MicroCSP Grid Integration

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ABSTRACT

On a typical sunny day, with clouds in the late morning and afternoon, the Holaniku solar field in Kona, Hawaii heats up water in a storage tank and then begins to produce electricity. When clouds roll in, the field operator releases the hot water in the storage tank for continued production until the sun reappears. After the sun sets, the operator again opens the storage tank to continue production until hot water from the storage tank is spent.

Sopogy's MicroCSP system provides clean, reliable electricity for the Hawaii Electric Light Company (HELCO). Instead of using batteries or grid consumption as back-up, MicroCSP relies on low cost thermal storage. Large, insulated holding tanks behave like thermoses for hot water. Low cost thermal storage sets MicroCSP apart from photovoltaic and wind systems. Sopogy's MicroCSP is SRCC™ certified [1] and ready for commercialization.

Keywords: solar, thermal, storage, microcsp, electricity

1 MICRO CSP GRID INTEGRATION

MicroCSP is a clean, reliable source of energy delivered through modular, parabolic solar collectors. Sopogy's MicroCSP collectors are twelve feet long, and weigh less than 200 pounds. They are installed on the ground or roof for commercial, industrial and utility projects.

Figure 1: Sopogy's MicroCSP collectors at Holaniku

MicroCSP tracks the sun and concentrates the sun's rays onto a receiver tube. Transfer fluid inside the tube absorbs the solar energy and increases in temperature as it passes through a series of collectors. This hot transfer fluid is clean, renewable fuel.

To generate electricity, heat transfer fluid carries heat from the solar field to Organic Rankine Cycle (ORC) engines. ORCs produce electricity at lower temperatures than traditional concentrated solar power systems. As a result, MicroCSP thermal storage is low cost compared to other renewable energy storage systems, such as batteries and molten salt. Low cost storage increases a MicroCSP plant's capacity factor and allows peak hour production.

In addition to low cost thermal storage, MicroCSP's automated tracking and control system contributes to stable temperatures for electricity production. Stable power generation reduces the risk to utility grids.

Holaniku, the 2-megawatt thermal demonstration plant in Kona, Hawaii, has automated tracking and controls, and two thermal storage tanks. The power generation system includes two 50-kilowatt Electrotherm "Green Machine" ORC engines. HELCO buys Holaniku's electricity through a net metering system. Keahole Solar Power (KSP) operates the plant.

Figure 2: Holaniku 2-megawatt thermal solar field

MicroCSP enables optimal grid integration through combining low cost storage, automatic tracking and temperature controls. Data from Holaniku illustrate MicroCSP grid integration benefits:

- continued electricity production when clouds roll in
- extended production past sunset
- delayed electricity generation to peak hours
- stable electricity generation

1.1 MicroCSP Power Generation System

The MicroCSP solar array heats Xceltherm mineral oil in a closed loop. A heat exchanger transfers heat from the mineral oil to water. The field operator controls hot water flow to thermal storage tanks and the Organic Rankine Cycle (ORC) engines in any combination. The water then flows back to the heat exchanger in another closed loop. As part of the National Energy Laboratories Hawaii Authority (NELHA), cold ocean water cools the plant's ORC engines.

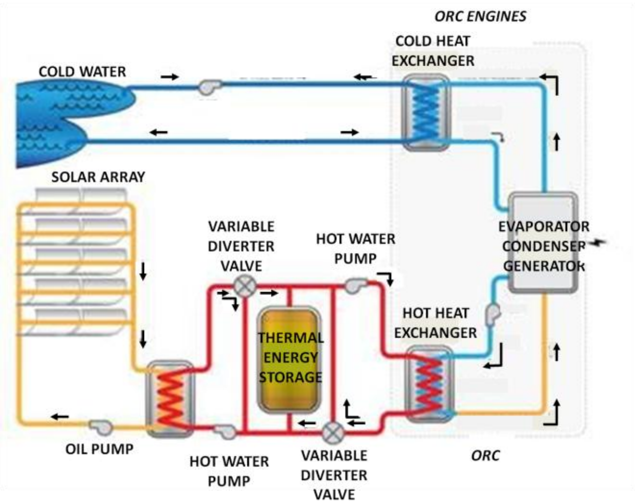

Figure 3: Holaniku Power Generation Schematic

1.2 When Clouds Roll In

As with traditional concentrating solar power technologies, MicroCSP relies on the sun's Direct Normal Irradiance (DNI) for energy. Figures 4 thru 6 show DNI, thermal data from the solar field and net kilowatt data in 15 minute increments from HELCO on July 9, 2011.

The day was sunny with some clouds in the late morning and heavy clouds in the afternoon. The blue line in Figure 4 shows this weather pattern. From 8:30 until 10:40, the sun became stronger with Direct Normal Irradiance (DNI) rising to over 800 watts per square meter. Passing clouds rolled in at 10:40 creating volatile DNI until noon. From noon until 14:40, DNI peaked until overcast clouds blocked DNI to unusable levels at 15:00.

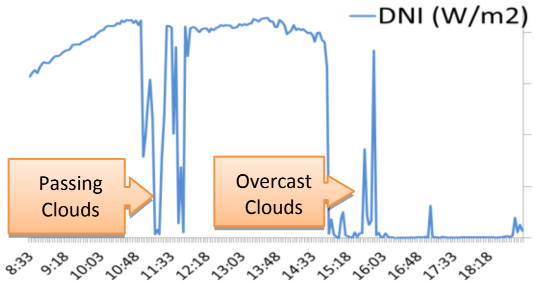

Figure 4: Holaniku Direct Normal Irradiance, July 9, 2011

In Figure 5, the green line associated with the left hand axis shows kilowatts of thermal energy captured by the MicroCSP solar field. With strong DNI, the collectors consistently captured 2,000 kilowatts of thermal energy. When the field clouded over at 10:40 and 14:40, energy capture fell off as expected.

