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# The Smart Meter: Vanguard of the Smart Grid

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The Smart Grid was in the news recently when $4.5 billion in grants for qualified projects relating to grid enhancements were included in the American Reinvestment and Recovery Act, in the first quarter of 2009.

The Smart Grid is best understood as a set of measures for modernizing the nation's electricity delivery system that has both institutional and technology components. That is, in order to get the most benefit from the technological component, institutions (utilities) will need to change they way they do business and interact with customers. While many potential technologies might be pitched under Smart Grid's expanding tent, current efforts focus mainly on

• Two-way communications between the grid and utility end-users, and
• Appliances that can utilize this communication.

There are many benefits that can be gained from the Smart Grid. For utilities, there is the possibility of limiting growth in the use of electricity at peak times, and in reducing the year-to-year growth in electricity demand. For residential users, there is the possibility of reducing electricity bills. For residential users with home-based power generation, there is the possibility of better compensation for home-generated power, when added to the grid.

The scale of deployment is potentially huge: the U.S. served 147 million electric meters in 2007, with nearly 15 million 'Smart' Meters under deployment last year. (subscription required) At recent cost levels, the $4.5 billion appropriated (if used entirely for new Smart Meters) would be enough to pay for about 12 million more Smart Meters. Because of their cost-savings benefits, growth is expected well beyond what has been funded by recent legislation.

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## Institutional Components of Smart Grid

The key institutional reforms advanced to enable Smart Grid are

• Implementation of Time of Use (TOU) rates and
• Decoupling of the traditional link between revenue and sales.

Two-way communications meters can of course be deployed without these measures in place, but only highly motivated customers can be expected to adjust the times they use appliances, if pricing remains on a flat-rate basis.

TOU rates is a regime in which customers, using their two-way meters, can receive continuous information regarding the hourly marginal price of electricity. Because loads vary greatly on a daily cycle, and utility fuel prices can fluctuate as well, the costs to bring generators on or to engage in wholesale power purchases changes hourly. A two-way meter (hereafter 'Smart Meter') simply makes these price changes transparent to customers, presenting the total rate (i.e., the marginal electricity price plus embedded charges, tiered usage charges). TOU rates have been offered under pilot programs and for some industrial and residential customers, but Smart Meters will allow TOU rates to be rolled out much more broadly.

This is not to say that customers will be expected to monitor rates and usage like a hawk. Smart Meter advocates envision customers setting alerts when prices reach certain levels, along with real time information regarding home demand. Instead of hourly changes in rates, customers may get signals in more manageable 4- or 8-hour blocks. Studies in pilot programs suggest that customers reduce demand by an average of 10% by cutting back on usage during peak periods and identifying loads of which they were unaware.

Decoupling of revenue from sales is a deeper institutional reform. At the retail level, traditional rate regulation stipulates a fixed return on assets built, given an expected level of electricity sales. If a utility exceeds the expected level of sales, it earns additional profit and can forestall future rate increases. Conversely, sales below the stipulations on which the rates are based can result in under-earning and pushes the utility to request rate increases. This bias toward boosting sales leads utilities to promote load growth and to discourage energy efficiency or conservation.

The most widely accepted remedy for this is to 'decouple' rates from sales by guaranteeing revenue to a utility over a fixed period regardless of performance against kilowatt-hour sales metrics. While not a perfect mechanism, the decoupling approach incentivizes the utility to consider all options for delivery of energy services, not merely those that build load. Decoupling mechanisms are in place in eight states; they were first implemented in California, and they are under consideration in roughly half of all states. (Cavanagh, Natural Resources Defense Council, Straight Talk about Smart Grid Funding, Planning, and Results, Energy Central webcast, 6/30/2009)

With a decoupling regime in place, a utility need no longer fear the revenue-eroding effects of customers taking steps to save energy. Data collected from Smart Meters can be analyzed to determine load patterns or appliance performance, which the utility then has a stronger incentive to act upon. Advocates envision that the utility-customer relationship then becomes more cooperative and less transactional.

## Technology components of Smart Grid: the Smart Meter and Smart Appliances

Aside from influencing customer behavior, appliance vendors are preparing to launch a series of 'smart' appliances that can work with signals from the Smart Meter or from other smart appliances to adjust electricity usage in beneficial ways. For instance, ordinary refrigerators cycle at regular intervals but a 'smart' refrigerator could respond to a signal from other operating appliances to delay its cycle until household load levels are lower. Smart appliances can also be programmed to reduce load or shut off in response to price triggers.

## Economics of Smart Meters and Smart Appliances

Based on information and claims available today, we can estimate a preliminary business case for

Smart Meters. On the cost side is the upgraded meter and communications software. Southern California Edison (SCE) and Baltimore Gas & Electric (BG&E) have both filed for cost recovery for two-way meters. SCE was approved to spend $1.6 billion to install 5.3 million meters, or $300 per meter. BG&E has requested $500 million to install 2 million new electric and gas meters, about $240 per meter.

