Is a Net-Zero Carbon Path in Your District's Future?

A 30-year master plan is helping Rice University achieve a net-zero carbon campus.

By John Carlson, PE, and Abbe Bjorklund, PE

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Rice University is working toward being a net-zero carbon campus.

As anyone in education knows, teaching students is only one aspect of the education equation. Administrators and school boards have even more considerations, such as maintaining facilities and planning for future needs. Sustainability is also an important issue.

Rice University in Houston, Texas, wanted to change the landscape of education and take more control of energy, finance, maintenance, and infrastructure factors on campus. In 2012, it embarked on a path to create a more energy-efficient campus. Rice worked with an engineering and design service provider to develop the Rice Integrated Climate and Energy Master Plan, or RICEMaP. The 30-year master plan is specific to Rice, and the university set a high goal of achieving a net-zero carbon campus.

Although not every school will set or achieve those same goals, other institutions can learn from Rice's experiences as they strive for their own energy-efficient future.

Setting the Course

Rice and the design and engineering team set out to balance multiple needs, including campus growth, utility capacity, reliability, energy efficiency, a net-zero carbon campus, reduced operating costs, and deferred maintenance. Rice could address all those goals by taking an integrated approach using RICEMaP.

Rice structured the master plan deliverables with three primary elements:

- Report 1—energy production, distribution, and storage plan
- Report 2—building-level energy-efficiency opportunities
- Report 3—energy system metering, measurements, and controls

All the reports are closely integrated. The performance of the utility infrastructure establishes the efficiency of production. The performance of facilities connected to the utility drives the peak demands, energy usage, and efficiency of the overall utility service. Meters and controls provide the basis for understanding, documenting, and managing utility assets, as well as the effective delivery of utility service.

The engineering and design team established a baseline for the age, condition, and capacity of the campus utility production and distribution systems. The campus already had chiller plants, boiler plants, and cogeneration capabilities, but it was anticipated that upgrades and the addition of new equipment would be essential to meeting campus energy needs.

The RICEMaP team believed the utility infrastructure must have the capacity to deliver cost-effective and reliable services to the campus, but it must also have the resiliency to respond to the dynamic energy supply conditions beyond the borders of the campus.

In parallel with the analysis of campus utility production and distribution systems, the engineering and design team investigated the energy usage profiles of campus academic, administrative, residential, and research buildings. Utility consumption data indicated that many buildings were operating well above energy intensity benchmarks.

On the basis of detailed energy audits of representative campus facilities, the team developed an achievable target of 30% thermal energy reduction (heating and cooling) and 20% electricity usage reduction. The relatively modest investments in energy-efficiency improvements were projected to provide Rice with a simple payback of two and a half years.

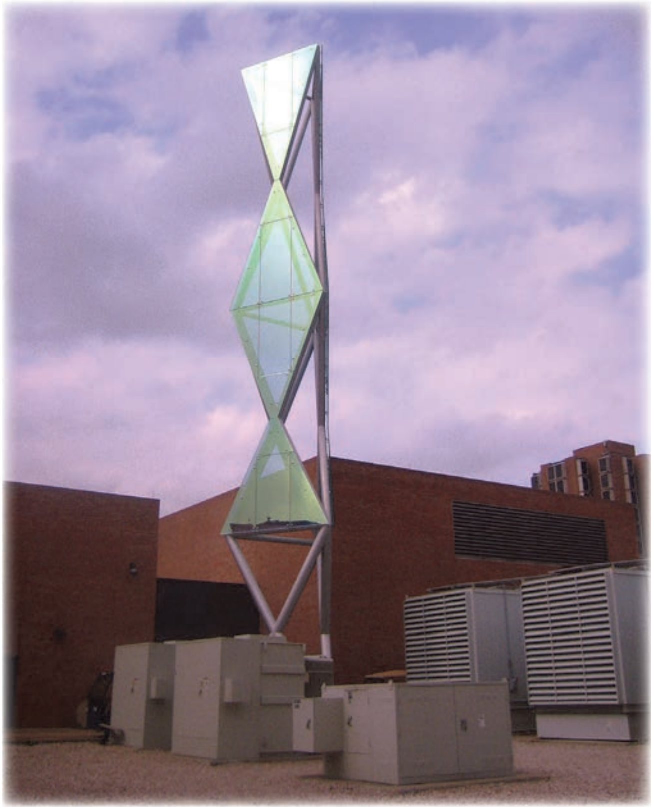
Similar to its investigations and analyses in the buildings, the engineering and design team uncovered opportunities to improve the efficiency of the plant operations as well. Those opportunities ranged from cooling tower upgrades and burner replacements to operational changes and improved efficiency. For example, steam piping was installed to interconnect the campus's north and south plants to provide more flexibility and efficiency in plant steam production operations, as well as increased reliability. The combination of reduced long-term campus energy usage and efficiency gains at the utility plants dramatically reduced the future capacity requirements of the utility infrastructure.

