Enabling price responsive demand
Discussion paper

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1. Need for Signal

The smart grid evolution is making it possible for consumers to base their power usage decisions in part on desires to be grid friendly and green as well as managing the impact of their utility rates. To facilitate such control, device manufacturers desire a consistently recognized signal or index that could be used across the United States. End user devices, also called edge devices, have the ability to receive and respond to signals and adjust their operations that support grid conditions and provide savings for consumers. The devices include appliances, thermostats, pool pumps, and other items that consume energy. The Association of Home Appliance Manufacturers has indicated smart appliances will be available starting in 2013. While smart devices will be able to respond automatically to signals, the choice of how the device responds remains with consumers.

2. Who generates the signal

One important obstacle to overcome is the diverse types of operational control of the electric grid across the country. In the majority of the county, the organized markets of either an Independent System Operator (ISO) or Regional Transmission Owner (RTO) are responsible for the reliability of the electric transmission grid. ISOs are generally single state grid operators while RTOs encompass multiple states. In other areas, integrated utilities manage the transmission grid and the distribution network. A few regions have a federal agency, such as the Tennessee Valley Authority and Bonneville Power Administration, which generates electricity and transmits it to the local distribution entities that include municipal utilities. These various structures differ in how they manage the grid.

ISOs don't own transmission or generation facilities and use markets to control the amounts of power generated and how it is transmitted. ISO markets reflect transmission grid conditions through locational marginal prices known as LMPs. The LMP ranges are unique to each ISO region and are not desirable for use by edge devices that serve a geographically wide consumer base. Because of differences in types of generation between regions, what might be a high price in one region may actually be a low price in another.

Balancing authorities responsible for operating grids in non-ISO regions typically don't use markets to maintain reliability and they don't publish market prices. They rely on different operational procedures, but could provide an index to indicate grid status for reliability. Because it should be straight forward for these authorities to construct a reliability index, the focus going forward in developing a signal-to-device methodology is on how ISOs will be able to translate their different markets into a consistently recognized reliability signal across the country.

3. What should the signal contain

In organized markets, grid conditions can be understood by the magnitude of prices and their differences across locations. Higher prices indicate that more expensive generation is being relied on to serve the load; as prices approach the market and bid caps, they are indicating potential shortages and hence reliability risks. Differences in prices between locations indicate congestion in the transmission system; lower cost generation cannot reach the load in some areas because transmission lines are full. This information could be captured in a locational index that could be adjusted to provide consistently recognized indications of grid reliability across regions for use by smart devices.

In addition to signals indicating the current status of the grid, device manufacturers and consumers would like a forward looking, advisory or trend signal to help make decisions for adjusting device operations. This could take the form of a day-ahead or possibly shorter time indicator that notes the following day is expected to have high prices.

Signals to edge devices should contain the LMP, location, reliability index and advisory indicator. ISO markets produce the LMPs and locations in a public and transparent method so it is clear how the reliability index was created. For example, the reliability index could be a number between 1 and 10 with low numbers indicating that the grid conditions were not a reliability issue. Indeed, a level of 1 might actually indicate negative prices and the grid's need for increased power use to balance out excess generation being created by renewable resources. Higher numbers would show unfavorable grid conditions and high prices. The advisory indicator could show an up or down trend. It could also summarize the forecast reliability index over some period of time, such as the price that was established in the day-ahead market.

While the locational element may seem to be an unnecessary complication, it is an important element for managing device responses. It may be possible that some areas actually have an oversupply of energy and need additional load to balance out the oversupply, while other areas are experiencing shortages of supply. The locational element will allow devices in both areas to respond appropriately and to help reduce impacts of the limited transmission capacity, which leads to the congestion reflected in different locational marginal prices.

4. Adjustments to the signal

The signals as described above would inform the consumer and devices of transmission grid conditions and allow the devices to proactively and independently become a beneficial part of grid management while remaining under customer control.

