Commercial and Industrial Thermal Applications of Micro-CSP

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ABSTRACT

MicroCSP delivers heat for industrial and commercial applications in the US, Asia, Latin America and the Middle East. By efficiently and economically replacing and fossil fuels, MicroCSP has created a thermal alternative for on-site, commercial and industrial renewable energy programs. MicroCSP powers new and existing thermal processes, heat exchangers, boiler and air conditioning systems with operating temperatures ranging up to 326°C/620°F.

Solar air conditioning in particular offers significant carbon savings toward sustainability targets. MicroCSP collectors fuel lithium-bromide absorption chillers to provide chilled water to existing ventilation systems. MicroCSP can also offer an elegant architectural statement about sustainability, as demonstrated by the Holcim-Apasco Cement Plant in Hermosillo, Mexico [1]. Sopogy's MicroCSP is SRCC™ certified [2] and ready for commercialization.

Keywords: solar, thermal, air conditioning, microcsp

1 MICRO CSP PROJECTS

According to the U.S. Energy Information Administration (EIA), industrial and commercial sectors consumed 50% of US energy in 2010 [3]. At US Department of Defense facilities, air conditioning alone accounts for 30-60% of total energy expenditures [4]. Sopogy's MicroCSP projects demonstrate how decision-makers can hedge energy costs, take advantage of renewable energy incentives and create a more sustainable future through solar thermal process heat, hot water and air conditioning.

1.1. MicroCSP Air Conditioning

A southern California utility tests a ten-ton solar air conditioning system powered by different solar thermal technologies at a local facility. MicroCSP passed successfully.

In 2009, the Los Angeles Times [5] covered the story: nine MicroCSP collectors installed on the roof of the utility company's research center. The collectors heat water to between 190°F and 203°F at a flow rate of between 8 to 9 gallons per minute. The single effect lithium bromide absorption chiller converts this thermal energy into chilled water that flows into the building's ventilation system. The collectors operate at 58-63% efficiency at this temperature range and design flow. They occupy 918 square feet on the rooftop.

The MicroCSP solar air conditioning system has strength in its simplicity. Single-axis parabolic trough collectors track the sun automatically and concentrate the its rays onto a receiver tube. Transfer fluid, in this case water, flows through the array and heats to 203°F. This water is clean, renewable fuel for the absorption chiller.

Figure 1: MicroCSP tracking sun in southern California to partially fuel a solar air conditioning system

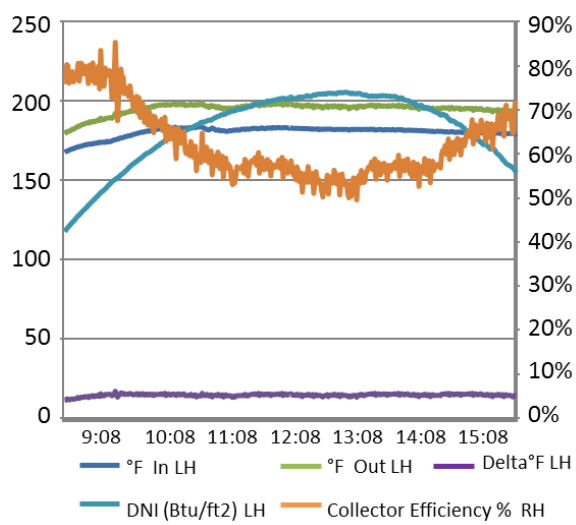

Figure 2: MicroCSP test data on September 24, 2009. Source: A utility company in southern California

Data from the southern California utility in Figure 2 show MicroCSP performance on a typical sunny day. The light blue curved line shows direct normal irradiance (DNI) rising in the morning and falling off in the afternoon. MicroCSP collector efficiency, represented by the jagged gold line, decreases at around 10:00, just as temperatures out of the solar array achieve the desired range, between 190°F and 203°F. Efficiency decreases because the automated tracking system de-focuses the collectors, automatically managing the temperature to keep it in the desired range.

The green line shows the temperatures out of the MicroCSP collectors. Absorption chillers appreciate a stable heat source, operating most efficiently when the collectors deliver the set temperature range continuously. Instead of straining under the heat like grid-based, electrical air conditioning, absorption chillers flex their muscles in the summer. The hotter the sun, the more efficient the solar air conditioning system.

Absorption chillers traditionally run on natural gas, bunker oil or diesel fuel. MicroCSP is a green alternative to these fossil fuels that can be used as back up, when the weather is not cooperative. Absorption chiller manufacturers include: Broad, Thermax, York, Carrier, Yazaki and Century.

MicroCSP air conditioning systems are economically viable in the 100 ton range and above. Test systems proving the technical feasilility of MicroCSP are running in California [5]; Fort Bliss, Texas [6]; Masdar City, Abu Dhabi [7]; Karak, Jordan; and Hermosillo, Mexico [1].

Figure 3: MicroCSP collectors on roof of Holcim-Apasco Cement Building in Hermosillo, Mexico

1.2 Industrial Process Heat and Hot Water

Sopogy's MicroCSP collectors capture about 60% of the sun's energy. Automated controls, thermal storage and heat exchangers stabilize naturally varying solar thermal energy for industrial process heat.

At Holaniku, the 2 megawatt thermal MicroCSP plant in Kona, Hawaii, the sun heats the solar field to 285°F with a flow rate of over 250 gallons per minute. Automated controls monitor MicroCSP solar collectors as they track the sun and concentrate its heat energy onto receiver tubes. At Holaniku, receiver tubes carry non-toxic Xceltherm 600 mineral oil.

