RSVP Renewables for Sustainable Village Power

PROJECT BRIEF

Wind-Electric Icemaking System Development

by Steve Drouilhet 7/98

Background

Small wind turbine suppliers in the United States and several international development agencies have expressed a need for a reliable and cost-effective wind-powered icemaking system. The need is driven by the demand for ice in remote fishing villages. Often, such villages in developing countries do not have access to grid power. With a reliable supply of ice to refrigerate their catch, fishermen in these villages would extend the market for their fish, reduce spoilage, and increase the quality of their delivered product.

Scope

To address the need of village fishermen, the National Renewable Energy Laboratory (NREL) decided to investigate the approach of using a commercial icemaker directly connected to the electrical output of a small variable-speed wind turbine generator. This approach was taken because it promised to be simpler and more cost effective than a system employing batteries and an inverter (to supply conventional AC power). The electric power supplied to the icemaker would vary in voltage and frequency as the wind speed varied. There would be no other energy storage in the system because ice is itself a storage medium. Ice would only be produced when there was sufficient wind power available.

Status

In the first phase of the project, NREL demonstrated variable frequency operation of a standard commercial icemaker connected to a Bergey wind turbine. While the icemaker (a Scotsman) produced ice over a range of electrical frequency and voltage, several operational problems were encountered. Particular difficulty was encountered in starting the compressor motor with the relatively weak (compared with a standard utility grid) wind turbine generator. NREL developed a computer model of the electromechanical system, looking at both the steady state and dynamic operation of the system, to get a thorough understanding of the system characteristics, including the start-up problem. Researchers then conducted bench-scale tests to validate the model and to prove the predicted effectiveness of series capacitors in increasing the starting capability of the compressor motor.

In the second phase of the project, NREL tested a Northstar icemaker, powered by a 10-kW wind turbine alternator, driven by a dynamometer. The Northstar icemaker was chosen because it appeared to have the robustness necessary to provide reliable service in a remote fishing village environment. It also can make ice from seawater (unlike the Scotsman), which eliminates the need for a fresh water supply. The icemaker start-ups were monitored at various combinations of alternator frequencies and capacitor size. Steady-state measurements were taken over the entire range of operating frequencies to determine the power vs. frequency and ice production rate vs. frequency characteristics of the system. The measurements, combined with the known wind turbine performance, were used to determine ice production vs. wind-speed for the system.

Unfortunately, the Northstar icemaker testing revealed its own set of operational problems associated with variable-speed operation. The problems included mechanical resonances, control malfunctions, poor spray jet performance, and attenuated ice production rate at the higher operating frequencies. Taken together, the resolution of these problems would call for a major redesign of the icemaker. The U.S. Department of Energy issued a Small Business Inno-vation Research (SBIR) request that included wind-electric icemaking as a development category. Three awards are anticipated in the category.

Thorough documentation of this project can be found in, "An Investigation of Wind-Electric Icemaking: Analysis and Dynomometer Testing," NREL technical report no. TP-500-24010, and in, "Wind-Electric Icemaking Investigation," NREL conference paper no. CP-500-24662. NREL is currently soliciting interest and proposals from U.S. icemaker manufacturers for continuing this work.

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