

## *Case Studies: Enhancing Reliability and Efficiency Using Locally Generated DC Power— The Hybrid Building*

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### ABSTRACT

Since Edison's day alternating current (AC) and direct current (DC) have co-existed by necessity: AC to make the trip from the generating plant and DC to power electronic loads. This has resulted in billions of electrical compromises in the form of the ubiquitous power supply, or a rectifier, that must stand in front of DC loads to convert AC to DC. As Arthur Rosenfeld a California Energy Commissioner calls them, our "Energy Vampires."

But now, many buildings are generating power of their own, usually direct current energy. Is this wasteful back-and-forth conversion really necessary? Just as the automobile industry has advanced to the hybrid car, buildings can use multiple sources of power to achieve dramatic increases in efficiency.

### BACKGROUND

Edison and Westinghouse fought the AC/DC battles around the turn of the century. AC won because Tesla's transformer allowed AC voltage to be boosted for easy transmission from Niagara Falls into the city. Edison's DC network required unpopular 'backyard' DC generation stations every few miles.

But where AC won in the transmission, it's DC that is now used inside almost all of our devices. Only DC can be precisely regulated to get the exact voltages needed for sensitive electronics. So building electrical systems are fed with AC that has to be converted to DC at every fluorescent ballast, computer power supply, phone system, and other electronic device.

This model works fine until we bring back Edison's original idea and buildings begin generating power of their own – usually DC power such as solar, fuel cell, and wind. The inefficiencies involved with inverting to AC, matching grid frequencies, and protecting utility line workers from hazards are all avoidable by creating a hybrid electrical system.

#### INEFFICIENCIES IN AN INVERTED SOLAR SYSTEM

The inverter model of the traditional solar system has several flaws:

##### **Inverter Efficiency**

Rated inverter efficiencies are between 90% and 95%, actual field efficiencies are even less. Many inverters consume power at night. Several models do not turn on in low-light conditions.

##### **Anti-Islanding**

For the protection of utility line workers, inverters are required to shut down in the event of grid failure. This means that, for most solar systems, there is no energy production during a power failure (when it is needed the most).

##### **Net Metering**

Power sent back into the grid is not always repurchased at full cost. Sending excess power back into a sometimes overburdened grid may not be the best way to manage the resource. Net-metering, as a business practice for utilities, is not sustainable and is likely to further erode the value of power sent back to the grid. Net-metering agreements and the meters that they require can be expensive.

##### **Reconversion Losses**

After suffering the losses of inverting DC to AC, additional losses are incurred converting the AC back to DC in the electronic devices like fluorescent ballasts, computers, and more.

#### THE HYBRID SOLUTION

The theory is simple: In a building that produces DC power of its own, use the DC power for the DC devices and use the AC power of the

grid for everything else. If more DC power is needed than is available, consume the grid power, convert it to DC, and use it to supplement the local source.

- Efficiency gains come from the locally generated DC power, which is never converted, and AC power from the grid, which is converted only when necessary.
- The system is more reliable because there are redundant sources of power. It is not necessary to shut down a DC system during a grid failure like it is with an AC system.
- The system is simpler because no net-metering or utility interconnection agreements are necessary. The utility cannot even 'see' the system and, in most cases, does not even need to be notified.

#### DRAWBACKS TO THE HYBRID SOLUTION

The only drawback to the hybrid system is there is no efficient provision to store excess electricity. The excess energy cannot be sent back into the grid and re-purchased later and storing excess power in batteries can be too expensive to justify.

The solution is to identify base DC loads that will always be on when the system is generating. If solar panels are the local DC source, then the local DC loads need to be on all day every day. An ideal example of this is commercial fluorescent lighting.

#### EXAMPLE OF A HYBRID LIGHTING SYSTEM

In this example, which can be seen live at [www.DirectCoupling.com](http://www.DirectCoupling.com), solar panels are connected to DC ballasts in the lighting system.

