities may follow the adoption of various project and programs identified by PSP as these technologies become more accessible, cost-effective, and manageable.
• Other electric utilities may monitor the success and failures of PSP to determine the value of implementing a project similar in scope.
• Other electric utilities can follow the analytical methods presented within this report to evaluate potential project ideas, but should evaluate ideas based upon the unique ways in which project ideas affect that utility's generation mix and electric system.
Other Policymakers
• The transparent approach of PSP should allow policymakers at the local, state, and federal level to monitor the implementation of emerging clean energy technologies and use this research to develop policies to ensure reliability and security concerns are achieved and develop incentives for projects that are successful.
• As an early adopter of emerging clean energy technologies and programs PSP has the opportunity to influence the types of technologies and programs that become widely adopted and determine the way in which the impacts are assessed.
• PSP is a local initiative of both a utility and corporate partners with vested interests in the technologies they support. Adoption of similar programs for non-public electric utilities may require a different approach.

Austin Energy and the City of Austin

Austin Energy will need to evaluate all PSP ideas that require connection to the electric grid based on the marginal and cumulative impact on its system,

customers, and the Austin community. As the primary supporter of PSP, AE must carefully evaluate the individual as well as the cumulative impacts of any project on its system, its customers, and the community. All potential costs and benefits should be determined prior to implementation. Analysis should be conducted in a consistent manner through an approach acceptable to Council and PSP members. Recommended metrics for evaluation are provided in Chapter 5 of this report.

Austin Energy will likely have to provide substantial staff support for the implementation and monitoring of all projects implemented under PSP. Staff support provided by AE will require approval from Council. In order to successfully implement and monitor all projects that connect to AE's electric grid and ensure that all research conducted off the grid is monitored by AE staffing requirements need to be identified by PSP. A mechanism for coordination between AE and PSP needs to be established.

The Austin City Council will need to consider whether to support PSP based upon an assessment of its potential impacts and determine whether or not to approve costs incurred for project support and implementation. Council, as representatives of the Austin community, should evaluate their support for PSP based on the interests of the community and the reporting completed during Phase I of the project. By approving the designation of a member of AE and Council to the PSP Board of Directors, it appears that Council is initially supporting this project. Council should provide guidance for how it feels PSP should operate as an entity, what role AE will have, and determine the amount of money that will be allocated to the project through staff support and specific program funding.

Austin Energy and the City of Austin will need to consider the costs and impacts upon the electric system, the environment, economic development, and electric rates to customers for all projects that relate to PSP that require Council approval for implementation and/or funding. In order for Council to make initial and proceeding decisions related to its support of PSP, AE and PSP must evaluate the costs, benefits, and impacts of PSP as a whole as well as for specific project ideas. Of particular concern will be the impact that different projects may have on customer electric rates. The addition of large sources of generation and additional demand reduction could impact AE's overall power generation mix and the costs associated with that mix, utility revenues, system reliability, and environmental costs; all of which can have impacts on customer electric rates. Societal benefits such as environmental improvements, avoided risks such as natural gas price hedging, and economic development should all be considered as AE and the City of Austin evaluate the true value of PSP and its project components as they come to fruition.

Other Electric Utilities

Other electric utilities may follow the adoption of various project and programs identified by PSP as these technologies become more accessible, cost-effective, and manageable. One major implication of PSP is that it provides one of the most comprehensive frameworks for developing the electric system of the future. As such, other electric utilities will likely follow the adoption of technologies tested and implemented, if successful, through PSP.

Other electric utilities may monitor the success and failures of PSP to determine the value of implementing a project similar in scope. Electric utilities should be made aware of the findings of PSP ideas through a transparent process of providing data acquired. Breaches of confidentiality regarding AE's internal operations should be carefully avoided. A transparent approach will allow PSP to gather support from its participating entities and will encourage adoption of technologies it supports by other utilities, enhancing PSP and AE's ability to increase the scale of emerging clean energy technologies at lower cost. The rate at which other electric utilities adopt these technologies will determine local, regional, and national successes for avoiding emissions, achieving other environmental benefits, and achieving a more efficient and reliable electric utility system. By freely distributing the data acquired by PSP, other electric utilities may mimic the standards adopted by AE to ensure successful interoperability.

Other electric utilities can follow the analytical methods presented within this report to evaluate potential project ideas, but should evaluate ideas based upon the unique ways in which project ideas affect that utility's generation mix and electric system. The technical analysis contained herein is intended to provide a general idea of the potential impacts of PSP and the project ideas that have been identified to date on AE specifically. While many of these analytical methods and the metrics identified to measure impacts can be applied to any utility, project ideas should be evaluated based upon the unique existing structure of that utility's generation mix and power system.

Other Policymakers

The transparent approach of PSP should allow policymakers at the local, state, and federal level to monitor the implementation of emerging clean energy technologies and use this research to develop policies to ensure reliability and security concerns are achieved and develop incentives for projects that are successful. The traditional utility business model has hindered the rapid adoption and success of emerging technologies that have significant societal and system benefits. Support from the government through incentives, regulatory requirements, and other regulatory mechanisms have been utilized traditionally to help overcome these barriers. Local, state, and federal governments can monitor PSP to determine what projects have the greatest success and determine what types and levels of incentives should be provided to encourage and/or require adoption of these emerging technologies and programs.

As an early adopter of emerging clean energy technologies and programs PSP has the opportunity to influence the types of technologies and programs that become widely adopted and determine the way in which the impacts are assessed. Again, as one of the most comprehensive initiatives to incorporate a diverse number of emerging technologies and programs related to producing, delivering, and using electricity, PSP has the opportunity to influence the technologies that become widely adopted and determine the analytical methods used to determine the impacts of these programs and technologies. AE, the City of Austin, and PSP should carefully consider the types of technologies it promotes, its methods of analysis, and the manner in which this material is presented. Governments and utilities that look at PSP for information and guidance in developing the electric system of the future should recognize that the impacts of project ideas on AE's system will not necessarily be felt universally. Potential impacts should be assessed based upon a utility's unique system.

PSP is a local initiative of both a utility and corporate partners with vested interests in the technologies they support. Adoption of similar programs for non-public electric utilities may require a different approach. As a municipally-owned utility under the purview of the City of Austin, AE is more inclined than investor-owned utilities to consider societal and external benefits as well as revenues. Non-public utilities may not be as likely to consider the adoption of technologies and programs identified by PSP. For this reason, policymakers should develop approaches that encourage for-profit utilities to adopt technologies and programs that have major societal benefits.

Appendix A
Project Ideas

This Appendix details all 150 plus project ideas that were formulized through the PSP process. Information on each project idea provided in these tables includes the name and idea of the project idea as well as its potential impact or cost. Project ideas are referenced by the number assigned during the PSP working group process (the first number denotes the group and the second number denotes the project idea within that group). I have noted project ideas that overlap as well as project ideas that provide support for other ideas. A brief description of each idea is provided and any assessment on the potential cost or impact of a project idea conducted by PSP is included.

