Case Study: State University of New York Energy Management Project

OptoGreen Grant for SUNY New Paltz' School of Science and Engineering Provides SNAP PAC System for Alternative Energy Solutions

Background

According to Professor Michael Otis of the State University of New York, farming in the state of New York has sharply decreased over the last several decades, due in large part to the high costs of energy. Otis has been a professor at SUNY New Paltz' department of Electrical and Computer Engineering (ECE) for close to 11 years. He and a team of his students are collaborating with The Solar Energy Consortium (TSEC), a group of private and public institutions focused on researching and developing new ways to deliver solar energy[1] at a large apple farm in upstate New York, with the hope that the energy savings realized by this particular farm will gain the attention of others and demonstrate the viability of solar and other alternative forms of energy for their business operations. The hope is that, ultimately, these alternative energies will significantly reduce farms' average yearly energy consumption and that the same technologies and energy sources can be adapted for use in urban areas.

"Hand-in-hand, integrating alternative forms of energy and automating and improving farming processes can help provide a completely sustainable energy solution and reduce what tend to be very high energy costs," Otis says.

Working with TSEC under a plan calling for the "Greening of New York State Farms," Otis and a team of his undergraduate students[2] outlined a set of goals for the pilot project, including reducing overall energy consumption, reducing greenhouse gas emissions, and identifying the best types of renewable energy. After touring and carefully studying operations at Wright's Apple Farm in Gardiner, New York, the team prepared their conclusions, recommendations, and action plan.

Wright's Apple Farm

Identifying Troublespots

A family owned and operated business since 1903, Wright's Apple Farm covers 450 acres in Gardiner, NY—part of the Hudson Valley northwest of New York City. Besides its orchards, the farm includes a mechanical room, packing line, office areas, cold storage areas, bakery, and fruit stand. Sadly, Wright's has been operating at an annual net loss financially, largely due to its exorbitant utility bills.

Detailed examination of operations and energy audits conducted at the farm by Otis' team revealed that there were serious issues with the existing control system as well as in the way key equipment was functioning. For example, multiple coolers were

1. The Solar Energy Consortium is a not-for-profit organization formed in June 2007 to meet the New York State and national need for energy independence and sustainability. TSEC hopes to double the efficiency of photovoltaic (PV) cells, while halving installation costs, simplifying installation, and developing unique forms of PV for urban areas, such as New York City. Research and Development partners include Binghamton University, City University of New York (CUNY), Clarkson University, Cornell University, Rensselaer Polytechnic Institute, and State University of New York at New Paltz. TSEC members involved in this project were Vincent Cozzolino (CEO), John Harrington (VP R&D), and Petra Klein (VP of Operations.)

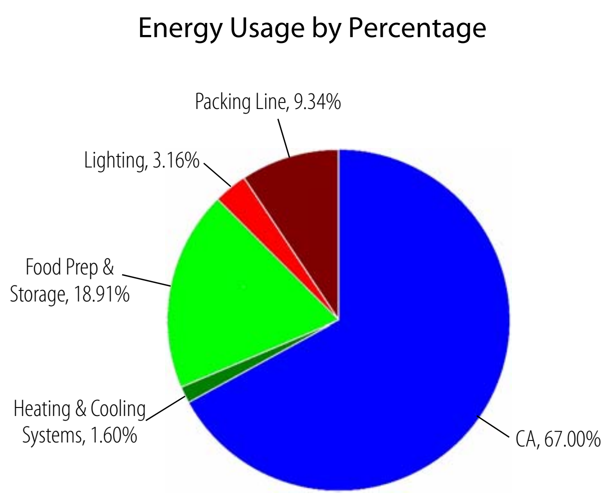
2. The SUNY New Paltz Engineering Team for this farm project consisted of Robert Dickman, Kenneth Cheung, and Adam Schoenwald, advised by Michael Otis.

often running simultaneously and unnecessarily. This was heavily increasing demand, leading to heavy surcharges.

"Also, transients were damaging equipment," says Otis. "Compressors were switching on and off way too often, which is a big waste of energy."

Furthermore, most of the farm's cold storage defrost mechanisms were timer based, so defrosting was occurring whether it was needed or not—even during the cold winter months. To make matters worse, the defrosting process was creating heat build-up in the surrounding area and cooling was often needed to remove this heat, thus leading to even more power consumption.

After all energy usage and equipment consumption data was aggregated, the team had a much better understanding of why Wright's energy bill averaged a startling 710,000 kWh per year, at a cost of $68,825.98.