Figure 4: Holaniku, 2 Megawatt Thermal MicroCSP Demonstration Plant in Kona, Hawaii

The mineral oil flows through 36 parallel loops of collectors, increasing in temperature until it reaches a preselected maximum of 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. To further stabilize process heat 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.

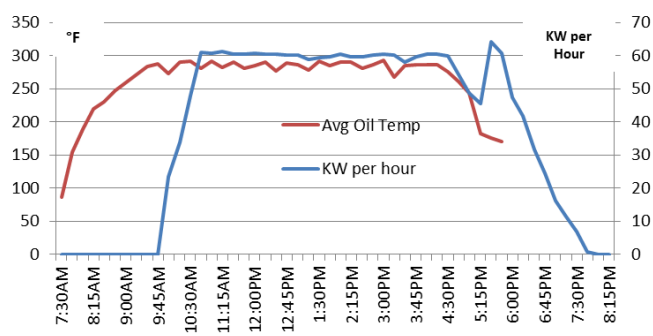

Figure 5: Holaniku Power Generation, August 30, 2011
Avg Oil Temp=average temperature of oil from solar field.
Source: Keahole Solar Power
Kilowatts per hour=Net electricity to Grid.
Source: HELCO

To demonstrate higher temperature capabilities, the operator increased the solar field set-point temperature to 482°F (250°C) on June 6, 2010. He configured a loop of 56 SopoNova collectors and set the mineral oil flow rate to 6 gallons per minute.

With Direct Normal Irradiance (DNI) of 630-730 watts per square meter, the mineral oil reached the target temperature in 50 minutes. Automatic controls maintained temperatures near 482°F for an hour (see Figure 6). Design limits of this installation prohibited taking temperatures to the higher SopoNova maximum of 518°F (270°C).

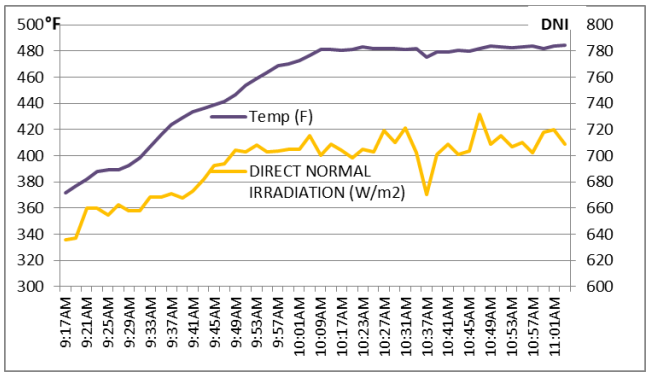

Figure 6: Holaniku High Temperature Demonstration, June 6, 2010. Source: Sopogy

Most industrial and commercial hot water and process heat systems are economically viable. The California Solar Initiative and other state subsidies make these systems even more attractive. Pay back periods of less than three years are common.

1.3. MicroCSP Hot Water in Japan

An industrial hot water test in Japan continues to deliver satisfactory results. Twenty-four collectors heat water from 15°C to 150°C just outside of Tokyo. In this system, mineral oil, the heat transfer fluid, flows at 8 gallons per minute through the collectors to a heat exchanger. While Japan is not traditionally recognized as market for concentrated solar power, direct normal irradiance (DNI) is proving to be sufficient for hot water at industrial volumes.

1.4. MicroCSP Process Heat for Hawaii Oil Refinery

Due to limited availability of natural gas, oil refineries in the Asian-Pacific region burn Bunker B/Diesel fuels in the refinery boiler to create steam. The current cost runs at approximately $66.28 per ton of steam.

MicroCSP can reduce refinery operational costs to approximately $22 to $30 per ton of steam at locations with a direct normal irradiance (DNI) of 5.5 to 7.5, respectively.

Sopogy proposes to deploy its highly efficient, SopoTitan parabolic trough solar collector to produce refinery grade, 150 pound steam through concentrated solar power. The demonstration project for the new collector will include 95% efficient thin-glass for the reflective material. MicroCSP will reduce the amount of diesel burned at the Chevron Refinery on Oahu, Hawaii by creating approximately 48,515,701 lbs of steam per year.

This project will: 1) determine the feasibility of applying solar technologies for process heat opportunities in refinery locations worldwide; 2) analyze how a variable heat/energy source interacts in a continuous manufacturing operation; and 3) evaluate the use of thermal storage to create smooth production of steam.

1.5. MicroCSP Hot Water for Tuna Factory in Papua New Guinea

On the coast of Lae City in Papua New Guinea, the Frabelle Tuna company is installing 480 MicroCSP collectors on the roof of its new facility.

The MicroCSP system will provide hot water at 98°C for thawing, pre-heating a boiler for pre-cooking, and can washing during the tuna packing process.


Figure 7: Solar hot water and process heat installation, Frabelle tuna factory, Oct. 2011, Papua New Guinea

1.6. MicroCSP Tri-Generation: Electricity, Air Conditioning and Hot Water, Mu'tah University, Karak, Jordan

The Kingdom of Jordan has granted research funding to Mu'tah University to study tri-generation concepts with concentrated solar collectors. Researchers have installed MicroCSP collectors to generate electricity via a back-pressure type steam turbine. The steam exhaust from the turbine will then operate an absorption chiller, and the remaining thermal energy will heat water for domestic use.

Figure 8: Mu'tah University, Karak Jordan. MicroCSP installation for tri-generation project: electricity, air conditioning and domestic hot water. October 2011

2 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.

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[6] Fort Bliss: Ground-Zero for Net Zero

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