##### **Daytime**

The solar power from the panels is sent directly to the lighting, with no conversion, at nearly 100% efficiency. Wiring losses are the only significant losses. The system is designed so, at full sun, about 90% of the power needed for the lighting is supplied by the panels, as shown in Figure 1. The additional 10% is taken from the grid, converted to DC at the NPS1000 power gateway.

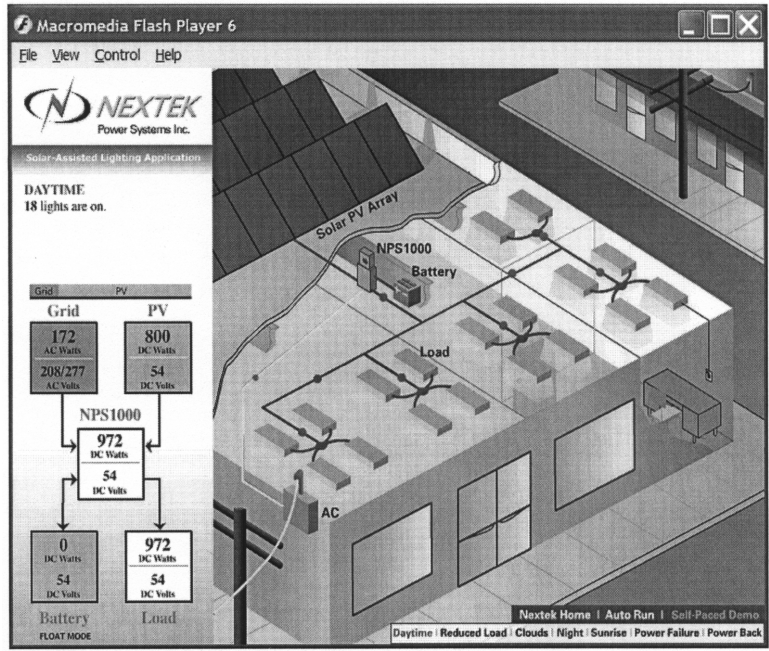


Figure 1. Normal Day Operation Mode

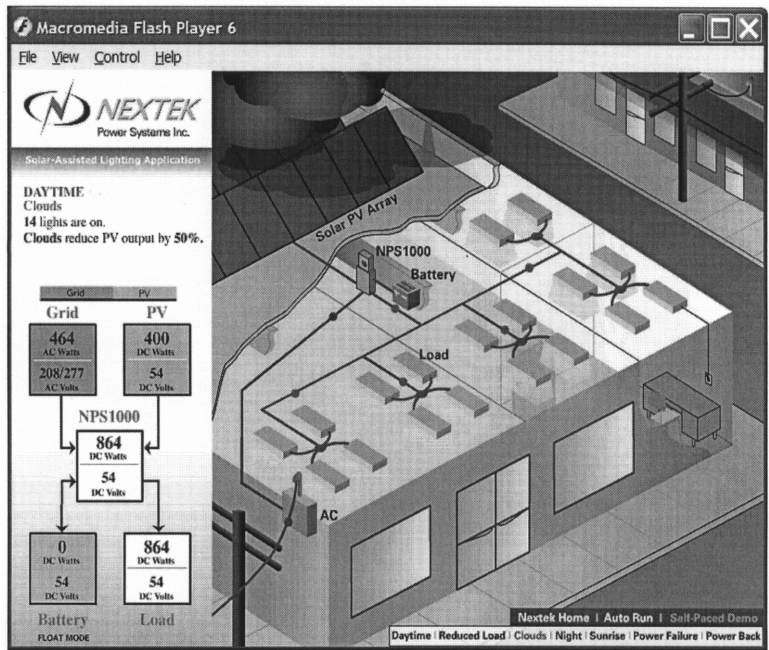


Figure 2. Cloudy Day Operation Mode

**Clouds**

When clouds reduce the PV production, more power is taken from the grid and converted to DC. The system is using all available power from the panels (the least expensive source) and using the grid as the backup, as shown in Figure 2.