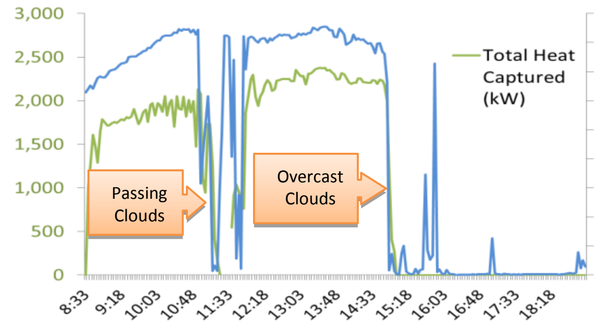

Figure 5: Holaniku DNI and Heat Captured, July 9, 2011

In Figure 6, the red shaded area associated with the left hand axis shows 15-minute net electricity sold to HELCO. The data records energy production from 9:30, about an hour after the collectors began to track the sun. The field operator started the day heating the storage tanks before allowing the ORCs to generate electricity.

Around 10:40, while productive DNI was intermittent due to passing clouds, the ORCs continued to produce electricity steadily with heat from storage. Production dropped slightly at around 11:40 when the field operator directed slightly cooler fluid from the solar field to the ORCs. Energy production came back up to higher levels and continued to climb through the afternoon.

At 14:40, DNI fell dramatically when overcast clouds rolled in. The ORC engines continued to produce electricity for 45 more minutes using stored heat. At 15:30, the field operator turned off one ORC. Electricity production then ramped down with the storage providing heat until 19:00—over four hours after DNI fell to unusable levels. The production ramp-down allows time to notify the utility that production is done for the day.

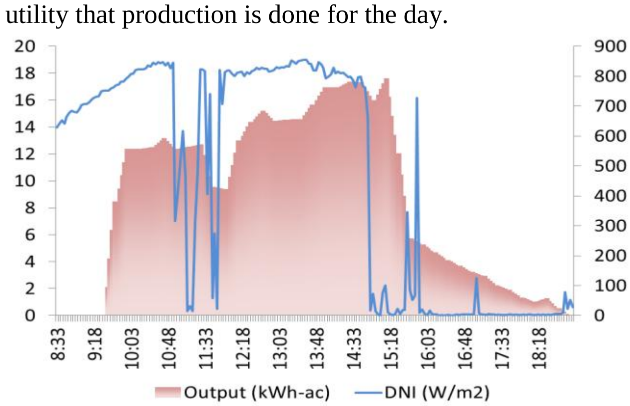

Figure 6: Holaniku DNI and Net Electricity in 15-Minute Intervals, July 9, 2011

1.3 Stabilizing Energy Production

MicroCSP can stabilize electricity production through automated tracking and thermal storage. At Holaniku, the sun heats the solar field to a preselected maximum of 285°F. Receiver tubes carry non-toxic Xceltherm 600 mineral oil that flows through 36 parallel loops of collectors, increasing in temperature until it reaches 285°F. Temperature sensors cause the collector tracking system to automatically defocus and refocus on the sun to maintain the temperature near the set-point.

The zig-zagging red line in Figure 7 shows how automated tracking keeps the solar field's temperature around 285°F.

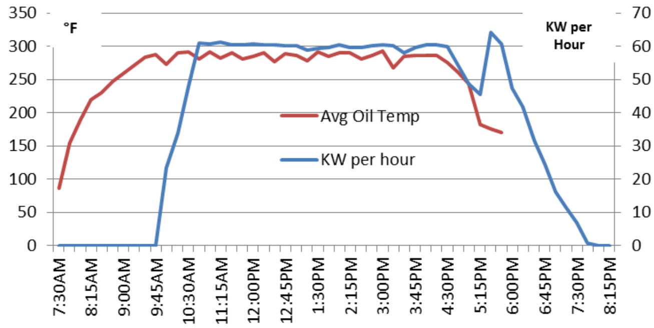

Figure 7: Holaniku DNI and Net Electricity Generation, Aug. 30, 2011

To further stabilize temperatures, a heat exchanger transfers the heat from the mineral oil to water, and the hot water flows to a thermal storage system before it fuels the power blocks and desalination unit.

The blue line in Figure 7 shows net electricity from Holaniku to the utility grid. Production commenced after the storage tanks were heated at around 9:45 AM and was stable from 10:30 to 4:30 PM. Automatic defocusing controls the natural variability of solar energy and thermal storage acts as a buffer to further regulate temperatures for stable power generation.

2 HIGH VALUE GRID INTEGRATION

Relative to intermittant suppliers of energy to the grid, MicroCSP offers high value grid integration. Thermal storage increases a MicroCSP plant's capacity factor and enables energy production during peak hours when kilowatts are most valuable. Automated tracking and controls stabilize production, further reducing risks to the grid associated with intermittancy. MicroCSP technologies eliminate costs associated with intermittant production, including risk management, peaker plant investment and peaker plant start-up and maintenance costs.

Figure 8. Thermal storage at Holaniku, Kona, HI

3 ABOUT SOPOGY

Sopogy stands for SOlar POwer technoloGY. Sopogy develops micro-concentrated solar power technology, or MicroCSP. MicroCSP is a renewable source of energy delivered through modular, parabolic solar collectors. Sopogy's MicroCSP collectors are suitable for installation on the ground or roof top.

REFERENCES

[1] SRCC™ Solar Collector Certification #2010113A, Supplier: Sopogy, Inc.