Geisinger Health System power plant saves $2.2 million a year

Combined heat and power facility latest in system's energy conservation efforts

Among U.S. healthcare organizations that have successfully implemented energy conservation measures saving millions of dollars while improving community health, Geisinger Health System has few peers.

Since embarking on such programs nearly two decades ago, the Danville, PA-based system has notched close to $100 million in savings from programs as simple as energy-saving lighting to as complex as an innovative power plant that produces its own electricity, heating and cooling.

In August 2013, Geisinger joined an elite group of hospitals that have earned a perfect score in its Energy Star certification from the U.S. Environmental Protection Agency (less than 4 percent of all hospitals have achieved such recognition).

Geisinger is a six-hospital system with more than 60 care sites across central and northeastern Pennsylvania. Its 20,000 employees serve a population of nearly 3 million people in the state.

According to Betterbricks.com, the commercial building initiative of the Northwest Energy Efficiency Alliance, up to 30 percent of any hospital's consumed energy can be saved at little or no cost, without sacrificing the quality of care through energy efficient technologies and improved management practices.

To Vice President of Facility Operations Al Neuner, a mechanical engineer who came to Geisinger more than two decades ago after work in the American steel and gas industries, there are profound yet remarkably simple ways for hospitals to conserve energy and dramatically cut costs today.

GEISINGER

As Neuner has discovered, most conservation projects have relatively low risk yet high return (ROIs of fewer than five years are common) and are almost always profitable. Geisinger's return on investment in energy conservation projects has averaged 3.7 years, far lower than the national average among hospitals. And today, as healthcare organizations struggle to squeeze costs and tap new sources of revenue, such projects are literally win-win.

$9 million/year in energy savings

As detailed in a recent white paper Neuner wrote for Premier, Geisinger has implemented a series of energy conservation efforts for the past 15 years resulting in dramatic reductions in energy use and greenhouse gas emissions. To date, those efforts have allowed the system to save more than $9 million a year in lower electric, gas and water bills, as well as avoided costs in expensive maintenance and upgrades of aging technologies and plants.

Energy costs continue taking a bigger and bigger bite out of hospitals' operating budgets, and nearly double-digit rate hikes are becoming commonplace across the country. While most U.S. hospitals are among the highest energy consumers, Geisinger is one of the most efficient healthcare organizations in the country.

Thanks in large part to an innovative co-generation plant on Geisinger's main campus installed in 2011 (see page 2),

SUCCESS SNAPSHOT

- More than $9 million annual savings from energy conservation programs, bolstered significantly by an innovative co-generation plant on Geisinger's Danville campus.
- Energy cost per square foot is now $1.69 – roughly a third of national average.
- Co-generation power plant (which accounts for more than 33% of the system's overall reduction in energy cost per square foot).
- An average ROI of 3.7 years on energy conservation investments.
- 80 percent annual reduction of greenhouse gas emissions (more than 62,000 tons).
- 20 percent annual water use reduction (25 million gallons).
- Doubling of Danville campus square footage since 1988 with no increase in electrical demand.
- Received a rare perfect score in Energy Star certification effort in mid-2013.
- Has completed 10 new LEED-certified buildings comprising nearly 1 million square feet since 2008, representing 40 percent of all registered/certified LEED projects in the state of Pennsylvan

Geisinger's energy costs per square foot are $1.69 – roughly a third of the national average among hospitals. Geisinger also has successfully cut its energy purchases even while more than doubling its building space since 1988.

Energy-efficient LEED certified 'green' buildings

Geisinger also has been a national leader in green construction, completing 10 new LEED-certified hospitals, clinics and office buildings comprising nearly 1 million square feet since 2008.

All told, those structures represent nearly half of all registered/certified LEED projects in the state of Pennsylvania. All of the structures feature high-efficiency heating and cooling systems and renewable resources such as natural daylight.

Greenhouse gas reduction to improve health

Aside from costs, Geisinger's energy conservation efforts are in synch with the system's mission to improve public health, Neuner said. Lower energy consumption reduces pollution and emissions from power plants. The EPA's Energy Star program recognizes the top 25% of business whose energy efficiencies help reduce greenhouse gas emissions." It's obviously something we're very proud of, but to me, I know of more opportunities," said Neuner. "We have plans in place to be better." Unlike many U.S. hospitals, the system has significantly reduced harmful emissions of greenhouse gases as a result of its energy efficient conservation efforts – up to an 80 percent annual reduction of greenhouse gas emissions of carbon dioxide, nitrogen oxide, sulphur dioxide and mercury (more than 62,000 tons). Neuner arrived at these figures using Practice Greenhealth's energy impact calculator.