**Night**

When there is no solar power available, all the power is taken from the grid and converted to DC, as shown in Figure 3. As discussed previously, a typical AC lighting system uses AC power from the grid, which is converted to DC at every ballast. In this DC system, the conversion is handled centrally. The number of conversions (AC to DC) is not increased.

**Power Failure**

In the event of a grid outage, the lighting system continues to be powered by the solar panels and, if needed by optional batteries, as shown in Figure 4. In a traditional inverter based solar system the inverter is required to shut down, shutting off the lights.

Other suitable DC loads in commercial buildings include telephone systems, motor controllers, computer server systems, and more.

**INSTALLATIONS**

Current installations of this technology approach include grocery stores, offices, big-box retailers, and, most recently, a Frito Lay Distribution center in Rochester, New York.

**Whole Foods, Berkeley**

This 30-kW system powers the lighting and was installed with Powerlight photovoltaics. One of the primary benefits of this system, besides increased efficiency, is the reliability aspect. Power failures are extremely expensive for grocery stores, not because of the freezers, but because 200 people with shopping carts full of frozen food abandon the carts and leave the store. This creates an expensive emergency for the store as the staff need to scramble around, reshelving the food by opening coolers which should really stay closed. This, as well as the lost sales cost the average small grocery store over \$8,000 per five-