Since a system cannot be controlled if its performance cannot be measured, the team analyzed and reviewed Rice's utility metering and data acquisition systems. Recommendations included developing a budget to upgrade and maintain the system to address issues with the accuracy and integrity of the data collected.

Master Plan

Combining the findings of the utility infrastructure, building efficiency, and metering investigations, the engineering and design team developed integrated analyses of future energy requirements and associated investments for the campus over the 30-year RICEMaP horizon. The team analyzed and compared four scenarios for capital cost, operating expense, and associated environmental performance, which gave Rice the opportunity to pick a course of action:

- **Scenario 1** was the baseline scenario if Rice continues with current facility operations while expanding its facilities to meet future campus growth.
- **Scenario 2** looked at the impact that investing in campus demand-side management (energy-efficiency improvements) and plant operational improvements would provide to minimize the magnitude of additional utility capacity to meet future growth.
- **Scenario 3**, which built on Scenario 2, looked at the impact of installing 6.2 megawatts of cogeneration capacity at the campus's south plant.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Purchasing solar electricity has proven to be cost-effective.

- **Scenario 4**, which built on Scenario 3, included expanded cogeneration capacity at the campus's north plant when the current cogeneration system needs to be replaced (estimated for 2024).

Scenario 1 is estimated to have a $282 million net present value over a 30-year study period. This scenario is dominated by projected electric and gas procurement costs of close to $250 million and also includes almost $34 million in infrastructure upgrades to meet future campus energy requirements.

For Scenario 2, the team determined that by investing $28.4 million in energy-efficiency improvements in campus buildings and infrastructure, Rice could both offset the need to add more utility production capacity to support campus growth and reduce total campus energy and capital costs, achieving a net-present-value reduction of more than $17 million. This scenario would also reduce cumulative campus greenhouse gas emissions over the 30-year period by about 30%.

For Scenario 3, investing an additional $25 million in cogeneration infrastructure (beyond Scenario 2 capital) at the south plant would result in a $12.8 million present-value reduction in overall campus costs compared with Scenario 1.

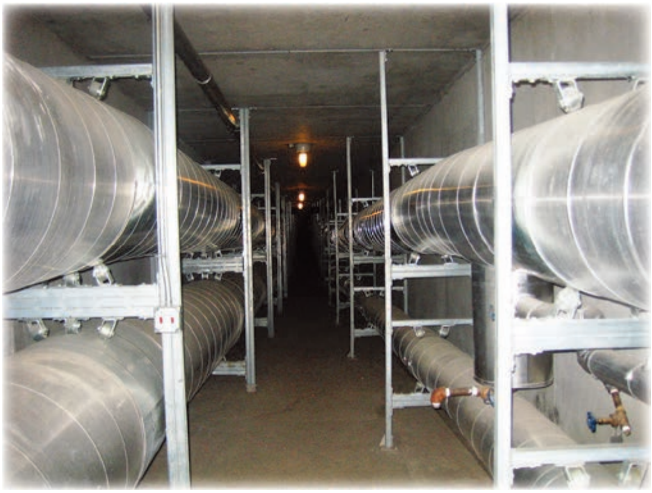
One of the advantages of Scenario 3 is that through cogeneration, Rice has less susceptibility to volatile electricity markets and more opportunity to exploit Texas's

