Distributed Generation in Minigrids

A minigrid — a set of generators that supply the entire electricity demand to a localized group of customers — represents one of the best near-term prospects for renewable energy technologies in general, and photovoltaics (PV) in particular. By avoiding the cost of transmitting electricity from a distant central-station power plant, or transporting fuel from a distant supply source, a minigrid can significantly improve the economics of generating electricity with PV.

Distributed generation involves adding modular electricity generators close to the point of consumption on a power grid. Minigrids typically use the same technologies employed by electric utilities in distributed power applications, but are not always connected to the central grid. In some cases, the generators are installed to relieve utility constraints on the existing grid, with a view to possibly disconnecting these generators and their load from the grid at a later date. In other cases, an electrically isolated minigrid is created; this minigrid may then be integrated with the central grid if that option becomes attractive. The essential point is that the generators in a minigrid are capable of serving their load independently.

Using a mix of generating and demand-side-management technologies gives the power supplier the flexibility to meet a wider range of loads, and aligning with other technologies enables PV to reach new markets. Minigrids thus represent an important market for PV power systems, which are already cost-effective in many such applications, as the Block Island Power case study, below, illustrates.

Focus on Rhode Island — Block Island Power

Block Island, located about 10 miles off the coast of the Rhode Island mainland, is a good example of a community that already has its own electrically isolated minigrid. The island obtains its electricity from diesel generators, meeting some of its heating needs with propane. Bringing all this fuel from the mainland by boat is costly, giving Block Island one of the highest electricity costs on the East Coast — three times higher than mainland rates during summer peak season.

Due to pollution from the diesel generators, the island has not been in compliance with the Clean Air Act, and Block Island Power Company (BIPCO) was recently faced with the prospect of either installing a submarine cable to carry electricity from the mainland, or purchasing a new fleet of cleaner diesel generators. Both options threatened to drive the island's electricity rates up even higher than they already were. Islanders turned to the U.S. Department of Energy (DOE) and the National Renewable Energy Laboratory (NREL) for help.

Christopher Warfel/PIX08092

PV panels outside a Block Island residence

A study commissioned by NREL found that distributed resources provide a technically and economically viable alternative method for meeting the island's heating and power needs. Islanders would need to implement the following changes (percentages indicate the relative contribution of each element to meeting the total load):

- *Energy efficiency* — Replace 20,000 incandescent light bulbs with compact fluorescents (or their equivalent), roughly two lights for each person during the peak summer months. Replace existing refrigerators with high-efficiency models for all year-round residents. *(Total contribution: 25%)*

- *Renewable energy* — Install 1 MW of PV (21%) and 1 MW of wind power (19%). *(Total contribution: 40%)*

- *Cogeneration of electricity and hot water with fuel cells* — Install 1.5 MW of cogeneration to serve commercial customers (29%) and 0.3 MW to serve year-round residential customers (8%). *(Total contribution: 37%)*

Note: Totals add up to more than 100% to cover system losses.

With this scenario, there would be a very close monthly match between electricity generation and demand. As Figure 1 shows, the diesel generators would have to be operated only during extreme peaks or emergencies, which would meet EPA emissions requirements. The study noted that, as most of the technologies evaluated are nondispatchable, a more in-depth evaluation would be necessary to ensure that there would also be a close hourly match between supply and demand. Total annual costs of the distributed resource approach were found to be less than the cost of the submarine cable.

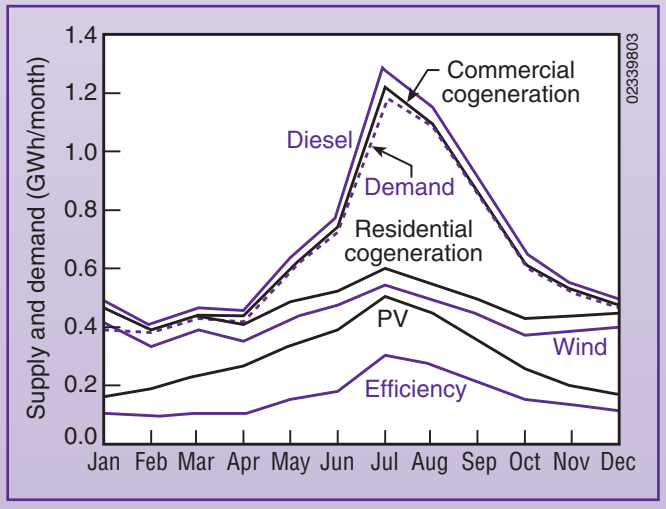

Figure 1. Distributed resources provide a very close monthly match between electricity supply and demand. The dramatic variation in load during the year is because the island's base population of 800 residents swells to roughly 10,000 during the summer months.

To find out if the distributed resource approach would meet local needs, Rhode Island was granted $400,000 by DOE to develop diesel displacement projects — such as photovoltaics, solar hot water, and wind — on Block Island.

Sources of Information

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A Preliminary Analysis of Block Island Power Company's Use of Clean Distributed Resources to Provide Power to Its Customers by Thomas E. Hoff. National Renewable Energy Laboratory, August 1998.

Distributed Generation and Micro-Grids by Thomas E. Hoff, H. J. Wenger, C. Herig, and R. W. Shaw, Jr. Presented at the 18th USAEE/IAEE, San Francisco, CA, September 1997. This paper provides a method to evaluate the technical and economic feasibility of minigrids.

These and other utility-oriented PV publications are available on the NCPV Web site at: *www.eren.doe.gov/pv/onlineutil.html*

Additional copies of this brochure are available on the internet at: *http://www.nrel.gov/ncpv/pdfs/23398b.pdf*

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