Table A-1
Pecan Street Project Supply-Side Ideas

Idea Number	Originating Group	Paired Ideas	Idea Name	Description	Potential
1.01	Distributed Generation (DG)	8.03	Solar PV on large commercial roofs	AE leasing large commercial rooftops to install large-scale grid-tied PV systems (>500 kW)	20-200 MW (46 by 2020)
1.02	DG	8.03	Solar PV on small-medium commercial roofs	AE leasing small and medium commercial rooftops to install grid-tied PV systems (250-500 kW)	100-550 MW (50 by 2020)
1.03	DG	7.08	Residential solar PV, low-power density	Residential solar PV on rooftops, low-cost, low-power density	705 MW+
1.04	DG	7.08	Residential solar PV, high-power density	Residential solar PV on rooftops, higher-power density	236 MW+
1.05	DG	7.08, 10.03	Modify building codes for PV	Update City of Austin building codes to require new constructions and renovations to be "PV friendly"	Adoption support
1.06	DG		Solar arrays for parking lots	Install solar arrays above parking lots to produce energy, provide shading, and support PEV and EV recharging	50 MW (10 by 2020)
1.07	DG	8.04	Solar PV farms-city land	Build ground-mounted solar PV farms on city land	300 MW+ (85 by 2020)
1.08	DG	8.04	Solar PV farms-flood plain land	Build ground-mounted solar "water gardens" on flood plain land	300 MW+ (0 by 2020)
1.09	DG	2.07	BIPV incentives for commercial and industrial buildings	AE rebate for grid-tied building-integrated PV (BIPV) for new/renovated buildings	Unknown
1.10	DG		Landfill gas	Expand power generation capacity from landfill-gas facilities	11 MW
1.11	DG	8.23	Waste-to-energy	Develop a waste-to-energy or energy recovery plant in Austin fed by regionally available feed stocks	Up to 200,000 MWh/yr (6 MW by 2020
1.12	DG	8.09	Combined heat and power or waste "heat to electricity"	Convert waste heat from reciprocating engines or geothermal sources to electricity	15 MW by 2020
1.13	DG		Micro-wind capability profiling	Design and implement a pilot program for remote data acquisition of wind data within Austin to assess small-scale wind turbine distributed generation potential	$50,000 cost
1.14	DG		Micro-hydro capability profiling	Assess the opportunities and technologies that could be applied in Austin to generate electricity from run-off, reservoir releases, and	$50,000 cost

				pressurized water flows	
1.19	DG		AE-owned smart inverters for residential PV	Allow AE to own smart inverters for residential PV to provide the utility with more granular control over systems	Revenue support
1.20	DG		Waste heat resource assessment	Compile and analyze regional data to access waste heat power generation potential	Unknown cost
2.07	Low-Tech/Low-Emission Options	1.09	Building integrated PV	Provide incentives, rebates and develop integration of PV on the facade or roof of a building	Unknown
3.17	DG		Ground source heat pump study	Conduct a study on potential for ground source heat pumps in the Austin area	$50,000 cost
3.18	DG		Combined heat and power study	Conduct a study on potential for combined heat and power in the Austin area	$50,000 cost
7.08	Operations and Systems Integration	1.03-1.05	Rooftop solar PV/On-site storage	Support of integration of solar PV and on-site storage to AE power system	Adoption support
8.01	New Utility Business Model (BM)		Blended "Clean" Energy Rates	Package distributed renewables with low carbon central plant generation	Adoption support
8.02	BM		Recovery for distributed generation	Transmission and distribution and standby (generation) charge for distributed generation owners	Revenue support
8.03	BM	1.01, 1.02	Commercial and industrial solar PV	Support AE leasing large rooftop space for solar PV	Adoption support
8.04	BM	1.07, 1.08	Ground-mounted solar on City land	Support AE-owned or PPA for solar PV on city land	Adoption support
8.09	BM	1.12	Energy from waste heat	Support energy from waste heat (chillers or boilers run through organic rankin cycle)	Adoption support
8.21	BM		Leasing equipment	AE leasing distributed resources to customers (solar and storage)	Adoption support
8.23	BM	1.11	Recoverable energy	Support energy generated from urban solid waste	Adoption support
10.03	Legislative and Regulatory Requirements (LRR)	1.05	Solar-ready building code	Update City of Austin building codes to require new constructions and renovations to be "PV friendly"	Adoption support
10.04	LRR		Building and zoning code incentives for new homes	Access easements to building and zoning codes for solar PV for new homes	Adoption support

10.05	LRR		Solar-ready subdivision criteria	Greenfield developments that maximize solar potential for new subdivision development	Adoption support

Source: PSP, “Pecan Street Project Ideas,” May 2009.

Table A-2
Pecan Street Project Demand-Side Ideas

Idea Number	Originating Group	Paired Ideas	Idea Name	Description	Potential Energy Savings
2.01	LT/LE	8.07	Solar water heating	Potentially increase rebate program and implement marketing program for solar water heating systems to supply buildings with hot water	500,000-1,000,000 kWh/yr (9,979 MWh by 2020)
2.02	LT/LE		Lighting controls and daylighting	Support lighting controls that use information about daylight levels and building occupancy to determine whether lights should be on or off	26,000 MWh by 2020
2.03	LT/LE		Smart off and smart power strips	Implement rebate and marketing program for smart power strips to reduce "vampire" loads, or electricity consumed by devices when plugged in but not in use	40,800 MWh by 2020
2.04	LT/LE		Passive design strategies	Support passive designs for buildings (such as orientation, window placement, and thermal mass) through marketing program, incentives, and zoning regulations	16,950 MWh by 2020
2.05	LT/LE		Community design	Smart community design through incentives for density, public transportation, and solar access	High (depends on type of design)
2.06	LT/LE		Shading, sun control	Support shading as a passive building design strategy coupled with a high-quality glazing with a low solar heat gain coefficient through marketing program and building codes	10,121 MWh by 2020
2.08	LT/LE		Solar absorption cooling	Implement marketing and incentive programs for solar absorption cooling systems that use thermal energy for cooling	660 MWh by 2020
2.10	LT/LE		Performance-based energy code	Change energy codes to allocate an amount of energy for each building type of use and allow discretion in how that level of energy is achieved	High (50-75% reduction potential compared to current codes)
3.01	Demand Response (DR)		Prepay plans	Allow customers to pre-pay for energy through kiosks enabled by smart meters	10-15% reduction in residential energy consumption
3.02	DR	8.06	Residential peak time rebates	Reward residential customers for reducing load during peak times	10% reduction in peak demand

3.03	DR	8.06	Residential critical peak pricing	Charge customers substantially higher rates for power during critical peak periods, typically in the middle of a very hot day	10-15% reduction potential
3.04	DR	8.06	Residential time-of-use pricing	Charge customers for electricity used during a specific time of the day based on the cost of producing electricity at that time	Unknown
3.13	Energy Efficiency (EE)		Data center energy management	Provide incentives to commercial customers to update servers and personal computers	Unknown
3.14	EE		Expand rebates to energy star appliances	Expand the rebates given to energy star appliances beyond current rebates provided	Unknown
3.15	EE		Stricter energy codes	Continue AE's efforts for continuous and aggressive development of the building energy codes for all sectors	Unknown
3.16	EE		Building improvement	Support rebates for building improvements that enhance the energy efficiency of a building including duct sealing, insulation, weatherization, and window shading as well as high efficiency air conditioners	Unknown
4.08	Energy Storage (ES)	7.05, 8.19	Networked thermal storage	Implement utility-scale thermal storage as a distributed, dispatchable option to dynamically manage congestion on distribution lines and help to balance energy supply and demand in real time	Unknown
4.11	ES	7.05	Grid support storage	Implement micro-grid storage to maintain the stability otherwise available in a large grid system and support variable wind and solar technologies	Unknown
5.01	Water Conservation (WC)		Reducing outdoor residential and commercial watering	Implement turf replacement incentives and rebates, year-round watering restrictions, and incentive smart irrigation systems to reduce water use during peak energy demand	Unknown
5.02	WC		Water usage limits	Effectively manage peak day water demand through water usage limits	Unknown
5.03	WC		Residential water audit	Implement a free residential water audit system to provide customers with recommendations for changes and retrofits that would be tied to incentive and rebate programs	Unknown
5.04	WC		Enhanced city infrastructure/building codes	Increase installation of purple pipes and gray water irrigation systems to promote gray water for irrigation and install leak sensors for better leak detection and remediation	Unknown
5.05	WC		Smart water meters and billing	Install newer, smarter meters to enable time-of-use billing, increase amount of information to utility and customers, and potentially remotely operate some water activities	Unknown
6.01	ES		Neighborhood Electric	Pilot to test electric storage (15kWh-25kWh) at the last	Unknown

