Making Electricity a Value Proposition for the Consumer

Successes from Pecan Street's Smart Grid Demonstration Project

Introduction

In Austin, Texas, the Pecan Street Smart Grid Demonstration Program (SGDP) project shows that the environmentally friendly lifestyle of the future is possible now, in the form of the 711-acre, green Mueller neighborhood (Fig. 1). On the former grounds of the airport, Mueller is only three miles from downtown Austin. In today's fast-paced world, Mueller residents enjoy a hybrid small-town, high-tech lifestyle, with houses and businesses linked to each other by bike paths, and to utility companies by the smart grid.

Since 2010, researchers have connected 1,200 homes to the smart grid, providing real-time data to users and researchers. Scientists from the University of Texas, the National Renewable Energy Laboratory, and the Environmental Defense Fund are collaborating on the project, which received a $24.6M grant of which $10.4M was the federal share from the Department of Energy. Other partners include Austin Energy; OnStar; and General Motors, who, together, provided $14.2M in matching funds.

Project Objective

The project objective was to create value for customers from electrical energy without jeopardizing utility revenue streams. Value is created from cost savings on current usage, and from new products and services.

The main new products and services are:

1) Effective demand response technology
2) Electric vehicles
3) Appropriately installed and operating solar power

Figure 1. Mueller provides a hybrid small-town, high-tech lifestyle.
Courtesy of Pecan Street

Together, these products and services can lead to cost, reliability, and societal and environmental benefits, as electric vehicles replace conventional cars on congested streets, solar power addresses peak load, and consumers use simple community-centered tools to reduce peak consumption.

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Influencing Consumer Behavior

Pecan Street and Austin Energy worked together to influence consumers to reduce energy use during critical peak events. Incentives to save are built into the Austin Energy tariff[1] as time-of-use rates. However, Pecan St. study participants received assistance to respond to existing signals and project specific signals/incentives as well. 60 homes participated in experimental wind and critical peak pricing, while 60 were in a control group. Critical peak pricing (CPP, $0.64 per kWh) applied during emergency days of the summer, whereas a very low night-time rate ($0.0265 per kWh) applied during the five windiest months. Additionally, participants received a surcharge or discount based on total monthly consumption during the non-peak and non-wind hours. Otherwise the rate was the same as the standard Austin Energy rate. To assist consumers, text message appeals to 50 participants helped them take advantage of the cost-saving opportunities. These text messages issued for critical peak events yielded an average of 7 percent use reductions and were simple and low-cost to administer.

Also assisting in peak load reduction were 240 programmable communicating thermostats controllable by the utility and by the consumer using the web portal. These thermostats were interfaced with the smart meters to provide the same data to consumer and utility.

Data Caching is Critical

The researchers discovered that for smart meters to support demand response and conservation they should provide data to the utility and consumer on a real-time basis, currently on a per-minute basis. For example, a malfunctioning air conditioner that is cycling on and off every 60 seconds wouldn't be noticed if data were taken only every 15 minutes. This sampling will provide the basis for consumer applications that can help the consumer understand their electricity usage and take actions to help both the utility manage peak loads and lower their utility bills. Because this system is built to work similarly to utility meter data management systems, data needs to be cached for data integrity purposes – outages on the grid or of consumer broadband yield data gaps that need to be corrected with saved data. "If a time element is important for the data obtained from the meter – such as in time-of-use pricing and the meter does not cache data, then data gaps could result," said Brewster McCracken, principal investigator for the Pecan Street SGDP project.

Pecan Street purchased off-the-shelf data caching devices to complement smart meters. These devices bridge the data gaps that occur due to communication signal intermittencies. Pecan Street worked closely with the vendor in field testing their product.

[1] Austin Energy Tariff, http://interchange.puc.state.tx.us/WebApp/Interchange/Documents/40627_424_752607.PDF, accessed 12/5/14

Solar Panels: Look Westward

Adding to its futuristic appeal, Mueller's buildings display an impressive array of solar panels, including west-facing systems. Pecan Street researchers found that west-facing rooftop solar panels out-produced south-facing systems by 50 percent during peak demand hours. The westward advantage would aid utilities that struggle to meet afternoon demand. "While solar panel performance is highly localized, utilities have frequently refused to provide rooftop solar rebates to customers who wanted to install west-facing systems," McCracken said. "Our findings, however, indicate that utilities and policymakers should study the potential system regulation and consumer benefits of west-facing solar panels in more regions of the nation."

To understand this, optimal daily total solar collection is typically achieved when solar panels face south. However, to meet costly peak energy demand, the Pecan St. researchers found that facing solar panels to the west is much more cost effective, because their generation peaks near 3 PM, rather than 1 PM (Fig. 2). Also, in summer 2013, total energy production of westward facing panels slightly outpaced the southern facing ones in the Mueller neighborhood, on a per kW installed capacity basis.

