EVERYBO

A study finds that positive net benefits flow to all customers—whatever their level of particip

Across the nation, electric utilities are deploying smart meters (also called advanced metering infrastructure) to their residential customers as the basic building block of the smart grid. In a few areas of the country, such as California and Texas, the vast majority of customers have smart meters. As of June 2011, approximately 20 million smart meters had been deployed in the United States, and that number likely will rise to approximately 65 million by 2015, or about half of all U.S. households. By the end of this decade, it is possible that almost every household will have a smart meter in the United States.

Another noteworthy trend is the growing number of home energy management devices. In a recent report, Greentech Media estimated that approximately 6 million U.S. households will have some type of energy management device by 2015. This represents about 10 percent of the expected 65 million households with smart meters—and, in our view, a realistic estimate of the size of the home energy management market.

Dreamstime

Dreamstime

Courtesy: Energate

ODY WINS

ation in energy management—when utilities invest in AMI. By Lisa Wood and Adam Cooper

Despite the rapid growth in that space (almost 100-percent growth is expected over the next three to four years, according to Greentech Media) and the significant energy management opportunity that the combination of smart meters and smart home energy management devices unleashes, concerns about the adverse effects of smart meters continue to dominate conversations among regulators, consumer advocates, and electric utilities.

With an eye toward resolving some of these controversies, we developed a framework for quantifying the costs and benefits of smart meters across a range of electric utility and customer types. The results show how the magnitude of both costs and benefits might vary across different types of electric utilities—which vary in terms of load shape, generation supply mix, cost structures, and current metering technology—and different types of customers, who vary in terms of how engaged they are in energy management.

By leveraging real-world utility characteristics and utility advanced metering infrastructure (AMI) installation costs based on composites of actual deployments, we find that positive net benefits flow to all customers—whatever their level of participation—when utilities adopt AMI as part of their smart grid modernization plans.

Courtesy: PG&E

Courtesy: Cisco

Courtesy: GE

Quantifying Benefits

Smart meters provide two-way digital communications between the utility and the customer, and the benefits of that connection are well known: It enables customer energy management and demand response via both information and rate programs; utility operational advantages such as outage management, remote meter reading, and remote customer hook-ups; smart charging of plug-in electric cars; and integration of distributed generation resources.

One question that continually arises in discussions of grid modernization is whether investment in smart meters makes economic sense from a benefit and cost perspective. We quantify three benefit categories:

This article is adapted from "The Costs and Benefits of Smart Meters for Residential Customers," published by the Institute for Electric Efficiency in July 2011 and available at www.edisonfoundation.net/IEE.

- *operational benefits* derive from the utility's ability to reduce the cost of meter reads, connect and disconnect service rapidly and remotely, provide better outage detection and recovery, and lower costs to the entire customer base;
- *customer benefits* arise from engagement in energy management driven by information and price signals, leading to electricity usage reduction or load shifting and the opportunity to lower bills or mitigate cost increases; and
- *societal benefits* emerge from demand response and direct load control that reduce peak power purchases and apply downward pressure on energy prices in spot markets, offset the need for new generation and delivery capacity, and lower carbon emissions through integration of cleaner distributed generation and household usage reductions.

We bound the range of different utility types using four prototypical utility examples, based on different stages of smart grid deployment—"pioneer," "committed," "exploratory," and "cautious." (See the sidebar, "What's Your Prototype?") The profiles of the four are based on real-world factors that influence the overall business case for smart meters: current generation mix, renewable energy portfolio, regulatory environment, emphasis on efficiency and conservation, and so on. In addition, we factor in the possibility that a utility already has automated meter reading (AMR) and is therefore likely to have lower operational benefits from smart meters.

For purposes of the study, each prototype utility serves 1 million customers—segmented in terms of their energy worldview. These segments vary regionally and by household, in terms of their use of in-home energy management devices, willingness to engage in smart rate programs, types of vehicles and appliances they purchase, and overall engagement in energy management. Based on multiple studies cited in the Smart Grid Consumer Collaborative's "2011 State of the Consumer Report," we assume that customer adoption patterns will align with customer energy worldviews and developed energy management participation plans to correspond with four dominant customer segments:

- basic (customers who do not wish to engage at all);
- comfort (customers who own large-load homes equipped with air conditioning, pool pumps, smart appliances, etc, and have minimal interest in energy engagement and limited concern about their bills);
- saver (customers primarily motivated by the opportunity to save money on their bills or mitigate potential bill increases); and
- green (customers motivated by environmental concerns and willing to be more engaged). (See Figure 1.)