Energy savings per customer varies widely depending on the type of dwelling, existing appliance efficiency levels, and a customer's level of engagement and motivation. BG&E's plan targets an average of 15% savings in its proposed program, pinning its targets on changes in customer behavior in response to rebates and other incentives. Vendors of Smart Appliances are targeting electricity usage reductions of 30-50% during peak periods, shifting load to periods when demand is lower. GE, a Smart Appliance vendor, has indicated that programmable appliances will have a price premium over their 'dumb' brethren of $10, once in mass deployment.

The table below summarizes the relative kWh cost and simple payback for an average SCE residential customer (based on a year of savings, conservatively assuming 10% for the Smart Meter and an additional 10% per appliance). For an SCE customer, 10% savings at 2007 usage levels is 708 kWh. SCE's rate structure is multi-tiered, but 2007 average revenue per customer was over 15 cents/kWh. Using this as a proxy for rates yields a simple payback of $107.80 per year, or a little under three years. With time-of-use rates, the simple payback could be shorter.

| Measure | Premium ($)[1] | Annual Savings[2] (kWh) | One Year Cost $/kWh | Payback @ 15 cents/kWh (Years) |
|---|---|---|---|---|
| CFL Changeout | 3 | 30 | 0.09 | 0.6 |
| Smart Meter, response to TOU | 300 | 708 | 0.42 | 2.8 |
| *Smart Appliance bundles* | | | | |
| Smart Meter + Smart A/C | 310 | 974 | 0.32 | 2.1 |
| Smart Meter + Smart Refrigerator | 310 | 746 | 0.42 | 2.8 |
| Smart Meter + Smart TV | 310 | 726 | 0.43 | 2.8 |
| Smart Meter + Smart Dryer | 310 | 728 | 0.43 | 2.8 |
| Smart Meter + all appliances | 340 | 1050 | 0.32 | 2.2 |

1. At $300/meter, and $10 increased cost per appliance
2. Savings estimates based on usage obtained from EPA's EnergyStar web site: www.energystar.gov

California is an extreme case, since its rates are among the highest in the nation. Many states have residential rates that are half this level, which would double the payback period.

Included in the table is the simple payback associated with changing out incandescent bulbs with CFLs. For a cost/benefit 'purist', Smart Grid money would be better devoted first to ensuring CFLs were deployed as widely as possible.

Nevertheless, the economic case for Smart Meters and Smart Appliances looks good, if 10% savings levels can be achieved. An important part of the success of the Smart Meter deployment will be customer acceptance and active engagement with energy savings and programmable appliances. Since the payback calculation in the table above is based on the incremental cost of new appliances, it assumes a changeout of appliances once the old appliances end their service life.

In addition to resource benefits, utilities cite several potential operational benefits of two-way communications that do not directly save electricity:

• Remote disconnection and reconnection of customers, easing a major cost driver for service areas with lots of account turnover, such as college towns.

• The ability to locate power outages with greater precision, increasing response time and reducing the number of search crews for each outage.

• Better assignment of costs for small power generation, allowing greater penetration of home-based power such as small wind turbines or photovoltaic systems.

For those partial to home-based power systems, the last point is crucial. Currently, if a home-based system produces excess power, a utility can (a) allow it to dump power on the grid free to the utility, or (b) install a 'net meter' that pays the homeowner at their current rate by allowing the meter to run backwards during times of excess production. Option (a) undercompensates the homeowner while option (b) implicitly subsidizes the homeowner at the expense of other ratepayers, at times paying prices that double the system marginal rate.

A third option for compensating home-based power systems is a feed-in tariff, such as the one approved by Gainesville Regional Utilities (Florida). A feed-in-tariff provides a much larger explicit subsidy, in this case to a limited number of solar installations. The higher feed-in tariff for solar installations in part reflects the utility's higher costs for the time panels are typically generating power, and partly reflects a desire to encourage residential power generation.

## So What's Not to Like?

The opportunity to revolutionize electricity delivery and cost at reasonable prices has jump started the Smart Meter industry. But it is not cheap. SCE's $1.6 billion rollout of Smart Meters will cover its entire service territory at about the same cost as a new large combined cycle power plant. A 1500 MW plant generating 60% of the time would serve about 10% of SCE's 2007 demand. Smart Meter implementation has greater potential, but more uncertainty as to the kWh savings it will ultimately deliver.

## Conclusions

The cost of implementing Smart Meters appears justified by the resource savings available and by the (less well quantified) operational benefits to implementing utilities. The case for Smart Meters is strong in areas with high electricity rates such as California, the Mid-Atlantic states, and New England states. In states where residential rates are lower, the case rests more heavily on operational benefits utilities can hope to achieve, which could prevent penetration of Smart Meters.

If appliance vendors can truly keep the additional cost of Smart Appliances low, they have good odds of penetrating territories where Smart Meters are in place. The pairing of Smart Meters and Smart Air Conditioners or Heat Pumps looks especially promising.