			Storage	transformer on a distribution feeder to manage peak load	
7.05	Operations and Systems Integration (O/SI)	4.08, 4.11	Utility-scale storage	Own and operate utility-scale storage facilities at major customers site to ensure power during outages and a high level of power quality	Unknown
7.06	O/SI		Partner Energy Program	Implement a program that would promote the widespread use of either distributed generation or demand response and provide a separate rate class for those that qualify	Adoption support
8.05	New Utility Business Model (BM)		AE branded aggregation idea	Third party aggregator of residential demand response, energy efficiency, storage and distributed generation infrastructure	New business model approach
8.06	BM	3.02-3.04	Time-of-use/dynamic/critical peak pricing	Provide time-differentiated rates for customers to reduce demand, particularly during peak hours	New business model approach
8.07	BM	2.01	Solar water heaters	Sell solar hot water to customers	New business model approach
8.08	BM		Sell the function	Sell the service provided by AE (air conditioner, hot water, storage) to redefine the utility's role in the value chain	New business model approach
8.11	BM		Building energy modeling	Provide design services to builders, architects, etc. to help move to zero-energy capable building standards	New business model approach
8.12	BM		Carbon offset program with solar hot water	Operate a certified non-profit carbon offset program to install solar water heaters for low-income residents	New business model approach
8.13	BM		?	?	?
8.17	BM		Reliability rates	Charge customers for higher reliability or better power quality through back-up power, redundant feeds, storage, etc.	New business model approach
8.18	BM		Energy management systems	Implement technologies to allow customers to manage energy use	New business model approach
8.19	BM	4.08	Distributed thermal storage	Support thermal storage as AE-owned	New business model approach
8.26	BM		Service, operations and maintenance	Provide warranty or service plan to customer-sited distributed generation resources	New business model approach
10.07	Legislative and regulatory requirements		Smart-grid fast-track committee	Establish a committee to maximize the timeline by which AE implements its full smart grid system, given the constraint of standards being created	Support

Source: PSP, "Pecan Street Project Ideas," May 2009.

Table A-3
Pecan Street Project Transportation Ideas

Idea Number	Originating Group	Paired Ideas	Idea Name	Description	Potential Impact
4.01	Transportation		Market research sessions with Austin residents	Conduct market research sessions with AE customers to assess customer preferences and likely behavior with PEVs	Adoption Support
4.02	Transportation		On-going consumer incentives for PEVs	Develop protocols and implementation tools for AE to provide a coupon voucher for installation of home charging which might include bundling all PEV incentives	192,000 PEVs by 2020 (resulting in 243,566 MWh of demand or 19 MW of peak demand)
4.03	Transportation	8.20	Mid-term regional program for non-road PEVs	Implement a program to convert existing non-road vehicles to electric when significant environmental improvements can be realized	Unknown
4.04	Transportation		Coordinated customer acceptance program	Implement a customer acceptance program to provide information on PEVs and increase adoption	Adoption Support
4.05	Transportation		Teach PEV maintenance and certify mechanics	Identify local technical/mechanic groups, educational institutions, or professional organizations in Austin who could teach PEV maintenance and certify mechanics	Adoption Support
4.06	Transportation	9.18, 9.19, 9.20	Demonstration project of smart charging technology in single and multi-family homes	Demonstration project to deploy smart charging technology in diverse single and multi-family residences and use these locations as a test bed for the technology and assessing customer use and preferences	Adoption Support
4.07	Transportation		Smart charging: communications and infrastructure trial	Pilot project for several different methods for establishing two-way connectivity between different vehicles and central control server	Adoption Support
4.07(2)	Transportation		Electrified mass transit	Expanding electrified mass transit in Austin and AE service territory with light rail and buses	Unknown
4.09 and 4.10	Transportation		Aggregating vehicles to shave peak demand	Targeting of two vehicle groups (vehicles parked at airport during the day and school buses) to shave peak demand	Unknown
7.11	Operations and Systems Integration	8.14, 8.24	PEV charging stations	Support the implementation and operation by AE of PEV charging stations	Adoption Support
8.14	New Utility	7.11	Charge management for	Managing the charging of electric vehicles for the benefit	New business model

	Business Model (BM)		PEVs	of the utility and prevent power supply and quality issues	approach
8.20	BM	4.03	Electrification of non-road vehicles	Support electrification of airport support vehicles and other industrial and off-road vehicles	New business model approach
8.24	BM	7.11	Public charging for PEVs	Support publicly available charging stations for PEVs	New business model approach
8.25	BM		Electric transportation-water busses	Implement mass transit driven by electric power to have a large reliable customer for AE energy to sell power in off-peak periods and solve other mass transit and social needs.	New business model approach

Source: PSP, “Pecan Street Project Ideas,” May 2009.

Table A-4
Pecan Street Project Research Ideas

Idea Number	Originating Group	Paired Ideas	Idea Name	Description	Potential Cost ($)
1.13	Distributed Generation (DG)		Micro-wind capability profiling	Design and implement a pilot program for remote data acquisition of wind data within Austin to assess small-scale wind turbine distributed generation potential	50,000
1.14	DG		Micro-hydro capability profiling	Assess the opportunities and technologies that could be applied in Austin to generate electricity from run-off, reservoir releases, and pressurized water flows	50,000
1.15	DG		Cost modeling tool for renewable energy technologies	Develop a standardized cost model of record for the objective analysis of technology types based on end-use installation parameters	Unknown
1.16	DG	11.11	Demonstration/open source pilot facility	Construct a demonstration facility for purposes of fast-tracking research and development activities to improve performance in real-world applications	Unknown
1.17	DG		Database of renewable energy technology companies	Develop an online database of companies developing renewable energy technology	Unknown
1.20	DG		Waste heat resource assessment	Compile and analyze regional data to access waste heat power generation potential	Unknown
2.09	Low-Tech/Low-Emission Options (LT/LE)	8.27	Zero net energy demo project	Implement a zero net energy buildings demonstration project to model a high-density, transit-oriented, highly energy efficient, sustainable, mixed-use community to implement project ideas	5-10 million
3.08	Demand-side management (DSM)		Advanced residential DSM pilot	Conduct a pilot of advanced DSM technologies with 1,000 customers that provides a wide geographic and demographic distribution	3,000 per customer
3.09	DSM		Advanced commercial DSM pilot	Conduct a pilot of advanced DSM technologies, including lighting retrofits, using a municipal building	Unknown
3.10	Energy storage (ES)		Thermal storage for residential communities study	Work with developers of planned communities to study thermal energy storage (chilled water or ice)	Unknown
3.11	DSM		Municipal buildings DSM	Conduct a pilot of intelligent load management technology and	Unknown

