

*THE MANY MEANS OF "SMART GRID"*

optimal strategy is not to give every customer an expensive real-time meter, but rather to introduce them selectively to the larger more flexible customers.

- Meters that communicate to customers. Just as the utility can gain valuable information on current usage, so can the customer. Today, most customers only receive information through their monthly bill, which arrives days after decisions such as whether to turn the thermostat up or down. A display that tells interested consumers their current rate of electricity use, and its cost, would give customers information to make informed decisions.
- Control of customers' loads. Nobody wants to sit and watch the meter all day to see what the price of electricity is. Adding simple control circuits allows loads like air conditioners or water pumps to be cycled on and off automatically, without damage to the equipment and little or no customer discomfort. Often turning off or "shedding" as little as 5% of the load can halve the need for expensive peaking generation. Since more than 5% of total load is being wasted in lighting unoccupied rooms or cooling unoccupied



in phase between the two ends of the line, but if that difference becomes too great, the line will no longer transmit power. There are very few measurements of phase being made across today's transmission systems. With many more measurements at key locations, and with high-speed communication and advanced control systems to make use of the data, the efficiency and stability of power system operation could be improved substantially. Some of these changes are being made, but much more slowly than many experts believe is socially desirable. More advanced capabilities are also possible, but funding for such research has been limited.

- FACTS and other advanced control devices. Power flows through transmission grids in accordance with the laws of physics, not the laws of economics. This means that often it will flow in parts of the network where it is not wanted, and not flow in places that would be more economically desirable. A family of devices based on solid-state power electronics can change the electrical properties of lines and make power flow where it is wanted. These Flexible AC Transmission System control devices are called FACTS devices (there are a variety of different devices that can all be lumped under this general name). While FACTS devices are expensive, a few utilities have started to use them when they are the most cost-effective way to solve a transmission problem (e.g. because using them is cheaper than building whole new lines, or because such lines simply cannot be built). The control of FACTS systems requires advanced communication and system-level control technology. Today, most FACTS devices run on single lines. If FACTS devices become more widely used, it will become necessary to develop advanced control systems to deal with the potential interaction between these systems. Again, funding for such research has been limited.
- Distribute

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simple inexpensive devices that can carry out our instructions as electricity prices change (see the discussion above on time-of-use meters and on control of customers' loads).

*What vulnerabilities could "smart grid" create?*

All the systems we have described require communication between various components. Some of this communication will take place over wires or fiber optics. Some of it will involve wireless