Charging Is OK for Local Transformers

Mueller's roads host more electric vehicles per capita than any other U.S. residential neighborhood, providing an ideal test site for vehicle-battery charging patterns. Even though battery charging peaks in the late afternoon, the associated load on the grid during the study period was lower than the Pecan St. researchers predicted, indicating that in this neighborhood, a significant increase in market penetration of these vehicles will not exceed the capacity of local distribution transformers. If the number of EVs in the neighborhood increases dramatically, transformers could age prematurely, so transformer monitoring should be a part of long term smart grid strategy.[2] Reliability of service is not an immediate concern, since utilities provide each household typically 200 amps as standard service. This design safety margin improves power quality, reducing dimming and excess brightening as household loads come on and go off. "Home

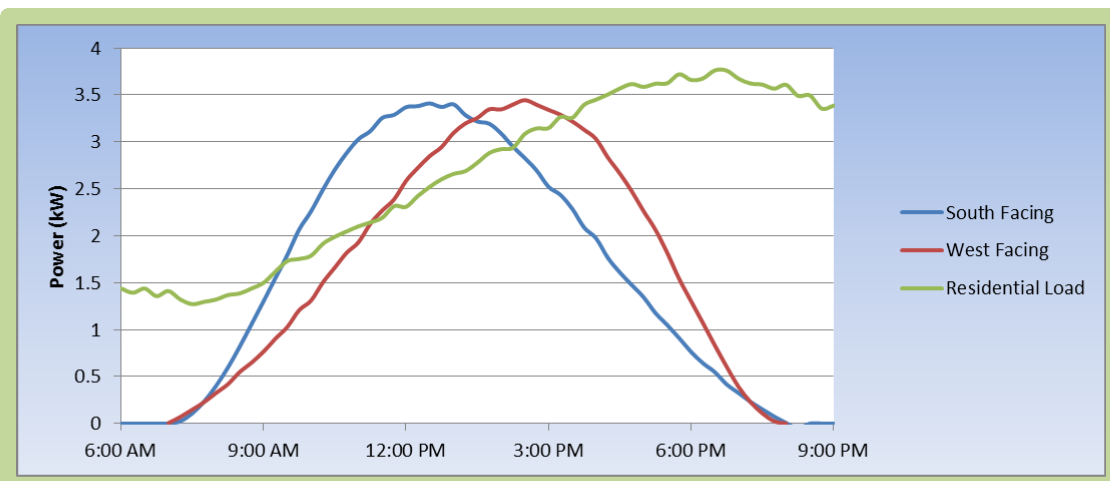
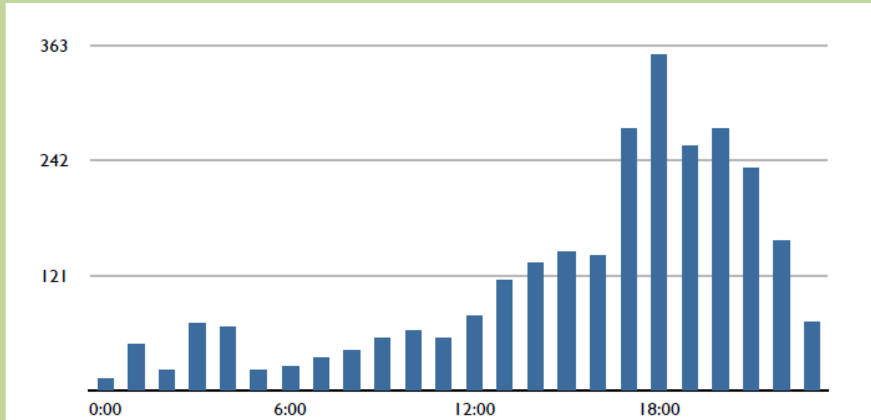


Figure 2. Average Daily Generation Profile (kW) for Rooftop PV systems, Summer 2013 (Source: Pecan Street Institute)

[2] Hilshey, A., et. Al., Estimating the Impact of Electric Vehicle Smart Charging on Distribution Transformer Aging, IEEE Transactions on Smart Grid, vol. 4, no. 2, 2013.

electric-vehicle charging is far more distributed in terms of timing than had been broadly assumed," McCracken said. "Electric vehicles are unlikely to produce grid- management challenges, even at fairly high levels of adoption on individual distribution systems." Preliminary data indicate that 12 percent more charging occurs on weekdays than on weekends, and that 35 percent begins between 4:00 p.m. and 8:00 p.m (see Fig. 3). To ensure a large study pool of electric vehicles, Pecan Street offered participants a $7,500 rebate for purchasing a Chevrolet Volt, and a $3,000 rebate for leasing one for at least three years. This is in addition to the $7,500 government rebate available.

Figure 3. Electric-vehicle charging start times (Y axis = number of instances; X axis = start times)
Courtesy of Pecan Street



Pecan Street participants also received other incentives to buy energy-saving products, including rooftop solar panels.

Next Steps

Pecan Street's demonstration project, which runs until February 2015, continues to explore how solar-generated electricity can help reduce the peak demand for power. As these and other critical findings become available, the project will provide the data to university researchers and on-government organizations via its website, WikiEnergy, which is one of the world's largest energy-use databases. As McCracken said: "In the era of big data, Pecan Street is bringing this discipline to its research on customer needs and preferences."

Further Reading

For more information about Pecan Street's project, read its Technology Performance Report, published on the SmartGrid.gov website. A more detailed description of SGDP can also be found at SmartGrid.gov.

Under the American Recovery and Reinvestment Act of 2009, the U.S. Department of Energy and the electricity industry have jointly invested over $1.5 billion in 32 cost-shared Smart Grid Demonstration Program projects to modernize the electric grid, strengthen cybersecurity, demonstrate energy storage, improve interoperability, and collect an unprecedented level of data on smart transmission, distribution operations, and customer behavior.