For in-depth information on Geisinger's energy conservation projects, including lighting upgrades, energy distribution system improvements, and chiller plant upgrades and consolidations, see Neuner's white paper on GreenCorner and the Geisinger website.

Case study

Co-generation program a cornerstone of energy conservation initiatives

Co-generation (also called "co-gen") is a process that simultaneously produces heat and electricity. It's also commonly referred to as combined heat and power (CHP). After years of research and closely monitoring how successful plants functioned, Geisinger Health System in 2011 constructed and commissioned its own co-gen power plant on its main campus in Danville.

Today, the Geisinger co-gen plant uses a high-efficiency natural gas-powered turbine to generate about 40 percent of the Danville campus' electricity and heating needs, and unlike major utility companies, captures virtually all waste heat (from the exhaust) and uses the captured energy to power boilers and steam-driven chiller turbines.

Geisinger co-gen plant

According to Neuner, the co-gen plant is responsible for nearly one-third of the $9 million in savings Geisinger Health System achieves each year as a result of its energy conservation programs.

The main "engine" of the co-gen plant is essentially a 5 megawatt jet engine powered by natural gas. As it is combusted inside the turbine, a shaft connected to a generator turns, producing electricity.

Geisinger's central plant also includes:

- An 800 horsepower heat recovery boiler with economizer;
- Two, 1,000 horsepower water tube boilers;
- A 300 horsepower floating head boiler;
- A 6 megawatt high voltage electric boiler;
- Four 900-ton electric chillers;
- A thermal storage tank; and
- A 1,500-ton steam turbine-powered chiller.

The back story on co-gen

Geisinger actually began eying supplementary energy sources back in 1999 following deregulation of Pennsylvania's utility companies. At the time, the state placed protective caps on electric rates while allowing utilities to depreciate their generating assets at a faster rate. But the rate caps were set to expire in 10 years. "Under rate caps, we in essence had artificially low electric rates," Neuner said.

"We were protected from the market rates but we knew that would change by 2009."

Geisinger visited and revisited co-generation nearly a dozen times over that 10-year period as one means to help soften the blow from impending rate hikes. It was only after it did a feasibility study that they knew the math was in their favor. The study showed that the plant would cost $5.3 million to build and have an ROI of about $1.4 million per year from energy savings. Those numbers were based on the assumption that the plant would be operated in "economic dispatch mode," a method in which the plant would run or not run based on current market-based electric rates.

Neuner said he presented the plan to a receptive Geisinger senior leadership team. "They were excited about the project because it was a three-year return on investment," he said. Coincidentally, federal and state energy conservation grants were plentiful at the time and Neuner was able to secure a $2.25 million American Resource and Recovery Act (ARRA) grant, which covered about 40% of the total project cost.

In March 2011, Geisinger broke ground on the 2,000-square-foot co-gen plant on the Danville campus. By November, the plant was fully operational. From initial research to project completion, Neuner did face some challenges, all of which he was able to overcome. One was the state EPA, which challenged Geisinger to add gas cleaning equipment Neuner was able to demonstrate as unnecessary. Another challenge was the sheer novelty of co-gen.

"We had never seen a gas turbine and none of the area contractors who got bids had ever installed a gas turbine"

"We had never seen a gas turbine and none of the area contractors who got bids had ever installed a gas turbine," he said. "So we had to teach ourselves as we went along. My team basically taught themselves this technology from the ground up." Neuner also attended a turbine school for several days in Connecticut during his free time. The manufacturer periodically dispatched its own engineers to check on Geisinger's progress and offer installation troubleshooting.

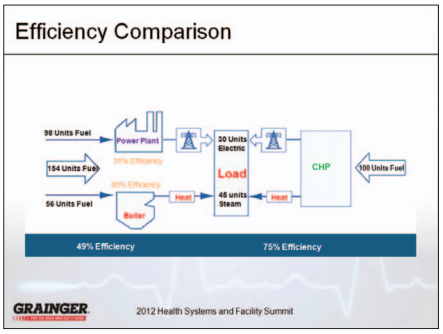
Another challenge was missed opportunities. "After I went to turbine school I learned about duct burners, which I hate to admit I knew nothing," Neuner said. Duct burners are placed at the boiler inlet to raise the air temperature, improving efficiency. Neuner said he is considering installing duct burners at some point.