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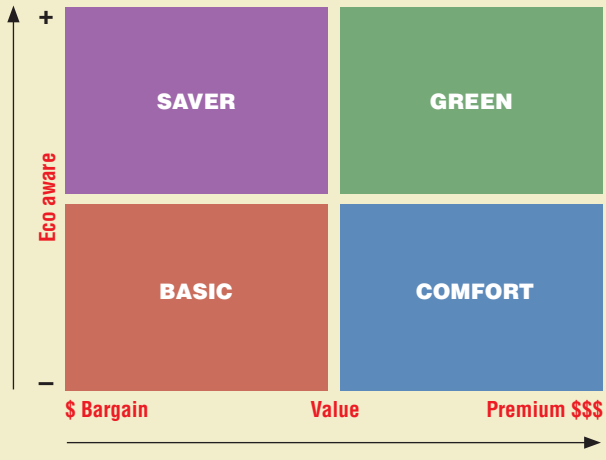
The Customer's Path

We assume that all customers have access to a web portal with simple energy-use feedback information and that all customers receive the operational benefits and the avoided costs of AMI, whether they choose to engage in energy management or not. They have access to a variety of technologies such as displays, programmable communicating thermostats, and home energy management systems, as well as smart rate and program options, including no-risk peak-time rebates (PTRs), heat wave critical-peak pricing (CPP), time-of-use rates for electric cars, and direct load control. We account for technology costs independent of whether technology is paid for by the customer, the utility, or a subsidy.

Within each segment, we anticipate customers will manage their energy usage in a variety of ways, from passive behaviors to active energy management to investing in

FIGURE 1
FOUR CUSTOMER SEGMENTS



The comfort segment is environmentally and price insensitive when it comes to energy use. The saver segment is the most bargain-conscious with some degree of eco-awareness. The green segment has a higher level of eco-awareness and is willing to pay a premium for environmentally friendly energy solutions. And finally, the basic segment is relatively indifferent to environmental concerns and, while wanting low bills, is less willing to take action than the savers.

Source: Institute for Electric Efficiency

more elaborate automation. (See Figure 2.) Our model shows that attentive customers without automation will be able to save energy, shift tasks, and realize savings, although those who automate likely will realize the largest customer-driven savings. Ultimately, there are five customer engagement pathways:

- *passive* (unengaged households that benefit indirectly from a utility's operational improvements due to smart meters and incrementally if the household coincidentally defers usage on demand response event days);
- *active* (engaged households that make conscious and manual adjustments to electricity use based on energy information and price signals from peak rate plans obtained via a web portal, a display, or other communications methods);
- *set-and-forget* (engaged households that use automation to adjust their electricity use via technologies such as programmable communicating thermostats or home energy management systems based on energy information and price signals from peak rate plans);
- *utility automation* (households that allow the utility or a third party to control directly their central air conditioning via a signal sent to their smart thermostats or to a switch on their air conditioner with customers retaining the ability to override); and
- *energy partners* (highly interested and engaged households that have electric vehicles and home energy management systems to automatically control electricity usage); the time-of-use rate applies to the entire household on a daily basis.

Our approach assumes that customers will choose an engagement pathway that resonates with their worldview but will select different technology and rate options based on whether they have central air conditioning, smart appliances, home energy management systems, or electric cars. (See Table 1.)

What's Your Prototype?

Pioneer: Previously invested in automatic meter reading with very high energy prices and that purchases all power.

Committed: Relatively high energy prices, primarily natural gas-fired generation, and a mandate to aggressively pursue renewable generation.

Exploratory: Relatively low-cost generation available, high population density, and highest demand in winter months.

Cautious: Low population density, high annual demand growth, and coal, nuclear, and natural gas dominant in the generation portfolio.

Pioneers Discover Savings

The Pioneer utility serves a region with a strong social norm of frugality (35 percent in the Saver customer segment) and a general belief that climate change is a problem that needs to be addressed (25 percent in the Green segment). Communities here generally see the connection between a green mindset and economic vitality. The balance of households less interested in action are divided between those who are indifferent to energy (20 percent Basic) and those who are price insensitive but willing to invest in technology if it makes their lives easier and better (20 percent Comfort).