Top 10 Priorities

1. Define your goals.
2. Research energy opportunities already available in your area.
3. Look at what other schools have done, so lessons can be adapted to your institution.
4. Create a committee that is inclusive of your entire population, including faculty, staff, and students.
5. Reach for broad options and opportunities, but use a well-defined path.
6. Compare the results with current operating efforts.
7. Prepare to be flexible, as not all projects are immediately feasible.
8. Involve your community members and get them excited about the energy improvements.
9. Review results so growth can be visualized.
10. Achieve your goals and set more.

real-time electricity market through self-generation. The additional cogeneration, plus the purchase of $7.4 million in green power and renewable energy credit electricity, brings Rice closer to its net-zero carbon goal. The combination of energy-efficiency improvements and cogeneration reduces cumulative campus greenhouse gas emissions by 68 percent compared with Scenario 1. Even with the additional investments in cogeneration and renewable energy, Scenario 3 has a total net-present-value savings of $5 million versus Scenario 1.

Scenario 4 has about $21 million in increased capital expenditure beyond Scenario 3 for additional north plant cogeneration capacity, with $5 million less green power and renewable energy credit purchases and lower energy purchases. Scenario 4 is estimated to have a total net present value of $269 million, a $13 million savings compared with Scenario 1. Scenario 4 also reduces campus greenhouse gas emissions by about 70%, compared with Scenario 1.



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Rice is implementing a variety of utility infrastructure improvements.

One of the goals of RICEMaP was to chart a course to achieve a net-zero carbon campus. The engineering and design team estimated that Rice would get to about 70% of that goal with Scenarios 3 and 4. To achieve the remaining 30% reduction, a combination of renewable energy generation and carbon sequestration was recommended. Rice can achieve carbon sequestration through prudent management of the forests it owns through the Rice-Land Lumber Company. By deploying these strategies, the team projected that Rice could reasonably achieve its net-zero carbon goal by 2038.

RICEMaP Implementation

When RICEMaP was completed in 2013, it provided the campus administration with a clear road map and financial justification for investing in building and utility system infrastructure. The Rice administration, facilities and plant operations, and sustainability leadership chose to pursue Scenario 3. With assistance from the engineering and design team, Rice has begun to implement the recommended campus building energy-efficiency and utility infrastructure improvements.

As part of its move toward net-zero carbon, Rice has installed a 50-killowatt rooftop photovoltaic system onsite and has pursued offsite purchases of electricity produced from renewable sources. With an innovative electrical procurement method of purchasing electricity in a shaped load sliced in hourly increments, Rice was able to secure a deal through its retail electric provider—MP2 Energy, The Woodlands, Texas—to purchase about 7% of its purchased electricity from a solar photovoltaic field in Fort Stockton, Texas.

Moreover, given that the solar field produces electricity in a load with a shape similar to Rice's consumption, Rice and MP2 Energy were able to complete the deal at no increase in cost to Rice. For Rice, purchasing renewable offsite solar electricity has achieved cost parity with purchasing fossil-fuel brown power.

Lessons Learned

Rice's journey offers some valuable lessons. Setting goals and creating a plan of action are essential. Through long-term planning and an integrated approach, future energy savings can offset investments in energy-efficiency and infrastructure improvements. Along the way, bumps in the road are expected, and adjustments have to be made. Not only monetary savings but also an improved campus and built environment will be realized. No matter what steps a school takes, adding to the sustainability of the nation's education system is a good thing.

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