How Geisinger has benefitted from co-gen

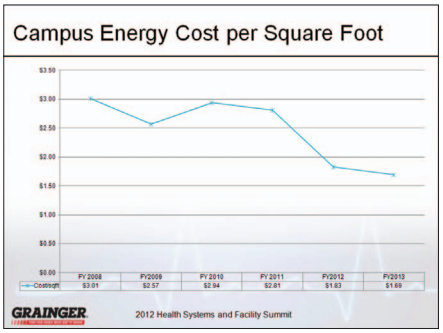
Lower energy costs, fast ROI

According to Neuner, co-generation plants are ideal for hospitals because of their 24-hour-a-day operation and high heat demands for sterilization and humidification in the off-season. Co-gen also significantly helps hospitals contribute less air pollutants. And because they can be powered by natural gas, the cost to operate them is significantly lower than electricity because of the now-plentiful supply of natural gas in most parts of the country.

Geisinger's electricity costs have dropped from approximately $4.4 million in 2011 to about $1.5 million today. Its natural gas costs are higher today than they were in 2011, but natural gas today is significantly cheaper than electricity. Before the shale gas drilling boom, both kinds of power paralleled each other in terms of costs.



In 2008, Geisinger's energy costs per square foot were $3.01 – still lower than the national average at the time. Today, its energy cost per square foot has dropped to around $1.69.



Unlike the scenario laid out on the earlier feasibility study, Geisinger decided to run the co-gen plant as a base load unit (or constantly at near capacity levels) instead of economic dispatch mode, which resulted in more than $800,000 a year in additional savings. All told, the co-gen plant saves Geisinger $2.2 million a year. After deducting the $2.25 million ARRA grant and a $500,000 Act 129 Utility Grant, the ROI on the plant is just 14 months.

The how and why behind co-gen's energy efficiency

In a nutshell, the natural-gas powered co-gen plant is at least a 50 percent more efficient process than the energy provided by coal-powered utility plants, which typically run at 30 percent efficiency. The biggest reason for that is the way

heat energy is recovered by co-gen yet wasted under traditional methods, Neuner said.

Neuner explains the comparison using hypothetical numbers. A traditional power plant and boiler consume 154 units of fuel (coal), while a co-gen plant consumes 100 units of fuel (natural gas) to each produce 30 units of electricity and 45 units of steam.

Presently, Geisinger's co-gen plant provides about 40 percent of the entire electricity needs of the 2.7 million-square-foot Danville campus; the rest is purchased from the local utility. Meanwhile, the co-gen plant now provides about 80 percent of the campuses' steam needs; the rest is provided using natural gas fired boilers.

The main reason for the higher efficiency is the way the system has been engineered to recover and harness waste heat. A heat recovery boiler attached to the main combustion turbine takes in 960-degree exhaust, cools it to 400 degrees, and then produces steam, which is used to heat water and power other devices.

During warm months, a steam-powered turbine chiller, essentially an air conditioner, uses excess waste heat produced by the cogeneration system to provide 1,500 tons of free cooling for the campus. The process reduces Danville's peak summer electrical load by a full megawatt, saving $300,000 annually.

"We learned after our first summer of operation that we had excess heat capacity off the turbine. So we took advantage of that," Neuner said. "We needed to increase our chiller capacity anyway." Neuner sourced a brand new chiller from a Connecticut pharmaceutical plant whose construction had been cancelled.

Chilled water storage saves energy

Neuner also implemented another innovative technique called chilled water storage, a process in which water is cooled to 42 degrees and stored in a 1 million gallon insulated thermal tank at night, when electricity rates are off-peak and about 33 percent lower, and the chillers are much more efficient because of cooler nighttime ambient air. The process is used to provide air conditioning to the Danville campuses' Hospital for Advanced Medicine, which added 344,000 square feet to the campus but had no on-site chillers. This allows Neuner to take two chillers off line during the day, saving about 1.5 megawatts of electricity from the campuses' overall electric load.

The process is called peak-load shaving, which, when combining shifting power loads to off-peak hours with thermal storage saves Geisinger an additional $450,000 a year.

Becoming a smart energy buyer

Geisinger Health System has about 400 electric accounts and 30 natural gas transportation accounts with local energy companies. But Neuner has negotiated a single rate across all of the accounts. And Geisinger buys energy on the open market, using hedges to limit market exposure.

Shifting power loads to access lower rates during off-peak hours is just one way the system efficiently manages and lowers its energy costs, and co-generation has greatly facilitated that.

While the co-gen plant only serves the system's Danville campus, its benefits extend far beyond.

"The co-gen does serve our other hospitals in a powerful way," Neuner said. "We buy as one customer. What happens is we make a better load profile [otherwise known as peak load contribution] here in Danville since Danville is a sizable consumer compared to the others. We're able to shape the power curve of the whole group."