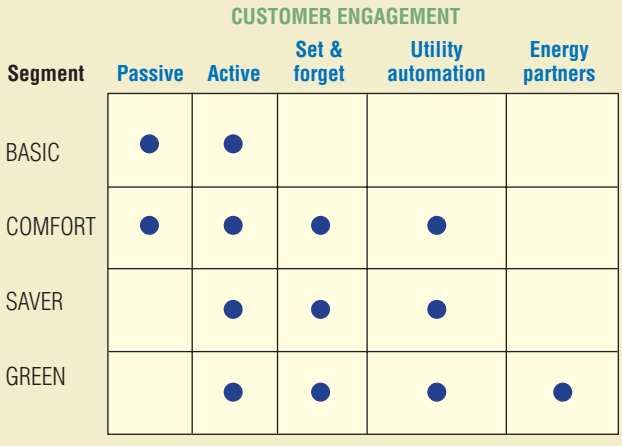
By 2030, all Saver and Green customers in the territory are actively engaged. (See Figure 3. Note: Similar figures are available for each of the prototype utilities in the white paper.) Also, most customers have migrated from "passive" to another engagement pathway, even among those who are indifferent today. An appropriate analogy is that 50 years ago, most people did not recycle. Today, almost everyone recycles.

Also, being a Pioneer, the utility has installed AMR prior to the deployment of AMI. For this utility, the total costs associated with meter installation plus any technologies that customers install are $198 million over the 20-year forecast horizon. (See Figure 4.) The total operational benefits for this utility are $77 million: avoided metering costs ($52 million), improved outage detection and avoidance ($24 million), and remote rapid connections ($1 million).

Due to the customer mix, the regulatory environment, and other factors, this utility has customers who are reasonably engaged (60 percent are in the Green or Saver market segments) and high customer benefits totaling $150 million (the largest customer benefits of the four utility prototypes). The significant contribution of the Energy Partners engagement pathway to consumer-driven savings (despite the fact that this pathway includes only 1.25 percent of customers) demonstrates the large benefit contribution potential of EVs. Total benefits for the Pioneer utility (both operational and customer-driven) are $227 million, indicating a net benefit of $29 million over the 20-year forecast horizon. So, in this

FIGURE 2

THE ENGAGEMENT OF DIFFERENT CUSTOMER SEGMENTS



Source: Institute for Electric Efficiency

TABLE 1

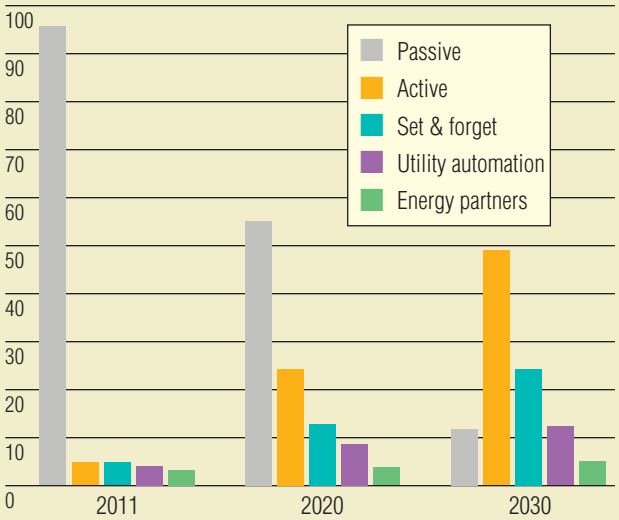
TECHNOLOGY AND RATES FOR CUSTOMER ENGAGEMENT PATHWAYS

Segment	Passive	Active	Set & forget	Utility automation	Energy partners
BASIC	N/A	Display/no display* No-risk rebate**			
COMFORT	N/A	Display/no display* No-risk rebate**	Programmable communicating thermostat No-risk rebate**	Direct load control Programmable communicating thermostat or switch No-risk rebate**	
SAVER	N/A	Display/no display* No-risk rebate**	Programmable communicating thermostat No-risk rebate** or heat-wave pricing+	Direct load control Programmable communicating thermostat or switch No-risk rebate**	
GREEN	N/A	Display/no display* No-risk rebate** or heat-wave pricing+	Programmable communicating thermostat Home energy management system Heat-wave pricing+	Direct load control Programmable communicating thermostat or switch No-risk rebate**	Electric vehicle Home energy management system Time-of-use rate

*Data and pricing displayed either in-home or on web. **Peak-time rebate. +Critical peak pricing. Source: Institute for Electric Efficiency

FIGURE 3

PIONEER UTILITY: CUSTOMER ENGAGEMENT PATHWAYS OVER TIME



Source: Institute for Electric Efficiency

case, even with a utility that has already deployed AMR, smart meter deployment still makes economic sense for residential customers.

