Greening the Johnson Space Center Aaron Cohen Child Care Center

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In 2007, Johnson Space Center (JSC) took a major step in the direction of renewable energy usage by constructing a Multi-Platform Renewable Energy System (MPRES) at the Aaron Cohen Child Care Center. The MPRES was constructed at the end of fiscal year (FY) 2007 and was brought on line in FY 2008. This project had several goals:

Fig. 1. *Johnson Space Center Aaron Cohen Child Care Center Multi-Platform Renewable Energy System.*

1. To support the Engineering Directorate's mission by providing an opportunity to gain an understanding of large, surface-based photovoltaic (PV) arrays necessary for lunar surface exploration.
2. To gain the JSC-specific experience with various renewable energy technologies.
3. To collect real field data to confirm the viability of renewable energy technologies at JSC.
4. To strive to meet energy Executive Order mandates.

The child care center was selected as the site for the MPRES because the size of the facility allowed for renewable energy system flexibility, the tie into the electrical grid would not be complicated, and it provided excellent educational opportunities. Solar PV, solar thermal, and wind technologies were determined to be the best fit for JSC's initial venture. Therefore, the MPRES consists of:

a. Eight 2.8-kW PV modules with a solar tracker for a system output of 22.4 kW

b. Three 1.0-kW PV modules with a solar tracker for a system output of 3 kW

c. Three 1.0-kW fixed PV modules for a system output of 3 kW, fashioned in a decorative "lollipop" design

d. Two 33-foot-high, 1.8-kW wind turbines rated at 3.6 kW and a peak output of 4.8 kW—the total system's electrical generation is rated at 32 kW

e. Solar Thermal Glycol Hot Water Generating System with an 80-gallon hot water storage tank

Benefits of the Project

This project provided a number of benefits:

1. Supported the JSC mission by providing the Engineering Directorate with data that demonstrated:

- How to build, operate, and maintain a large, surface-based PV array to accomplish lunar surface exploration
- A focus on systems engineering and integration issues
- A future robotic assembly and maintenance, automated monitoring, and advanced regenerative fuel cells
- That the objective of the Engineering Directorate was not only to capture information that would contribute to the development of lunar surface energy systems, but also to perfect technology that could be exported to other centers for a NASA-wide benefit

2. Gave JSC valuable experience with:

- Actual costs associated with implementing a successful renewable energy project
- The best design and constructability options for future renewable energy projects
- Maintaining and operating renewable energy systems

3. Allowed JSC to confirm the viability of renewable energy technologies with the real field data collected and assisted the center in making cost-effective decisions for future renewable energy projects.

4. Allowed JSC to move forward in compliance with the Energy Policy Act of 2005 renewable energy mandate. These mandates required that by 2013, a minimum of

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continued

7.5% of any Federal Government Agency's electrical consumption must be from a renewable energy source. As an additional bonus in the plan, any power generated on-site is given double credit in this percentage calculation. JSC determined that its new mission with energy conservation would not only achieve both energy reduction and renewable energy requirements, but attempted to lead the way with on-site generation.

5. Saved JSC critical funding with the reduction of purchased utilities, as well as reducing JSC's greenhouse gas footprint.

Green Savings

In 3 full years of operation, MPRES has:

- Generated 153,353 kilowatt (kW) hours
- Avoided 168,030 pounds carbon dioxide, 689 pounds nitrogen oxides, and 693 pounds oxides of sulfur

This renewable generation averted the gases emitted by 19 cars in 1 year and is enough power to operate eight homes for 1 year. The MPRES provides 20% of the electrical energy needs at the Aaron Cohen Child Care Center. When the building is unoccupied during evenings and weekends, and when electrical load requirements are low, the surplus energy is fed to the site's electrical grid and made available to the remainder of JSC.

Photovoltaic Details

The MPRES consist of tracking and stationary PV arrays. A photocell, affixed at the peak of the arrays, detects the brightest object in the sky (assumed to be the sun), and sends a signal to the small, low-voltage DC motor. Through a gear drive assembly, the PV array is moved to a perpendicular position relative to the sun's rays. The dual tracking system travels horizontally to follow the sun east to west throughout the day, and vertically for the sun's height in the sky for the different seasons. By tracking the sun and capturing all the power accessible—whenever it's available, at any time of the day—the system provides maximum efficiency and generation production.

The remainder of this system encompasses three 1-kW stationary decorative lollipop PV arrays. The three lollipop PV arrays do not track the sun, but they can be manually adjusted vertically for the different seasons throughout the year. The stationary PV systems, though less efficient than the tracking systems, require less initial investment.

Wind Turbine Details

The wind's renewable energy is captured by two 1.8-kW wind turbines. The turbines are based on new technology with simplified installation for plug-and-play grid interconnection. The controls and inverters are built into the turbine's unit. This provides quiet, clean electricity at low wind speeds. Using a slip ring and passive yawing, the wind turbines are able to follow the wind and produce maximum power from any direction.