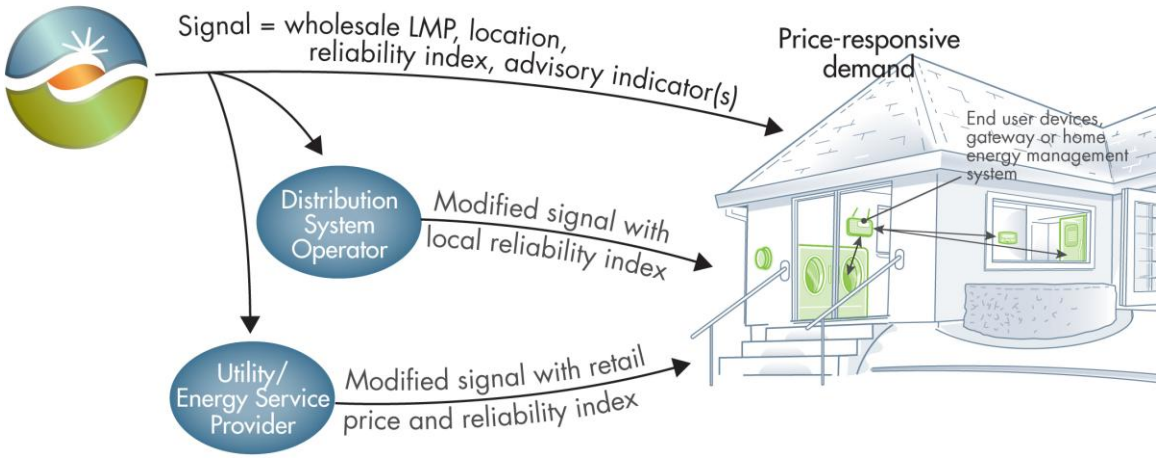
Another advantage of the reliability index is that operators responsible for the reliability of the distribution network, normally utilities, could adjust the reliability indicator to a higher or lower number depending on grid conditions in local areas

and make these signals available to consumers. This ability will become significantly more important as increasing amounts of distributed energy resources are connected to the distribution system and impact local system power flows.

In regions such as the California ISO where retail tariffs provide for constant prices so that the consumer does not see any change in costs when the signal changes, the ISO signal will benefit the system overall and reduce costs to all consumers, even if the individual consumer does not see any specific savings. Offering retail rates to provide individual consumers with a direct incentive to set their devices to respond to grid signals will increase the devices' effectiveness. The signals will be based on the wholesale price, but the consumer pays a retail rate. If a consumer is on a rate with no differentiation in how much they pay relative to the signal, then a signal based on reliability is sufficient for their devices to use. Any further consumer response will be only based on their desire to benefit society as a whole.

In cases where consumers are on dynamic rates, the signals could be modified by utilities, energy service providers or aggregators to be an economic indicator. For example, a consumer on a critical peak pricing tariff may be able to recognize that if the signal reaches a level of 9 or 10, the critical peak pricing will kick in and they would save money by responding.

The following diagram illustrates the choice of signals consumers could have for their device response.



5. Benefit to consumers

The ability for consumers and devices to receive signals aligned with grid conditions and eventually with what consumers actually pay enables them to become active participants in their energy use. Currently in many jurisdictions, retail tariffs provide for constant prices so that the consumer does not see any change in costs when the signal changes, which results in consumer responses

based only on their desire to benefit society as a whole. Device manufacturers must make it easy for consumers to set their device to respond automatically and to understand the implications of choosing to be grid friendly and green. Most importantly, consumers will have the ability to make choices that they do not have today.

In the future, this signal will enable consumers to better understand the time-varying cost of energy and change their consumption patterns accordingly. As retail rates and programs evolve to coordinate better with time-based energy costs, the signals to consumer devices will better indicate reliability and consumer cost.

6. Summary

Providing grid signals to devices accomplishes objectives to align end-user device responses based on grid conditions to maintain reliability, empower consumer choice, provide a widely recognizable signal for consistency across regions, and maintain flexibility to adjust the signals for local reliability needs and individual consumer rates.