The Committed Utility

The Committed utility is in a region with relatively high energy prices, a strong social norm of energy awareness, and a belief that climate change is a serious problem that needs to be addressed. The Committed utility serves many affluent households willing to invest in green behaviors and technologies (30 percent Green) and a relatively small number of price-insensitive customers (15 percent Comfort) unconcerned with conserving energy. Savers in this region (25 percent) are likely to be tuned into their energy costs as well as concerned with climate change issues. Those customers who are indifferent to environmental issues (30 percent Basic) are likely to become more responsive with financial incentives.

The four customer market segments start at different engagement points in 2011. For example, Green and Saver customers are more engaged in energy management than the Comfort customers, while Basic customers are almost totally passive. By 2030, like the Pioneer's customers, all the Saver and Green customers are actively engaged in a range of technologies, price signals, and programs; and most customers also have migrated from "passive" to another engagement pathway. For this prototype utility, there is a very modest penetration of electric vehicles (1.5 percent of customers are Energy Partners with EVs), although this type of service area is likely to be an epicenter of electric car adoption.

Over the 20-year forecast, total costs associated with meter installation plus devices and technologies in the customers' homes are $272 million. Operational benefits stemming from the utility investing in smart meters are $153 million: avoided metering costs ($128 million), improved outage detection and avoidance ($21 million), and remote rapid connections ($4 million). The difference between the Pioneer's and the Committed's avoided metering costs is due to the lack of automated meters in the Committed utility's service territory.

Over the study period, customers migrate towards technology offerings and rate plans that fit their lifestyles and budgets, leading to customer-driven savings totaling $140 million. The customer-driven savings are dominated by the Energy Partners pathway, demonstrating again the huge benefits contribution of electric cars. Total benefits for the Committed utility are $293 million, resulting in a net benefit of approximately $21 million over the forecast horizon.

Exploratory and Active

For the Exploratory utility, we assume a customer base that supports energy-use management due to a desire to save money (25 percent Saver) and a concern about energy independence (15 percent Green). The remaining households are less interested in action and are divided between those who are indifferent (30 percent Basic) and those who are price-insensitive (30 percent Comfort).

The four different customer market segments start at different engagement points in 2011 and initially very few customers are actively engaged in energy management. By 2030, all the Saver and Green customers are either actively engaged or using automation, and most (as with the previous utility prototypes) customers have migrated from "passive" to another engagement pathway.

Total costs associated with meter installation plus any devices or technologies in customers' homes are $223 million over the forecast horizon; and total operational benefits stemming from utility smart meter investment are $156 million, mostly avoided metering costs ($103 million), improved outage detection and avoidance ($50 million), and remote rapid connections ($3 million).

Customer migration over the 20 years to technology offerings and new rate plans leads to customer-driven savings totaling $131 million. The Active engagement pathway dominates here. Total benefits for the Exploratory utility (both operational and customer-driven) are $287 million, resulting in a net benefit of approximately $64 million over the time horizon. This prototype enjoys the largest net benefit of the four because their operational savings are relatively high relative to costs and their customer engagement is moderate. For the two utility prototypes with higher customer-driven savings (Pioneer and Committed), either the costs of installing and operating AMI are much higher (Committed) or the associated operational savings are much lower (Pioneer).

Minimal Engagement, High Operational Benefits

The Cautious utility serves a region in which customers are skeptical about climate change and have low energy costs in the absence of carbon surcharges. Most households are uninterested in action and are divided between the indifferent and the price insensitive (35 percent Basic and 35 percent Comfort).

This region also has the slowest adoption rate—that is, the highest percentage of customers in the Passive engagement pathway. Still, by 2030, a sizable number of customers have migrated from "passive" to another engagement pathway, though few are Energy Partners. Unless there is a significant price trigger, increase in carbon prices, or emphasis on education and engagement, this region will be slow to change.