An audit of Wright's Apple Farm detailed the farm's consumption data

Proposed Solutions

Otis' team performed feasibility studies of the various improvement and installation options before offering their final recommendations. These included implementation of a new control system to ensure that defrosting would take place only when necessary and that instances where multiple units were cooling simultaneously were minimized. Also proposed was a 100 kW photovoltaic (PV) system[1] consisting of a 40 kW ground array, along with a 60 kW array on the roof of the farm's main building. An additional recommendation was for two standing geothermal column wells[2] to provide the farm's cooling and refrigeration needs. As outlined in a final report prepared by Otis and his students, for the area in question, the ground temperature averages approximately 54 degrees year round. It was determined that creating two wells at this location would provide a much more efficient system, as cooling a 54 degree temperature down to 34 degrees (the preferred temperature for Wright's apple storage) would require much less energy than cooling a 100 degree temperature down to optimal level. As an added benefit, installation of this column well geothermal system would allow the farm to switch to a more environmentally safe refrigerant type.

All told, the three outlined energy improvements (new control system, photovoltaic system, and geothermal system) were expected to help the farm become more profitable, while simultaneously reducing its carbon footprint[3] and improving the environment. Otis thus began searching for a powerful, reliable, and affordable monitoring and control system.

Sourcing a Control System

Otis first learned about Opto 22 products in 1992 from a colleague who was formerly with IBM. While working together at Orange County Community College, the two integrated equipment donated by Opto 22 (*mistic*™ legacy systems equipment along with Cyrano software) into the Electrical Engineering Technology Department's Instrumentation and Controls Laboratory. Later, using Opto 22 equipment he'd purchased on eBay, Otis implemented a comprehensive control and monitoring system for his home. As the Wright's Farm pilot project began to take shape, Otis contacted Opto 22 with interest in the company's latest generation of SNAP PAC programmable automation controllers.

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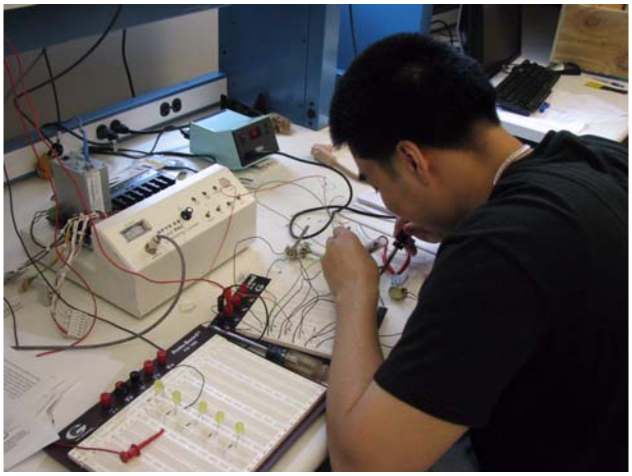
1. Photovoltaics refers to technology that converts light directly into electricity. Photovoltaics is best known as a method for generating solar power through the use of solar cells or panels that convert energy from the sun into electricity.
2. Geothermal energy solutions use the Earth as either a heat source, when operating in heating mode, or a heat sink, when operating in cooling mode.
3. A carbon footprint is the measure of the impact human activities have on the environment in relation to the amount of greenhouse gases produced. It is useful for conceptualizing and calculating a person's or organization's impact on the environment in correlation to their energy use.



Professor Otis' student working with an Opto 22 SNAP PAC controller

An "OptoGreen" Grant

"In speaking with Opto 22's pre-sales engineers and describing my project and what I was hoping to accomplish, I learned about the OptoGreen Grant Program," says Otis. "I downloaded and completed a grant application and in less than a week, we were informed that we qualified. Just days later, all the hardware we needed was in our hands."

"The type of project Mike and his students are undertaking is the exact reason we developed the OptoGreen Grant program," says Opto 22's Arun Sinha. "If an engineer has an idea regarding renewable energy that he or she wants to do a proof of concept for, the grant allows them to do so when funds might otherwise not be available"

The SUNY team is using a SNAP PAC System consisting of a powerful programmable automation controller residing on a rack with assorted analog I/O modules (used to connect to and take variable readings from equipment valves, gauges, and other instrumentation) and digital I/O modules (primarily used to read, switch, or toggle equipment states.) Collectively, this Opto 22 hardware comprises a system capable of remotely monitoring and controlling all of the farm's key industrial equipment, components, and instrumentation.