			aggregation project	demand response capabilities at all AE-serviced municipal and state buildings equipped with a building automation system	
3.12	DSM		Commercial DSM aggregation project	Conduct a pilot using direct demand control for ERCOT grid management	Unknown
3.17	DG		Ground source heat pump study	Conduct a study on potential for ground source heat pumps in the Austin area	50,000
3.18	DG		Combined heat and power study	Conduct a study on potential for combined heat and power in the Austin area	50,000
4.01	Transportation		Market research sessions with Austin residents	Conduct market research sessions with AE customers to assess customer preferences and likely behavior with PEVs	400,000
4.06	Transportation	9.18, 9.19, 9.20	Demonstration project of smart charging technology in single and multi-family homes	Demonstration project to deploy smart charging technology in diverse single and multi-family residences and use these locations as a test bed for the technology and assessing customer use and preferences	Unknown
4.07	Transportation		Smart charging: communications and infrastructure trial	Pilot project for several different methods for establishing two-way connectivity between different vehicles and central control server	Unknown
4.08	Transportation		Micro utility business model	Develop a business model for the utility to provide services at the distribution feeder level with large-scale PEV, on-site generation, and energy storage	Unknown
4.09	Transportation		Future green energy storage test lab	Build a test lab that will focus on emerging green energy storage technologies, including storage device applications	Unknown
4.10	Transportation		New investment model for energy storage solutions	Develop an investment model for determining the full value of storage and asses value streams for utility	Unknown
6.01	ES		Neighborhood electric storage	Pilot to test electric storage (15kWh-25kWh) at the last transformer on a distribution feeder to manage peak load.	Unknown
8.16	New Utility Business Model (BM)	7.1	Consulting services	AE would provide consulting services on its expertise related to PSP to generate revenue	New business model approach
8.27	BM	2.09, 9.15	ZECH pilot project	Zero-energy capable homes pilot project to assess the impacts of 2015 building code standards and preparation for time-of-use pricing	Unknown
9.15	Customer interfaces and impacts and behavioral	8.27	Time-of-use pilot	Pilot of 380 residential homes with experiential and control groups to research impacts of time-of-use pricing on AE system infrastructure and revenues	Unknown

	economics (CII/BE)				
9.16	CII/BE		Plug-in-hybrid demonstration pilot	Small-scale pilot to investigate potential impacts of PEV deployment to distribution system as well as customer acceptance and use	Unknown
9.18	CII/BE	4.06, 9.19, 9.20	Smart grid technology demonstration project	Pilot project to research customer acceptance and logistics of smart grid enabled technologies and communication protocols	Unknown
9.19	CII/BE	4.06, 9.18, 9.20	Investigation of potential impact of smart grid implementation on residential/commercial segments	Assess the potential costs to customer segments with regards to full-scale build out and implementation of smart grid technologies	Unknown
9.20	CII/BE	4.06, 9.18, 9.19	Economic analysis of commercial segments/potential for smart grid benefits	Analyze production profiles of mid-size commercial segments within AE service territory and identify those which would benefit the most from smart grid	Unknown
9.21	CII/BE		Delphi survey of national smart grid key leaders	Gather information on impact on customers through surveying smart grid energy leaders	Unknown
9.23	CII/BE		AE service territory residential conjoint study	Survey among 400 residential customers to determine the optimal mix of products and policies for smart grid implementation	Unknown
10.01	Legislative and regulatory requirements (LRR)		Smart grid monitoring project	Implement a system to track smart grid projects nationally	Unknown
10.02	LRR		Carbon impact model	Develop a model to analyze the real value of carbon for the utility and the impacts on valuing projects	Unknown
10.06	LRR		REC market study	Initiate a research project on the nature of the Texas renewable energy credit (REC) market	Unknown
11.11	Economic Development (ED)	1.16	Future energy and smart grid lab	Support SEMATECH and other partners in establishing a smart grid lab and test facility in Austin	Unknown
11.14	ED		Clean energy park/national lab opportunity	Investigate potential role of a clean energy park to support Phases 2 and 3 of PSP and support bringing National Renewable Energy Lab to Austin	Unknown

Source: PSP, “Pecan Street Project Ideas,” May 2009.

Table A-5
Pecan Street Project Public Outreach and Project Support Ideas

Idea Number	Originating Group	Paired Ideas	Idea Name	Description	Potential Cost ($)
3.05	Demand Response (DR)		Improve commercial participation in demand response programs	Increase commercial customer participation in DR programs through marketing and by studying best practices from other utilities to develop optimal incentives	Unknown
3.06	DR		Vampire load awareness program	Implement education program to market and promote reduction of vampire loads (use of electricity for electronic devices when not in use)	Unknown
3.07	Demand-Side Management (DSM)		PC energy portal	Upgrade the current AE customer account website using advanced metering infrastructure data to enable and encourage customer participation in DSM	Unknown
4.04	Transportation		Coordinated customer acceptance program	Implement a customer acceptance program to provide information on PEVs and increase adoption	Unknown
7.01	Operations and Systems Integration (O/SI)	8.16	Lab and consulting	Develop a PSP lab at the University of Texas at Austin and look into developing this into a consulting service	Unknown
7.02	O/SI		PSP reference manual	Publish and market a reference manual as a guidebook for PSP and the development of the smart grid	100,000 (50,000 annually)
7.03	O/SI	Many	Demonstration project	Design a PSP house, AE smart home, and/or AE smart business open for public education purposes	Unknown
9.01	Customer interfaces and impacts and behavioral economics (CII/BE)		Confidence campaign	Design a campaign to turn satisfied AE customers into PSP program recruits to maximize publicity and encourage customer participation	Unknown
9.02	CII/BE		Population projections/technology use	Conduct research in coordination with City demographic staff to develop detailed projections of the Austin population through year 2025	Unknown
9.03	CII/BE		Home energy report	Implement a 12-month energy comparison report by mail or email to customers to encourage DSM	Unknown

9.04	CII/BE		Multi-player gaming	Develop multi-player game for customer education and awareness to increase PSP program adoption rates	Unknown
9.05	CII/BE		Public demonstration or “hands-on” house/living lab/demo studio	Design a fixed or mobile public demonstration project that conveys the vision and value of applying smart grid systems	Unknown
9.06	CII/BE		Work-based education training and demonstration programs	Implement workplace-based education, awareness, and training programs on PSP programs	Unknown
9.07	CII/BE		Interactive web resources	Design a suite of web-based web resources for PSP programs and projects	Unknown
9.08	CII/BE		Retail-based kiosks	Staff booths around Austin for education and outreach purposes on PSP programs and projects	Unknown
9.09	CII/BE		Online map-based web applications	Create an online map to provide layers of information on impact of smart grid and PSP across geographical regions	Unknown
9.10	CII/BE		Contests and challenges	Design a series of social contests and challenges to engage the public in adoption of PSP programs and projects	Unknown
9.11	CII/BE	9.13	Social web team	Establish and maintain a web presence on social networking and other public internet sites	Unknown
9.12	CII/BE	9.17	Smart infrastructure/environment curriculum for public schools	Develop a curriculum program for local schools on PSP, smart grid, and the environment related to electric usage for public school implementation	Unknown
9.13	CII/BE	9.11	Web-based communication with customers	Increase web presence with community input	Unknown
9.14	CII/BE		Facilitation of community input and participation	Develop a mechanism by which members of the community that are not technology users can participate in discussion and adoption of PSP programs and projects	Unknown
9.17	CII/BE	9.12	Energy efficiency/conservation public school curriculum	Establish a broad curriculum for public school students regarding the benefits of conservation and energy efficiency	Unknown
9.22	CII/BE		National energy efficiency/conservation competition	Establish a national-level competition between regions of the country to engage in energy efficiency and conservation practices	Unknown
9.24	CII/BE		Establishment of customer panels	Develop long-term panels to collect information regarding customer acceptance and reaction to smart grid implementation	Unknown

Source: PSP, “Pecan Street Project Ideas,” May 2009.