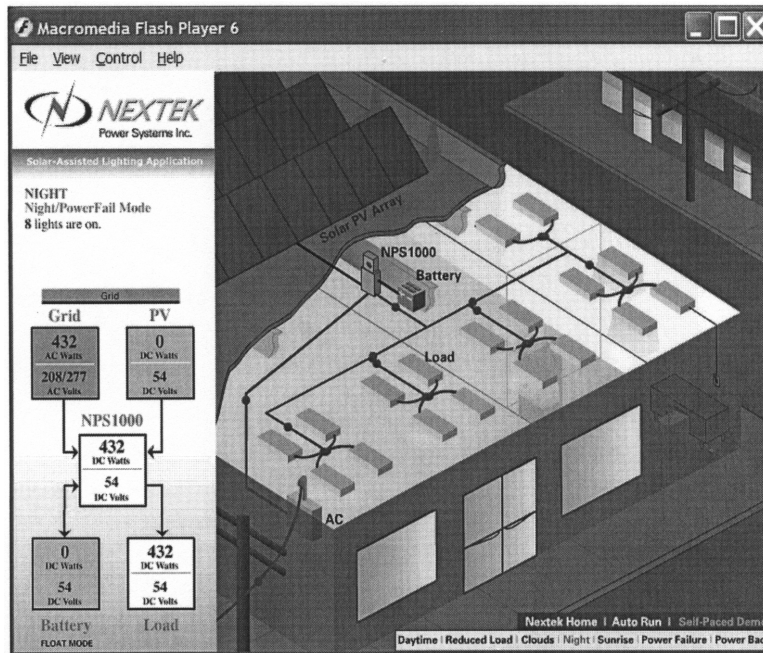


Figure 3. Night Operation Mode

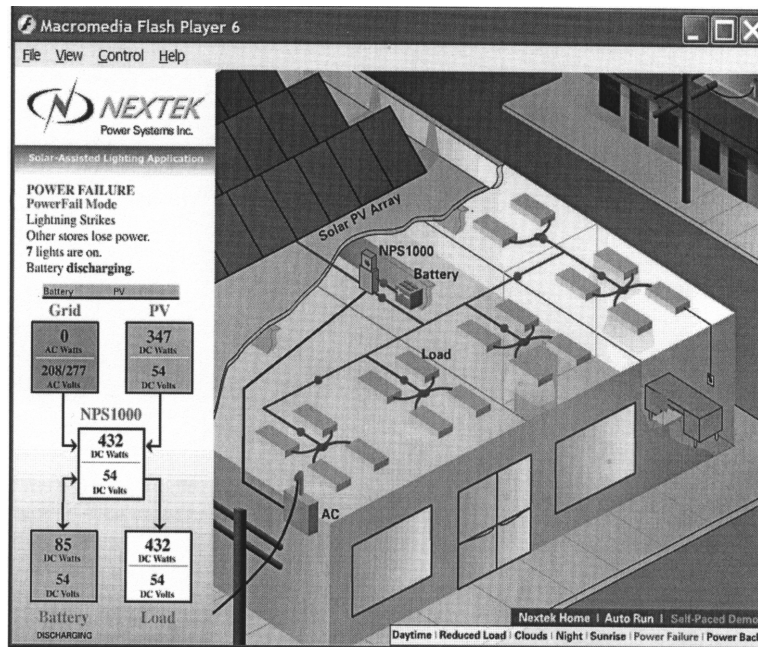


Figure 4. Power Failure Mode

minute failure.

Shortly after the installation, Whole foods experienced a brief power failure. The lights were powered by the solar panels and did not shut off. Customers remained in the store.

### Frito Lay, Rochester

One of the other benefits of low voltage DC ballasts is the ease at which they can be controlled. Each ballast has a phone wire-type connector which can be used to provide DC power to, and a light switch for an occupancy sensor. This reduces the installation cost of an occupancy sensor for \$200.00 each to \$75.00 each.

### Target Stores, El Cajon, CA.

This system uses the Nextek system for part of the store, and an inverter for the rest. This allows us to monitor each of the systems and compare the efficiency of both. Initial readings illustrate that the Nextek System is providing over 20% more power than the inverter based system, see Figure 5.

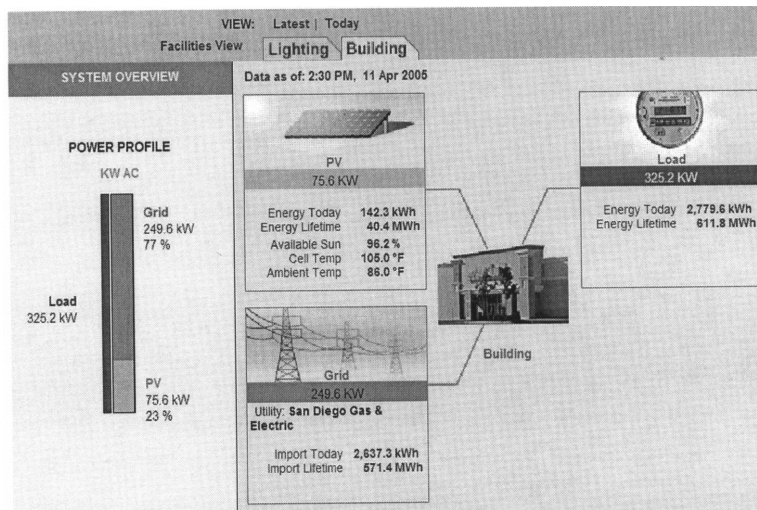


Figure 5.

## CONCLUSION

The most efficient way to utilize locally generated power is to consume it all, where, when, and how it is generated. We can accomplish this by identifying DC devices in a building and powering them with the locally generated energy and use the grid as a backup.

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## ABOUT THE AUTHOR

**Mr. Mark Robinson, LEED**, is the vice president for Sales and Marketing at Nextek Power Systems. Mark is a master electrician and was a nationally recognized salesman for Honeywell Systems. Formerly, Robinson was President of The Energy Grid, a consulting firm to the renewable energy industry and director of customer service and information systems at inverter manufacturer Advanced Energy, Inc. He comes to the renewable energy industry from the computer field, where he established a leading Boston area consulting firm. Mark is an accredited LEEDs professional and a certified Microsoft engineer.