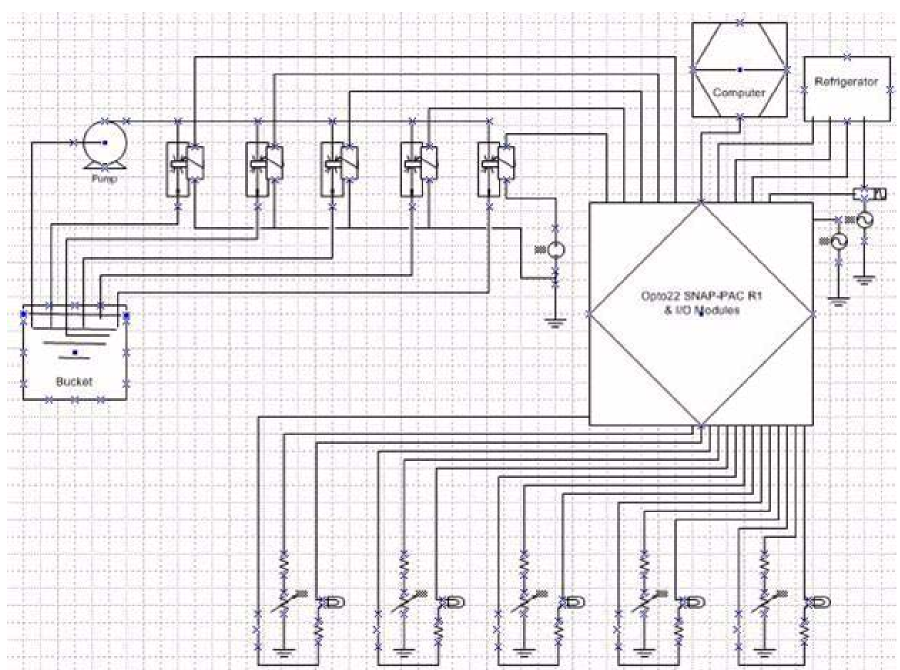
Communication takes place over a pre-existing Ethernet network. The system's main purpose is to reduce the farm's excessive energy consumption, thereby paving the way for renewable energy alternatives such as the solar PV for electricity and the geothermal for refrigeration and HVAC.

Project Start

The first step for the SUNY team was to offer proof of concept. A detailed mock-up was prepared to demonstrate how the SNAP PAC System could effectively monitor and control refrigerators, pumps, and relays—the same types of equipment and devices located at the apple farm. Five of the farm's cold storage units were—for the purposes of the mock-up—simulated using electronics such as sensors, potentiometers, switches, LEDs, and valves. A mini-fridge was used to simulate a sixth cold storage unit and the SNAP PAC System was programmed and configured to regulate all of this equipment along with temperature and defrost control.

Flowchart-based Programming

The SNAP PAC System was programmed with the PAC Project™ automation software suite, which includes tools for control programming, HMI development, and communication to virtually any database. Using PAC Control™ (PAC Project's control programming



Schematic of the Opto 22 system

application), Otis and his students were able to program using flowcharts, which proved to be a major benefit.

"Opto's flowchart-based development environment is just far superior—especially compared to ladder logic-based programs that I've used," says Otis. "Flowcharts are so much more intuitive and easy to use, particularly for today's engineering students, who, throughout their coursework, are used to seeing condition blocks, decision blocks, and the other flowchart-type elements. In the end, the Opto gear easily met all of the requirements in our mock-up and we successfully completed this stage of the project."

System Deployment

Next up is the actual deployment at Wright's farm. To make this deployment more manageable, Otis has broken the project down into three logical stages.

"There's a good deal we're hoping to accomplish," says Otis. "But one of the first things we want to do is reduce or eliminate the farm's largest expense—the peak-pricing charges they're incurring."

Peak pricing is a policy whereby utilities establish a threshold for large businesses and other high energy-consuming customers. If the threshold is exceeded, even briefly, over a designated period of time, the customer is charged a peak usage rate for the entire day.