Table A-6
Pecan Street Project Economic Development and Workforce Training Ideas

Idea Number	Originating Group	Paired Ideas	Idea Name	Description	Potential Impact
11.01	Economic Development (ED)		Implement local content requirements for PSP participants	Study local content requirements to determine if the benefit of local provision outweighs the cost of restricted supply and, if so, select the appropriate program	High ED
11.02	ED		Leverage PSP to allow early stage companies to access federal ARRA dollars	Create a mechanism to coordinate ARRA initiatives on behalf of smaller and start-up companies	High ED
11.03	ED		Accelerated ETF process for PSP-focused companies	Create an accelerated approval process for PSP-related companies for the State's Emerging Technology Fund	Medium ED
11.04	ED		Create PSP-focused investment funding mechanism	Partner with institutional investors who have a smart grid/distributed generation investment focus to fund local PSP-related start-ups	Medium-high ED
11.05	ED		Repurpose technological talent into PSP-related opportunities	Create mechanisms to deploy talent from the non-energy technology sectors into PSP-related start-ups	Medium ED
11.06	ED		PSP-focused business plan competition	Market the results of PSP to the Central Texas entrepreneurial community using a business plan competition as a vehicle to create new companies	High ED
11.07	ED		Incubation support for PSP-focused start-ups	Provide resources to Clean Energy Incubator to identify and support PSP-related start-ups	High ED
11.08	ED		Streamlined funding process for PSP-related start-ups	Create a process to validate companies as working on PSP-related efforts and provide a forum for these companies to communicate with interested investor groups	High ED
11.09	ED		Develop focus areas for economic development based on PSP outcomes	Leverage local community attributes to focus on most promising areas of PSP for ED	Medium ED
11.10	ED		Change city purchasing process	Incorporate preference for local manufacturing or research and development into city purchasing and accelerate the process	High ED
11.12	ED		PSP marketing campaign	Design a marketing program to target potential ED targets and aggressively implement the campaign	High ED
11.13	ED		Incentives coordination	Determine better ways to coordinate the economic	High ED

				development process and assess the appropriate level of incentives	
11.15	ED		Study other teams' findings to see if there are potential ED implications	Procedural initiative	High ED
12.01	Workforce Training (WT)		UT smart grid educational program	Develop a UT-Austin smart grid educational program	Increase trained professionals
12.02	WT		Solar installation technicians and trade skills	Identify the technical educational programs and skills training needed to execute PSP initiatives	Increase trained professionals

Source: PSP, "Pecan Street Project Ideas," May 2009.

Table A-7
New Utility Business Model Team Ideas

Idea Number	Originating Group	Paired Ideas	Idea Name	Description
8.01	New Utility Business Model (BM)		Blended "clean" energy rates	Package distributed renewables with low carbon central plant generation
8.02	BM		Recovery for distributed generation	Transmission and distribution and standby (generation) charge for distributed generation owners
8.03	BM	1.01, 1.02	Commercial and industrial solar PV	Support AE leasing large rooftop space for solar PV
8.04	BM	1.07, 1.08	Ground-mounted solar on city land	Support AE-owned or PPA for solar PV on city land
8.05	BM		AE branded aggregation idea	Third party aggregator of residential demand response, energy efficiency, storage and distributed generation infrastructure
8.06	BM	3.02-3.04	TOU/dynamic/critical peak pricing	Provide time-differentiated rates for customers to reduce demand, particularly during peak hours
8.07	BM	2.01	Solar water heaters	Providing the service of selling solar hot water to customers
8.08	BM		Sell the function	Sell for the service provided by AE (air conditioner, hot water, storage) to redefine utility role in the value chain
8.09	BM	1.12	Energy from waste heat	Support energy from waste heat (chillers or boilers run through organic rankin cycle)
8.11	BM		Building energy modeling	AE would provide design services to builders, architects, etc. to help move to zero-energy capable building standards
8.12	BM		Carbon offset program with solar hot water	Operate a certified non-profit carbon offset program operated by AE to install solar water heaters for low-income residents
8.13	BM		?	?
8.14	BM	7.11	Charge management for PEVs	Managing the charging of electric vehicles for the benefit of the utility and prevent power supply and quality issues
8.16	BM	7.1	Consulting services	AE would provide consulting services on its expertise related to PSP to generate revenue
8.17	BM		Reliability rates	Charge customers for higher reliability or better power quality through back-up power, redundant feeds, storage, etc.
8.18	BM		Energy management systems	Implement technologies to allow customers to manage energy use

8.19	BM	4.08	Distributed thermal storage	Support thermal storage as AE-owned
8.20	BM	4.03	Electrification of non-road vehicles	Support electrification of airport support vehicles and other industrial and off-road vehicles
8.21	BM		Leasing equipment	AE leasing distributed resources to customers (solar and storage)
8.23	BM	1.11	Recoverable energy	Support energy generated from urban solid waste
8.24	BM	7.11	Public charging for PEVs	Support publicly available charging stations for PEVs
8.25	BM		Electric transportation-water busses	Implement mass transit driven by electric power to have a large reliable customer for AE to sell power in off-peak periods and solve other mass transit and social needs.
8.26	BM		Service, operations and maintenance	Provide warranty or service plan to customer-sited distributed generation resources
8.27	BM	2.09, 9.15	ZECH pilot project	Zero-energy capable homes pilot project to assess the impacts of 2015 building code standards and preparation for time-of-use pricing

Source: PSP, "Pecan Street Project Ideas," May 2009.

Table A-8
Legislative and Regulatory Challenges

Idea Number	Originating Group	Paired Ideas	Idea Name	Description
10.01	Legislative and regulatory requirements (LRR)		Smart grid monitoring project	Implement a system to track smart grid projects nationally
10.02	LRR		Carbon impact model	Develop a model to analyze the real value of carbon for the utility and the impacts on valuing projects
10.03	LRR	1.05	Solar-ready building code	Update City of Austin building codes to require new constructions and renovations to be “PV friendly”
10.04	LRR		Building and zoning code incentives for new homes	Access easements to building and zoning codes for solar PV for new homes
10.05	LRR		Solar-ready subdivision criteria	Greenfield developments that maximize solar potential for new subdivision development
10.06	LRR		REC market study	Initiate a research project on the nature of the Texas renewable energy credit (REC) market
10.07	LRR		Smart-grid fast-track committee	Establish a committee to maximize the timeline by which AE implements its full smart grid system, given the constraint of standards being created

Source: PSP, “Pecan Street Project Ideas,” May 2009.

Appendix B
Pecan Street Project Technical Analysis

The information contained in this Appendix is a combination of data gathered from PSP working group project idea characterizations and core team final reports, external studies, and subjective ordinal variables determined by myself. Data and ordinal variables drawn from PSP documents are indicated with an asterisk, "*." Data drawn from external reports or determined by the author of this report are indicated with a "^." If a project idea has an "*" next to the title all metrics within that row not identified by a "^" came from internal PSP documents.

A discussion of the methodology used for calculations in these tables as well as the results of this analysis is provided in Chapter 5 of this report.

Table B-1
Energy Use, Cost, and Other Impacts of Pecan Street Project Ideas

	Metric	Costs	Costs	Cost Uncertainty	Power Generation Capacity	Annual Energy Generated, Saved, or New Demand	Peak Generation Potential, Savings, or Demand	Energy Security Through Reduced Oil Consumption	System Reliability Impact	Customer Satisfaction	Economic Development
	Measurement	$/kWh or low (L), medium (M), high (H) scale	$/kW, per unit, or low, medium, high scale	low, medium, high scale	MW total potential	MWh or low, medium, high scale	MW or low, medium, high scale	Annual barrels of crude oil avoided	low, medium, high scale	low, medium, high scale	number of jobs created or low, medium, high scale
Project Idea #	**Project Idea**										
Supply-Side / Generation											
1.01	Large commercial solar PV*	0.18-0.28	<6,000	H^	46	104,770	23	N/A	L-Positive	L-Positive^	450-900
1.02	Small-medium commercial solar PV*	0.25-0.47	~6,000	H^	50	113,880	25	N/A	L-Positive	L-Positive^	750-1550
1.03, 1.04	Residential solar PV, single-family*	0.27-0.32 (and revenue losses)	6,500-8,500	H^	50	113,880	25	N/A	M-Positive or Negative^	M-Positive^	750-1500
1.03, 1.04	Residential solar PV, multi-family*	0.29-0.45 (and revenue losses)	6,500-8,500	H^	22	50,107	11	N/A	M-Positive or Negative^	M-Positive^	330-660
1.06	Solar arrays for parking lots*	0.17-0.35	~4,000	H^	10	22,776	5	N/A	L-Negative	L-Positive^	150-300
1.07	Solar PV farms on city-owned land*	0.14-0.22	3,000-5,000	H^	85	193,596	43	N/A	L-Negative	L-Positive^	1200-2400
1.07	Solar PV Farms on private land*	0.16-0.25	3,000-5,000	H^	85	193,596	43	N/A	L-Negative	L-Positive^	1200-2400
1.08	Solar farms on flood plain land*	H^	H^	H^	Assess Feasibilty	M^	H^	N/A	L-Positive or Negative^	M-Positive^	M^
1.09, 2.07	Building-integrated solar PV	Higher than rooftop solar PV	Higher than rooftop solar PV	H^	Assess Feasibilty	M-H^	H^	N/A	M-Positive or Negative^	M-Positive^	M-H
1.1O	Landfill gas*	0.07-0.09	2,263^	L^	11	81,906	11	N/A	H-Positive	L-Positive^	5-10
1.11	Waste to energy*	0.03-0.05	Unknown	L^	6	44,676	6	N/A	H-Positive	L-Positive^	75-150
1.12	Combined Heat and Power / Waste Heat Recovery	0.01-0.03	1,500-3,200	L^	15	111,690	15	N/A	H-Positive	L-Positive^	225-450
1.18	Small to medium solar PV farm -PPAs*	Zero costs to utility	Zero costs to utility	H^	10	22,776	5	N/A	M-Positive or Negative^	M-Positive or Negative^	M