GeoExchange Heating, Ventilation, and Air Conditioning System

In keeping with JSC's commitment to implement green technologies, the center replaced the existing Heating, Ventilation, and Air Conditioning (HVAC) system at the Aaron Cohen Child Care Center with an extremely efficient GeoExchange HVAC system. This system uses the Earth for both a heat source and a heat sink. Water is pumped from a geothermal heat pump to a vertical closed-loop polyethylene piping system in the Earth where heat is either discarded from the water or absorbed by the water. On the air-conditioning side, the Earth works as a cooling tower to cool the water and heat it up on the heating side.

Forty 300-ft-deep, 4¾-in.-diameter bore holes were drilled, and two 1-in.-diameter polyethylene pipes (supply and return) connected at one end by u-bend pipe were placed in each hole. These 40 loops were then connected to a manifold at the other end using 3-in. to 1-in. polyethylene piping to create a reverse return with the water flow though the piping system. Reverse return is employed to create a constant flow and to spread out the thermal energy through the well field. A 150-ft horizontal bore was completed from the well field to a closet on the back of the child care center. Two 4-in. polyethylene pipes (supply and return)

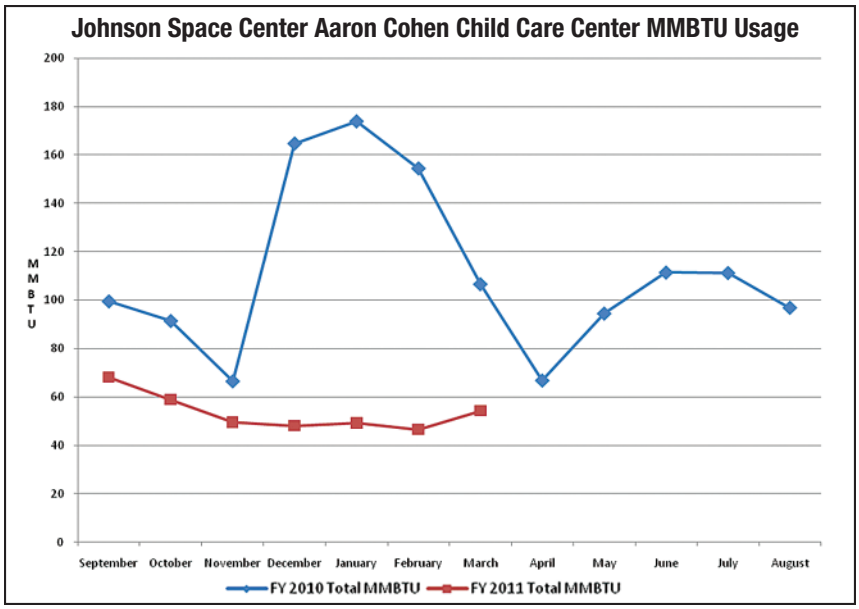

Fig. 2. *Million British Thermal Units (MMBTU) Reduction After GeoExchange HVAC System installation.*

were pulled through this horizontal bore up through the ceiling of the closet where the size decreased to 2 in., and eventually to 1 in., and through the attic to a platform where the 12 GeoExchange units were installed.

The existing HVAC system consisted of a four-zone, direct expansion air-conditioning system with natural gas duct heaters for heating. This project involved changing to a 12-zone system with complete duct replacement. The interior construction involved a great deal of coordination and flexibility. The child care center had to remain open and the air conditioning had to be maintained during the construction. With these challenges, the existing HVAC system was demolished one zone at a time and temporary air conditioning was provided until the new units and duct work was installed and operational. This work was completed at night. A Web-based thermostat system controlled the new 12-zone GeoExchange system.

The GeoExchange system has been in operation since September 2010 and has reduced the million British thermal units usage in the child care center by 44% without compromising comfort (figure Rowlands Greening 2).

System Monitoring

A Web-based metering system collects MPRES data in real time and is displayed locally and on the internet, showing performance figures on each individual system as well as historical information. This metering system impacts both research and education at JSC, as well as other NASA sites. This page is easily accessible through the website. It can be viewed by all of JSC, other NASA facilities, and educational institutions, thereby permitting the data accumulated to be used for both research and education. Additionally, a kiosk that displays the page shown below with real-time data has been placed in the lobby of the child care center for educational purposes.

Blue Marble Award

In FY 2009, the MPRES was featured in the Federal Energy Management Program Leadership poster. This project was part of the winning NASA Headquarters Environmental Management Division's 2010 Blue Marble Awards for Environmental and Energy Excellence. The award was the NASA Excellence in Energy and Water Management Award – Group: Energy Efficiency and Water Conservation Team (JSC) – Renewable Energy and Energy Conservation Program.

Other Greening Projects

JSC has completed additional efficiency projects in an effort to reduce the electrical usage in the Aaron Cohen Child Care Center and, in turn, provide the building with added renewable energy. The center added solar screens to the windows to reduce the infiltration of thermal energy from the sun. Since the child care personnel complete an abundance of laundry each day, JSC replaced the two stacked washers and dryers with a high-efficiency, front-loading washer and dryer. The center replaced refrigeration equipment in the kitchen with ENERGY STAR apparatus. JSC resolved an issue with ventilation of the attic, which was adding to the HVAC loading, by adding vents and an attic fan. In the future, JSC may look into gaining a Leadership in Energy and Environmental Design Operations and Maintenance Certification for this building.