For example, the co-gen plan is able to lower daily electricity demand by as much as 4 megawatts. When adding the 1.5 megawatts saved with the chilled water storage, the savings become dramatic. The result may only drop Geisinger's rate by 3/10 of a cent, but when you consider the 150 million kilowatt hours the entire system uses in a given year the savings can be as much as $450,000 a year, he said.

Of course, Geisinger's co-gen experiment would not have been as successful as it is without Marcellus shale, the natural gas-rich underground field through most of eastern North America. Drilling for shale in many areas in recent years, including Pennsylvania, has resulted in plentiful, cheap fuel. It wasn't that long ago when gas and electric costs virtually paralleled each other.

"Historically, gas and electric prices have moved together," Neuner said. "Electricity today is going to rise higher and quicker than gas because it's a

fixed commodity. We're closing coal plants, not building new ones, so there's much more constrained supply. So I think we'll see that historical relationship widen, which in essence, should increase the savings of co-gen, because it's gas powered. The other thing that's happened is partly pure luck. We used to pay about $1.35 per 1 million BTU in transportation surcharges to move that gas up from the Gulf of Mexico.

Now, that gas is coming from upstate Pennsylvania, probably from within 50 miles of here. So our transportation costs have gone from $1.35 to negative 7 cents."

Future co-gen expansion at Geisinger

With almost two years of full capacity operation now under its belt, the co-gen plant and its success is getting the attention of engineers and hospital executives across the Geisinger system. "I've had folks in other parts of the system, including Wilkes-Barre, come up to me and ask, 'Where's our co-gen?'" Neuner said. "Obviously, we're looking at where the economies of scale would make such investment feasible. In order for co-gen to be worth investment, you need a higher energy load profile.

It makes the economics work better because it reduces the capital investment." Neuner said Wilkes-Barre, now planning an expansion project, will likely be the next location for a co-gen operation in the next three to four years.

Geisinger's advice to peers about energy and going green

It helps that the chief architect behind Geisinger's energy conservation efforts is a seasoned and well-heeled mechanical engineer. It also helps that the system's decision to implement co-generation was greatly aided by a serendipitous change in energy policy that led to domestic drilling and cheap and plentiful gas to power the system.

But Neuner's best advice is to other healthcare organizations:

>> Benchmark your efforts against the best practices of leaders, and do your homework. "Double-check your numbers before taking the plunge with co-gen," he said. "The bottom line is size the equipment based on your heat load, because if you're not using all the heat, you're essentially operating like the utility company at 31 percent efficiency. You're dumping all that heat. You're not doing any better than you would buying energy off the street. If there's a perfect candidate for co-gen, it's hospitals. The beauty of hospitals is they're always requiring heat load. Always making hot water for sterilization and humidification. All of these heat loads really help drive the economics."

>> Also, consider establishing a separate account funded by community donors who support sustainability. Geisinger recently established its own "Green Fund" under the Geisinger Foundation. The fund has accumulated $245,000 to date.

>> Focus on long-term savings, not initial cost. As Neuner states in his recent white paper, up to 30 percent of a hospital's consumed energy can be saved at little or no cost, without sacrificing the quality of care through energy efficient technologies and improved management practices.

Investments in energy efficiency are among the soundest ones today. Most energy projects yield a one- to five-year payback, which translates to a yield of 20 to 100 percent with little or no risk. "When you build a building, most people generally focus just on first cost," Neuner said. "They say 'We can't afford that more efficient chiller because it costs an extra $100,000. In many cases, this view is the tail wagging the dog. Construction costs are between 11 and 15 percent of the 40-year cost of owning that building. The much *larger* expense is the operating and maintenance expenses over those 40 years. By having more energy efficient technology to begin with, you're lowering your operating expense significantly.

Here's a classic example: When we built the [LEED Silver-certified] Hood Center on campus in 2007, we went through this same argument. They wanted to put rooftop units on instead of using chilled water systems. I was finally able to prevail and actually replace a chiller plant that was in an adjacent building and put a new one in a new building and then back-feed the old building.

Our electric costs decreased $14,000 by opening that building and the reason was the new chiller plant saved more energy than the 70,0000 square foot building consumed. This is quite a statement when you can add that large a building and actually drop your campus utility bills. "Even a five-year ROI is a 20 percent return per year," Neuner added. "And we did this in 14 months on the co-gen plant." "Would you invest your money at 20 percent, particularly when healthcare on average makes 2.5 percent? I can't fathom why more healthcare organizations don't invest in this technology.

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