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Playing in the Smart Grid Sandbox to Achieve Zero Net Energy

Written by Massoud Amin and Anthony M. Giacomoni

The University of Minnesota has built a microgrid at its Morris campus that is a microcosm of what eventually could be the norm everywhere. The campus, highly reliant on locally generated renewable energy, is almost self-sustaining in terms of energy and net-zero in terms of carbon. The next step will be to reduce energy use and improve efficiency, with the introduction of time-of-day pricing schemes.

The University of Minnesota Morris (UMM) is a small residential liberal arts college located about 150 miles northwest of Minneapolis. One of the university's five main campuses, it is a nationally recognized leader in sustainability, having been one of the first public colleges to generate on-site renewable power from local resources—specifically corn stover, in 2008.

Starting in 1998, the senior author of this article proposed that smart grid development begin with an end-to-end system strategy spanning everything from fuel sources and high-voltage transmission all the way to end use, integrating microgrids; and that the initial focus be on loads at the building level, gradually broadening to the larger power delivery and utilization system. On the principle of "thinking globally, acting locally," in 2008-10 we suggested using the University of Minnesota as a "smart grid sandbox," where companies could contribute expertise in experimentation and assess what works best. The UMM campus seemed ideally suited, with an electricity usage that ranges from 300,000 to 750,000 kWh per month, with a summer peak.

Today, the Morris campus's renewable energy resources include a biomass gasification plant fueled by crop residues from nearby farms, solar thermal panels, a solar photovoltaic system, and two 1.65 MW wind turbines. Even before the second turbine was installed last February, wind was meeting half of the campus's needs; now it can provide 70 percent on average, and 100 percent on exceptionally good days.

Thus, UMM is very close to being energy-self-sufficient, and since 2008 has already been zero-net-carbon. When the energy produced by the wind turbines exceeds the campus's demand, the excess is sold at a pre-negotiated rate to Otter Tail Power Company (OTPC), the local utility serving the Morris region.

The UMM grid was designed from the outset to integrate local renewable energy generation with energy obtained externally from the electricity grid or natural gas pipelines. The crowning element in the ongoing project will be to partner with leading industry partners to install automated energy controls and management communications to seamlessly integrate occupants, buildings, the campus as a whole and generation resources.

As is well known, traditional centralized power stations waste over 55 percent of the primary energy present in fuel, which is released as heat into the atmosphere (unless, of course, it is captured in combined heat-and-power systems). In addition, another 3 percent of primary energy is lost in high-voltage transmission and 4-6 percent in distribution. A centralized microgrid like the one being created at Morris has the potential to reduce such losses to just 10-20 percent—to be, that is, 80-90 percent efficient.

To the extent the Morris microgrid also makes the real cost of energy evident to the campus's main consumers, it also can lead to lower total energy consumption. Numerous pilot studies suggest that when consumers are provided with real-time energy use information, they use less electricity, among them the results from **Ameren's Energy Smart Pricing Plan pilot in Illinois** and its ensuing Power Smart Pricing program, and **a report by L. McClelland and S. W. Cook on conservation effects resulting from continuous in-home feedback**.

Using data on UMM's electricity consumption for the 2010 calendar year, we have calculated the expected benefits from switching to a time-of-day rate schedule and actively managing its load.

Contrary to a widely held perception that switching to variable time-of-day pricing will lead to higher total costs, we found the change in costs to be negligible or even positive. Using 2010 data, switching to a schedule based on time-of-day rates would have saved the campus approximately 1.1 percent of its electricity costs, even without implementation of active load management implemented. With active load management, significantly greater savings can be achieved.

In fact, our calculations showed that even small changes in behavior would result in appreciable costs savings. This is aided

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by the fact that the peak load for the UMM campus during each month tends to occur during a "shoulder" or off-peak pricing period. Thus, the UMM campus is advantageously positioned to benefit from an aggressive load management program utilizing time of day pricing. Small changes made to their current energy consumption patterns could lead to significant cost savings.

Such systems could be installed in a matter of months at the modest cost of $450,000-500,000. The biggest issue at Morris would be to get them put in place at a time when most campus residents are not there—probably during the summer—as to avoid interruptions to classes and other university functions.

Several additional calculations were performed to determine the benefits to the UMM campus from actively managing its load while utilizing time-of-day pricing. Cost savings were modeled for scenarios in which load is shifted to the next lowest price period and in which load is shifted to the lowest price period. For example, shifting load to the next lowest price period would result in some amount of on-peak period load being shifted to the shoulder period, and some amount of shoulder period load being shifted to the off-peak period. Shifting load to the lowest price period would result in some amount of on-peak period load and shoulder period load both being shifted to the off-peak period.

In a situation where up to half of the total load is managed, our computed cost savings ranged from 3-15 percent when load was shifted to the next-lowest price period; and when load was shifted to the lowest price period, the cost savings ranged from 4-22 percent. Estimates of cost savings from active load management and conservation, depending on the percentage of the load managed and the type of load management scheme implemented, would result in cost savings of 15-32 percent annually.

In the near future, we expect to see the full range of smart grid technologies deployed—demand response, two-way communication, distributed resources, supply-side management and advanced metering—not only at UMM but in larger communities and on bigger campuses as well. These projects serve as important demonstration sites and test platforms for assessing and testing architectures and technologies, the results of which can be leveraged by other smart grid projects throughout the country. From the above analysis, college campuses can be ideally situated to benefit from these investments in their campus energy infrastructures. UMM is well on its way to achieving its goals of significantly reducing its energy costs, and becoming energy self-sufficient and carbon neutral.

Tags: **sustainability**, **carbon**, **load management**, **time-of-day pricing**, **renewable energy**, **microgrid**

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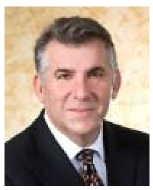

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