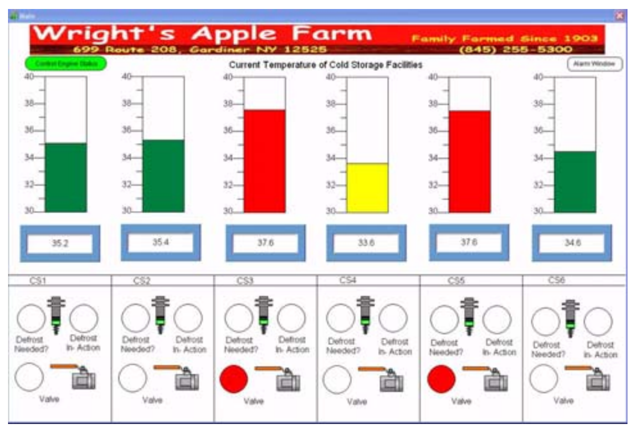
Otis explains that Wright's is subject to a policy where, for energy customers consuming more than 5,000 kWh per month, the power company calculates the largest amount of power consumed over any 15-minute period during the month, and this value is multiplied by $7.07 to determine that customer's charge. Only after the customer uses less than 2,500 kWh per month for three consecutive months are they eligible to come off this peak-pricing schedule.

Because of this peak-pricing policy, the first stage will consist of integrating the SNAP PAC System into the antiquated control environment, replacing the open-loop timer-based defrost mechanism with a sensor-based closed-loop system and applying a "round-robin" technique for the cold storage areas. Using analog input modules interfacing back to the controller, the SNAP PAC System will be configured to track and record the farm's power consumption data for comparison with the farm's original configuration. The hope is that this stage will ultimately result in elimination of the peak-pricing structure.

The second stage will consist of integrating the geothermal system (which will further cut down on electricity consumption) and upgrading the refrigeration fluid to R-410A from R-22, which is currently being phased out of refrigeration systems throughout the United States. After this, the farm's overall electrical energy consumption will be further monitored for additional comparisons. Finally, stage 3 of the project will be initiated and a new energy audit will be performed using the latest data (that is, with stages 1 and 2 completed.) The PV solar array will then be configured to handle the remaining electricity needs and arrive at net-zero grid usage.

Human-Machine Interface

To provide an easy-to-understand, easy-to-use control system interface for Wright's, Otis and his team used the PAC Display™ software (also part of Opto 22's PAC Project suite) to design HMI screens. A user display interface shows only the current temperature, valve status (open or closed), if defrost is needed, and if defrost is in action. An installer's display interface, meanwhile, allows the user to view this same data, but also logs historical trending data.



HMI screens were designed using PAC Display

As Otis explains, "The user display shows the temperature in a bar graph for each cold storage unit, so you can see, at a glance, if the temperature is in the correct range. Under the bar graph, the user can also see the temperature displayed. If the temperature is between 33°F and 34°F the bar is yellow; if the temperature is between 34°F and 37°F, the bar is green; and if it falls below 33°F or above 37°F, the bar is red."

The HMI was also configured to display visual alarm screens when temperatures in the cold storage unit go out of specified range, so the user can make corrections or contact a supervisor.

ROI

A final report prepared by Otis' students states that, "among programmable logic controllers, the Opto 22 platform has one of the fastest bring-up times due to the controller's simplified programming language." The students also assert that the "simplified programming language allowed for a faster [development] time, so we could focus on the electronics and other tasks."

Through the energy audit, and the assumption that the cold storage equipment is running 12 hours a day, Otis' team had concluded that the cold storage units represented 68.21% of the farm's electrical load draw. This means that the cold storage units consumed approximately 384,337.34 kWh of energy per year. The installation of the geothermal system will replace this heavy electrical load with a much smaller one. Based on projections, the geothermal system will save the farm $46,606.38 per year and pay for itself in just over six years. The solar PV sizing based on this geothermal system should be in the 60 kW range for the roof array, and the additional 40 kW ground array will offset the remainder of the farm's electricity needs.

Hand-in-hand with the farm's reduced energy consumption comes a major reduction in production of greenhouse gases across the Hudson Valley and the surrounding region.

Perhaps best of all, Otis is hopeful that the pilot project at Wright's will set the standard for future renewable energy projects throughout New York State.

"We're very encouraged that the success of this implementation will further TSEC's mission of developing efficient solar energy systems, reducing the cost of these systems, simplifying their installation, and promoting their widespread use."

About Opto 22

Opto 22 develops and manufactures hardware and software for applications involving industrial automation and control, remote monitoring, and data acquisition. Opto 22 products use standard, commercially available networking and computer technologies, and have an established reputation worldwide for simplicity, innovation, quality, and reliability. Opto 22 products are used by automation end-users, OEMs, and information technology and operations personnel. The company was founded in 1974 and is privately held in Temecula, California, USA. Opto 22 products are available through a worldwide network of distributors and system integrators. For more information, contact Opto 22 headquarters at 951-695-3000 or visit www.opto22.com.