Metric		Costs	Costs	Cost Uncertainty	Power Generation Capacity	Annual Energy Generated, Saved, or New Demand	Peak Generation Potential, Savings, or Demand	Energy Security Through Reduced Oil Consumption	System Reliability Impact	Customer Satisfaction	Economic Development
Measurement		$/kWh or low (L), medium (M), high (H) scale	$/kW, per unit, or low, medium, high scale	low, medium, high scale	MW total potential	MWh or low, medium, high scale	MW or low, medium, high scale	Annual barrels of crude oil avoided	low, medium, high scale	low, medium, high scale	number of jobs created or low, medium, high scale
Project Idea #	Project Idea										
DSM - Energy Efficiency											
2.01	Solar water heating*	L (rebates)	5,952 per unit	L^	N/A	9,979	23	N/A	N/A	M-Positive^	M
2.02	Lighting controls, daylighting (commercial)*	L (awareness program)	0.50-0.75 / square foot	L^	N/A	26,000	52,000	N/A	L	M-Positive^	L-M
2.03	Smart Off and Smart Power Strips (residential)*	L (rebates)	20-90 per unit	L^	N/A	40,800	L^	N/A	N/A	M-Negative or Positive^	L
2.04	Passive Design Strategies (residential)*	L (program implementation)	L (program development)	L^	N/A	16,950	N/A	N/A	N/A	H-Positive^	M
2.05	Community Design*	L (program implementation)	L (program development)	L^	N/A	H (depends on type of design)	L	N/A	N/A	H-Positive^	H
2.06	Shading, Sun Control (new construction and tree planting)*	L (program implementation)	L (program development)	L^	N/A	10,121	M-H	N/A	N/A	H-Positive^	M
2.08	Solar Absorption Cooling (small commercial and residential)*	M (rebates)	Incremental change from current practice at $3,000 a unit	L^	0.6	660	0.6	N/A	N/A	M-Positive^	L-M
2.1O	Performance Based Energy Code*	L (revenue loss)^	L	L^	N/A	H (50-75% reduction potential compared to current codes)	L-M	N/A	N/A^	M-Negative or Positive^	L
3.13	Data Center Energy Management*	L^	L^	M^	N/A	M (need assessment)	L^	N/A	L-Positive^	M-Positive^	L^
3.14	Expand Rebates to Energy Star Appliances*	L (rebates) ^	100-250	M^	N/A	L	L	N/A	L-Positive^	M-Positive^	L^
3.15	Stricter Energy Codes*	L (revenue loss)	L	H^	N/A	M	M	N/A	L-Positive^	M-Negative or Positive^	H^
3.16	Building Improvement*	L (rebates)	250-400	M^	N/A	M	M	N/A	L-Positive^	M-Positive^	M
7.05	Home Area Network (HAN) Rebates or subsidies*	L (rebates)^	$300/customer	L^	N/A	L	M^	N/A	H-Positive	M-Positive^	H
8.11	Building energy modeling	M^	M^	H^	N/A	Assess Impacts	M^	N/A	M-Positive^	M-Positive^	M^

	Metric	Costs	Costs	Cost Uncertainty	Power Generation Capacity	Annual Energy Generated, Saved, or New Demand	Peak Generation Potential, Savings, or Demand	Energy Security Through Reduced Oil Consumption	System Reliability Impact	Customer Satisfaction	Economic Development
	Measurement	$/kWh or low (L), medium (M), high (H) scale	$/kW, per unit, or low, medium, high scale	low, medium, high scale	MW total potential	MWh or low, medium, high scale	MW or low, medium, high scale	Annual barrels of crude oil avoided	low, medium, high scale	low, medium, high scale	number of jobs created or low, medium, high scale
Project Idea #	**Project Idea**										
DSM - Demand Response											
3.01	Prepay Plans*	L (potential to increase revenue)	L (program implementation)	M^	N/A	10-15% reduction potential	L	N/A	L	M-Positive^	L^
3.02	Residential Peak Time Rebates*	M-H (revenue loss)	L (program implementation)	M^	N/A	L	10% reduction potential	N/A	L	M-Positive or Negative^	L
3.03	Residential Critical Peak Pricing*	M (revenue loss)	M	H^	N/A	L	M	N/A	M-Positive	M-Positive or Negative^	L^
3.04	Residential Time of Use Pricing*	L (revenue loss)	L-M	H^	N/A	L	L-M	N/A	M-Positive	M-Positive or Negative^	L
8.18	Energy management systems	M (revenue loss)	M (rebates)	M^	N/A	Assess Impacts	H^	N/A	H-Positive^	H-Positive^	M^
DSM - Energy Storage											
4.08	Networked Thermal Storage*	H	H	M^	N/A	Assess Impacts	L-H^	N/A	H-Positive^	M-Positive^	L^
4.09 and 4.10	Aggregating vehicles to shave peak demand*	M-H	M-H	H	N/A	Assess Impacts	L-H^	N/A	H-Positive^	L-Positive^	L-M
4.11, 7.05, 7.09	Grid Support Storage*	H	H	H^	N/A	Assess Impacts	L-H^	N/A	H-Positive^	M-Positive^	M
6.01	Neighborhood Electric Storage	L-M	L-M	H^	N/A	Assess Impacts	L-H^	N/A	H-Positive^	M-Positive^	M^
7.11 and 8.14	EV and PHEV charging stations with management*	L-M (revenue loss)	L-M	M^	N/A	Indirect	L-H^	N/A	H-Positive	H-Positive^	L
DSM - Conservation											
5.01	Reducing Outdoor Residential and Commercial Watering*	L (revenue loss)	L (rebates)	M^	N/A	M	L	N/A	L-Positive	L-Positive^	L
5.02	COA Water Usage Limits*	L (revenue loss)	L (cost savings)	M^	N/A	M	M	N/A	M-Positive	L-Positive^	L
5.03	Residential Water Audit*	L (revenue loss)	L	M^	N/A	L-M	L	N/A	L-Positive	L-Positive^	L^
5.04	Enhanced City Infrastructure /Building Codes*	L (revenue loss)	M (cost savings)	M^	N/A	L-M	L^	N/A	L-Positive^	L-Positive^	L^
5.05	Smart Water Meters and Billing*	L (revenue loss)	L	M^	N/A	H	L	N/A	M-Positive^	M-Positive^	M