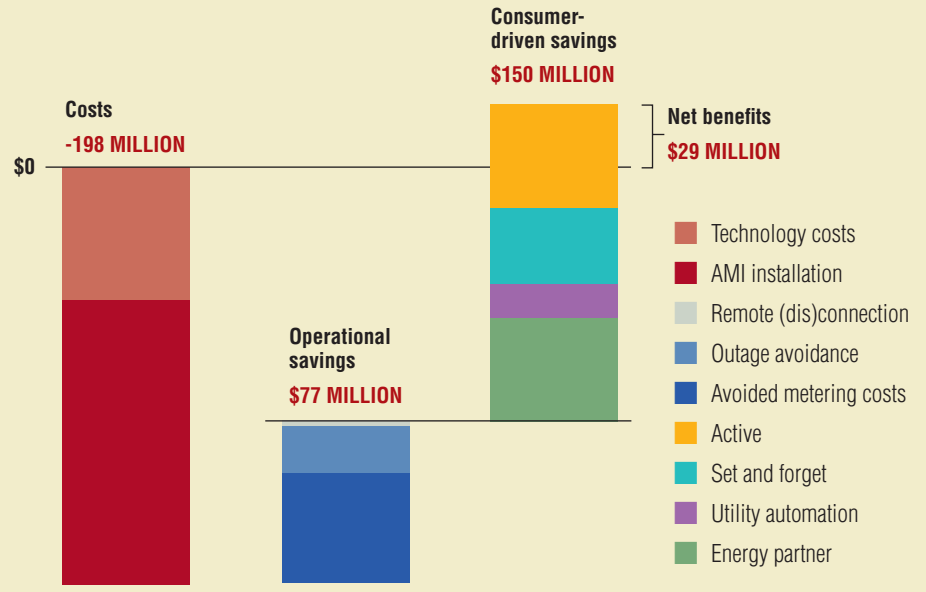
Total costs associated with meter installation plus devices and technologies in customers' homes are $258 million over the study period. Total operational benefits for the Cautious utility are $208 million: avoided metering costs ($155 million), improved outage detection and avoidance ($48 million), and remote rapid connections ($5 million). These are the largest operational benefits of the four utilities examined, which offsets the slower energy management adoption rates.

Over the longer horizon, even minimal migration towards technology offerings and rate plans leads to customer-driven savings totaling $100 million, growing to a total benefit of $308 million and a net benefit of approximately $50 million.

Positive Net Benefits for All Customers

Utilities and regulators can use this framework to evaluate investments in smart meters and associated enabling technolo-

FIGURE 4
PIONEER UTILITY: COMPONENTS OF COSTS AND BENEFITS



Source: Institute for Electric Efficiency

gies from a benefit and cost perspective. Even with conservative assumptions regarding consumer engagement in technology, programs, and rate plans, the results show that positive net benefits are possible for all four utility types. (See Table 2.)

TABLE 2
SUMMARY OF COSTS AND BENEFITS BY UTILITY TYPE
(Net present value, $ millions)

	Pioneer	Committed	Exploratory	Cautious
Costs	198	272	223	258
Operational savings	77	153	156	208
Consumer-driven savings	150	140	131	100
Net benefits	29	21	64	50

Source: Institute for Electric Efficiency

Investments in smart meters make economic sense, and customer-driven benefits could be much greater with more investment in and focus on customer education and engagement. Over the study's 20-year horizon, and for all utility types, most customers migrate from passive engagement in energy management to much more active strategies. A potential area for further study is how to accelerate this process so that a broad array of customers are ready, willing, and able to engage in energy management soon after smart meters are deployed.

Given the high satisfaction ratings by participants in dynamic pricing pilots, particularly where education is a key part of the program, the combination of program choice based on personal preferences with comprehensive consumer education could yield even greater financial and societal benefits than we found.

Moreover, the strategy with the potential to achieve the greatest financial impact is to focus on accelerating the adoption of electric vehicles. Their benefits (as demonstrated by the contribution of the Energy Partners engagement pathway to overall consumer-driven savings) are disproportionately high, indicating that even modest increases in EV adoption will have a large impact on already demonstrable positive benefits. ◆