	Metric	Costs	Costs	Cost Uncertainty	Power Generation Capacity	Annual Energy Generated, Saved, or New Demand	Peak Generation Potential, Savings, or Demand	Energy Security Through Reduced Oil Consumption	System Reliability Impact	Customer Satisfaction	Economic Development
	Measurement	$/kWh or low (L), medium (M), high (H) scale	$/kW, per unit, or low, medium, high scale	low, medium, high scale	MW total potential	MWh or low, medium, high scale	MW or low, medium, high scale	Annual barrels of crude oil avoided	low, medium, high scale	low, medium, high scale	number of jobs created or low, medium, high scale
Project Idea #	**Project Idea**										
Transportation											
4.02	Incentives for EVs and PHEVs*	$500 per vehicle (and revenue generating)	96,000,000 in rebates	H^	~62 MW off-peak demand	~243,566	~19	2,579,489	L-Positive or Negative^	M-Positive or Negative^	H^
4.03	Non-road EVs and PHEVs	M (revenue generating)	M	M^	L^	Assess Impacts	L^	-	L-Positive or Negative^	L-Positive or Negative^	L^
4.07	Electrified mass transit*	M-H (and revenue generating)	M-H*	H^	M-H^	Assess Impacts	M-H^	-	M-Positive or Negative^	H-Positive^	M

Table B-2
Environmental Impacts of Pecan Street Project Ideas

	Pollutant	Carbon Dioxide	Sulfur Dioxide	Nitrogen Oxides	Volatile Organic Compounds	Total Suspended Particulates	Carbon Monoxide	Mercury	Cadmium	Lead	Land Use	Water Conservation	Value of CO2 Reductions
	Measurement	Annual Metric Tons Avoided	Annual Pounds Avoided	Annual Pounds Avoided	Annual Pounds Avoided	Annual Pounds Avoided	Annual Pounds Avoided	Annual Milograms Avoided	Milograms Avoided	Milograms Avoided	Acres of Land Required	Annual Gallons	Pounds of CO2 avoided per dollar spent
Project Idea #	**Project Idea**												
Supply-Side / Generation													
1.01	Large commercial solar PV*	61,814	85,911	94,293	3,143	11,525	66,005	826,632	37,717	1,223,709	212	47,146,320	5.64
1.02	Small-medium commercial solar PV*	67,189	93,382	102,492	3,416	12,527	71,744	898,513	40,997	1,330,118	230	51,246,000	3.61
1.03, 1.04	Residential solar PV, single-family*	67,189	93,382	102,492	3,416	12,527	71,744	898,513	40,997	1,330,118	230	51,246,000	4.40
1.03, 1.04	Residential solar PV, multi-family*	29,563	41,088	45,096	1,503	5,512	31,568	395,346	18,039	585,252	101	22,548,240	3.51
1.06	Solar arrays for parking lots*	13,438	18,676	20,498	683	2,505	14,349	179,703	8,199	266,024	46	10,249,200	4.99
1.07	Solar PV farms on city-owned land*	114,222	158,749	174,236	5,808	21,296	121,965	1,527,472	69,695	2,261,201	391	87,118,200	7.21
1.07	Solar PV Farms on private land*	114,222	158,749	174,236	5,808	21,296	121,965	1,527,472	69,695	2,261,201	391	87,118,200	6.33
1.08	Solar farms on flood plain land*	-	-	-	-	-	-	-	-	-	-	-	-
1.09	Building-integrated solar PV*	-	-	-	-	-	-	-	-	-	-	-	-
1.1O	Landfill gas*	48,325	67,163	73,715	2,457	9,010	51,601	646,238	29,486	956,662	Dual Use	36,857,700	16.23
1.11	Waste to energy*	26,359	36,634	40,208	1,340	4,914	28,146	352,494	16,083	521,816	Dual Use	20,104,200	32.45

	Pollutant	Carbon Dioxide	Sulfur Dioxide	Nitrogen Oxides	Volatile Organic Compounds	Total Suspended Particulates	Carbon Monoxide	Mercury	Cadmium	Lead	Land Use	Water Conservation	Value of CO2 Reductions
	Measurement	Annual Metric Tons Avoided	Annual Pounds Avoided	Annual Pounds Avoided	Annual Pounds Avoided	Annual Pounds Avoided	Annual Pounds Avoided	Annual Milograms Avoided	Milograms Avoided	Milograms Avoided	Acres of Land Required	Annual Gallons	Pounds of CO2 avoided per dollar spent
Project Idea #	**Project Idea**												
Supply-Side / Generation													
1.12	Combined Heat and Power / Waste Heat Recovery	65,897	91,586	100,521	3,351	12,286	70,365	881,234	40,208	1,304,539	Dual Use	50,260,500	64.90
1.18	Small to medium solar PV farm - PPAs*	13,438	18,676	20,498	683	2,505	14,349	179,703	8,199	266,024	-	10,249,200	-
DSM - Energy Efficiency													
2.01	Solar water heating*	5,888	8,183	8,981	299	1,098	6,287	78,734	3,592	116,555	-	4,490,550	-
2.02	Lighting controls, daylighting (commercial)*	15,340	21,320	23,400	780	2,860	16,380	205,140	9,360	303,680	-	11,700,000	-
2.03	Smart Off and Smart Power Strips (residential)*	24,072	33,456	36,720	1,224	4,488	25,704	321,912	14,688	476,544	-	18,360,000	-
2.04	Passive Design Strategies (residentia and commercial)*	10,001	13,899	15,255	509	1,865	10,679	133,736	6,102	197,976	-	7,627,500	-
2.05	Community Design*	-	-	-	-	-	-	-	-	-	-	-	-
2.06	Shading, Sun Control (new construction and tree planting)*	5,971	8,299	9,109	304	1,113	6,376	79,855	3,644	118,213	-	4,554,450	-
2.08	Solar Absorption Cooling (small commercial and residential)*	389	541	594	20	73	416	5,207	238	7,709	-	297,000	-
Transportation													
4.02	Incentives for EVs and PHEVs	684,250		3,254	-	-	-	-	-	-	Possible increased use	Increased use	-
4.03	Non-road EVs and PHEVs	-	-	-	-	-	-	-	-	-	Possible increased use	Increased use	-
4.07	Electrified mass transit	-	-	-	-	-	-	-	-	-	Possible increased use	Increased use	-

Table B-3
Impact of Pecan Street Project Ideas with Indirect Impacts

	Metric	Costs	Impact on Overall PSP Success	Level of Dependency With Other PSP project ideas	Customer Satisfaction	Economic Development
	Measurement	total cost in $ or low (L), medium (M), high (H) scale	low, medium, high scale	low, medium, high scale	low, medium, high scale	low, medium, high scale
Project Idea #	**Project Idea**					
Research and Studies						
1.13	Micro-wind capability profiling	~50,000*	L^	L^	L^	L*
1.14	Micro-hydro capability profiling	~50,000*	L^	L^	L^	L^
1.15	Cost modeling tool for renewable energy technologies	M*	L^	M^	L^	L^
1.16	Demonstration / open source pilot facility	M*	M^	M^	H^	H*
1.17	Database of renewable energy technology companies	L*	L^	M^	L^	M*
1.2O	Waste heat resource assessment	L^	L^	L^	L^	L^
2.09, 8.27	Zero net energy demo project	5-10 million*	H^	H^	M^	L*
3.08	Advanced residential DSM pilot	3,000 per customer*	M^	H^	H^	M^
3.09	Advanced commercial DSM pilot using a municipal bldg	H*	M^	M^	M^	M*
3.1O	Thermal storage for residential communities study	L (rebate)*	L^	L^	M^	L*
3.11	Municipal buildings DSM aggregation project	L*	M^	M^	M^	M^
3.12	commercial DSM aggregation project	M*	M^	M^	M^	M^

	Metric	Costs	Impact on Overall PSP Success	Level of Dependency With Other PSP project ideas	Customer Satisfaction	Economic Development
	Measurement	total cost in $ or low (L), medium (M), high (H) scale	low, medium, high scale	low, medium, high scale	low, medium, high scale	low, medium, high scale
Project Idea #	**Project Idea**					
Research and Studies						
3.17	Ground source heat pump study	~50,000*	L^	L^	L^	L^
3.18	Combined heat and power study	~50,000*	L^	L^	L^	H*
4.01	Market research sessions w/ Austin residents on EVs and PHEVs	~400,000*	L^	M^	M^	M*
4PR1	PHEV large public group testing of charging	L*	M^	M^	M^	L^
4PR2	Heavy duty vehicle test program	L*	L^	L^	L^	L^
4.06/PR3	Demonstration project of smart charging technology	M*	M^	M^	M^	L^
4PR4	Smart charging communications infrastructure trial	L*	M^	M^	M^	L^
4PR5	PHEV charging statin testing and development	L*	M^	M^	L^	M^
4PR6	PHEV ancillary services study	L*	L^	L^	L^	L^
4.09	Future green energy storage test lab	H*	L^	M^	L^	M^
4.1O	New investment model for energy storage	M*	L^	L^	L^	L^
7.01	Pecan street lab & smart grid consulting	L*	H^	H^	M^	H*
7.11	Distribution system management innovations	L*	M^	M^	M^	H*
7.12	Server farm efficiency modeling	L*	L^	M^	L^	M*
9.02	Population projections / technology use	L*	M^	H^	L^	N/A
9.15	Time-of-use pilot	M*	M^	H^	H^	L*

	Metric	Costs	Impact on Overall PSP Success	Level of Dependency With Other PSP project ideas	Customer Satisfaction	Economic Development
	Measurement	total cost in $ or low (L), medium (M), high (H) scale	low, medium, high scale	low, medium, high scale	low, medium, high scale	low, medium, high scale
Project Idea #	**Project Idea**					
Research and Studies						
9.16	PHEV demonstration pilot	M*	M^	M^	H^	L*
9.18	Smart grid technology demonstration pilot	M*	H^	H^	H^	L*
9.19	Investigate potential impact of smart grid implementation	L*	H^	H^	H^	N/A
9.2O	Economic analysis of commercial segments / potential for smart grid benefits	L*	M^	M^	M^	N/A
9.21	Delphi survey of national smart grid key leaders	L*	L^	L^	L^	N/A
9.23	AE service territory residential conjoint study	M*	M^	H^	H^	N/A
10.01	Smart grid monitoring project	L*	M^	L^	L^	L^
10.02	Carbon impact model	M*	L^	L^	L^	L*
10.06	REC market study	M*	L^	L^	L^	L^
11.11	Future energy and smart grid lab	H* (not direct to utility)	H^	H^	M^	H*
11.14	Clean energy park/national lab opportunity	L-H*	H^	H^	M^	M*
Public Awareness and Outreach						
3.05	Improve commercial customer participation in DR programs	L (incentives)*	M^	H^	M^	M^
3.06	Vampire load awareness program	L*	L^	L^	H^	L^
3.07	PC energy portal	L*	M^	M^	M^	L^
4.04	Coordinated consumer acceptance program	L*	M^	M^	H^	M*
4.05	PHEV maintenance and certification of mechanics	L*	L^	M^	M^	M*

	Metric	Costs	Impact on Overall PSP Success	Level of Dependency With Other PSP project ideas	Customer Satisfaction	Economic Development
	Measurement	total cost in $ or low (L), medium (M), high (H) scale	low, medium, high scale	low, medium, high scale	low, medium, high scale	low, medium, high scale
Project Idea #	**Project Idea**					
Public Awareness and Outreach						
7.02	Pecan street reference manual	100,000 initial cost, updated annually at 50,000*	H^	H^	M^	H*
7.03	Pecan street house, Austin Energy smart home (residential) and Austin Energy smart business (small commercial)	L*	H^	H^	M^	H*
7.04	Energy consumption data services	M*	H^	H^	H^	M*
7.06	Partner energy program	H (rebates and incentives)*	M^	M^	H^	H*
7.07	Planet saver program	M*	L^	M^	H^	H*
8.01	Blended clean energy rates	L*	L^	M^	M^	N/A
8.1O	Flat rate	L-M*	L^	M^	M^	N/A
9.01	Confidence campaign	L-M*	M^	M^	H^	L*
9.03	Home energy report	M^	M^	M^	M^	L*
9.04	Multi-player gaming for customer education, awareness and to improve adoption rates	M^	L^	M^	M^	L*
9.05	Public demonstration 'hands on' house / living lab / demo studio	M*	M^	H^	M^	M*
9.06	Work-based edu-training and demonstration programs	L-M*	M^	H^	M^	M*
9.07	Interactive web resources	L*	M^	H^	H^	L*
9.08	Retail-based kiosks	L-M*	M^	M^	M^	M*
9.09	Online map-based web applications	M*	M^	M^	M^	L-M*
9.1O	Contests & challenges	L-M*	L^	L^	L^	L-M*
9.11	Social web team	L*	L^	M^	H^	L*
9.12	'Smart' infrastructure / environment curriculum examples (schools)	L*	L^	M^	M^	L*

	Metric	Costs	Impact on Overall PSP Success	Level of Dependency With Other PSP project ideas	Customer Satisfaction	Economic Development
	Measurement	total cost in $ or low (L), medium (M), high (H) scale	low, medium, high scale	low, medium, high scale	low, medium, high scale	low, medium, high scale
Project Idea #	**Project Idea**					
Public Awareness and Outreach						
9.13	Web-based communication with customers	L*	L^	M^	M^	L*
9.14	Facilitation of community input and participation	L-M*	H^	H^	H^	N/A
9.17	Energy efficiency / conservation public school curriculum	M-H*	L^	M^	M^	L-M*
9.22	National energy efficiency / conservation competition	L-M*	L^	L^	L^	N/A
9.24	Establishment of customer panels	M*	H^	H^	H^	N/A

Table B-4
Impact of Economic Development Pecan Street Project Ideas

	Metric	Costs	Impact on Overall PSP Success	Level of Dependency for Other PSP project ideas	Economic Development
	Measurement	total cost in $ or low (L), medium (M), high (H) scale	low, medium, high scale	low, medium, high scale	low, medium, high scale
Project Idea #	**Project Idea**				
Research and Studies					
11.01	Implement local content requirements for PSP participants	L^	M^	M^	H*
11.02	Leverage PSP to allow early stage companies to access Federal ARRA dollars	<100,000*	L^	L^	H*
11.03	Accelerated ETF process for PSP-focused companies	<100,000*	L^	L^	M*
11.04	Create PSP-focused investment funding mechanism	L*	M^	M^	M-H*
11.05	"Repurpose" technological talent into PSP-related opportunities	<100,000*	L^	M^	M*
11.06	PSP-focused business plan competition	<100,000*	M^	M^	H*
11.07	Turbocharged incubation support for PSP-focused start-ups	~200,000*	M^	M^	H*
11.08	Streamlined funding process for PSP-related start-ups	L*	M^	M^	H*
11.09	Develop "focus areas" for economic development based on PSP outcomes	L*	L^	M^	M*
11.1O	Change City purchasing process	M*	L^	M^	H*
11.12	Turbo-charge the PSP marketing campaign	~500,000*	H^	H^	H*
11.13	Incentives Coordination	L*	M^	M^	H*
12.1O	Workforce Development – Advanced Energy Green Career Educational Programs	M^	M^	H^	H^
12.2	Workforce Development Clean Energy Education and Skills Training – Solar Energy and Smart Grid Technicians, and Energy Efficiency and Weatherization Trades Skills	M^	M^	H^	H^

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