Sopogy's MicroCSP

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ABSTRACT

Sopogy's micro-concentrated solar power technology, MicroCSP, launched in 2006 is now generating electricity, hot water and air conditioning at demonstration sites around the world. Sopogy's demonstration projects validate MicroCSP's place in the world's renewable energy portfolio. They are economically and politically viable with "fabless" manufacturing minimizing costs, and simple installation enabling local job creation. MicroCSP collectors are modular and suitable for roof top or ground mounting. This flexibility solves a wide range of renewable energy requirements in power generation, air conditioning and process heat. In addition, low cost thermal storage stabilizes energy production, setting MicroCSP apart from photovoltaic and wind power. Sopogy's MicroCSP is SRCC™ certified [1] and ready for commercialization.

Keywords: solar, thermal, storage, microcsp, electricity

1 SOPOGY'S MICRO CSP

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.

Specifications (SopoNova)	Metric	Standard
Collector Length Collector	3.657 m	12 ft
Width	1.65 m	5.4 ft
Collector Area (gross)	6.03 m²	65 ft²
Collector Area (net)	5.21 m²	56.04 ft²
Heat Collection Element, O.D.	25 mm	1 inch
Heat Transfer Fluid Capacity	2.098 ltr	0.554 gal
Recommended Flow Rate	22.7-45.4 ltr/min	6-12 gal/min
Operating Temperature Range	50-270°C	122-518°F
Collector Weight	68 kg	150 lbs
Focal Length	304.8 mm	12 inch
Ambient Operating Temp	-10 to 50°C	14 to 122°F
Max Wind Speed (stowed)	169 km/h	105 mph
Max Wind Speed (tracking)	54 km/h	33 mph
Useful Life Expectancy	30 + years	30 + years

Figure 1: Local labor installing MicroCSP collectors at Davis-Monthan Air Force Base in Arizona.

1.1. How MicroCSP Works

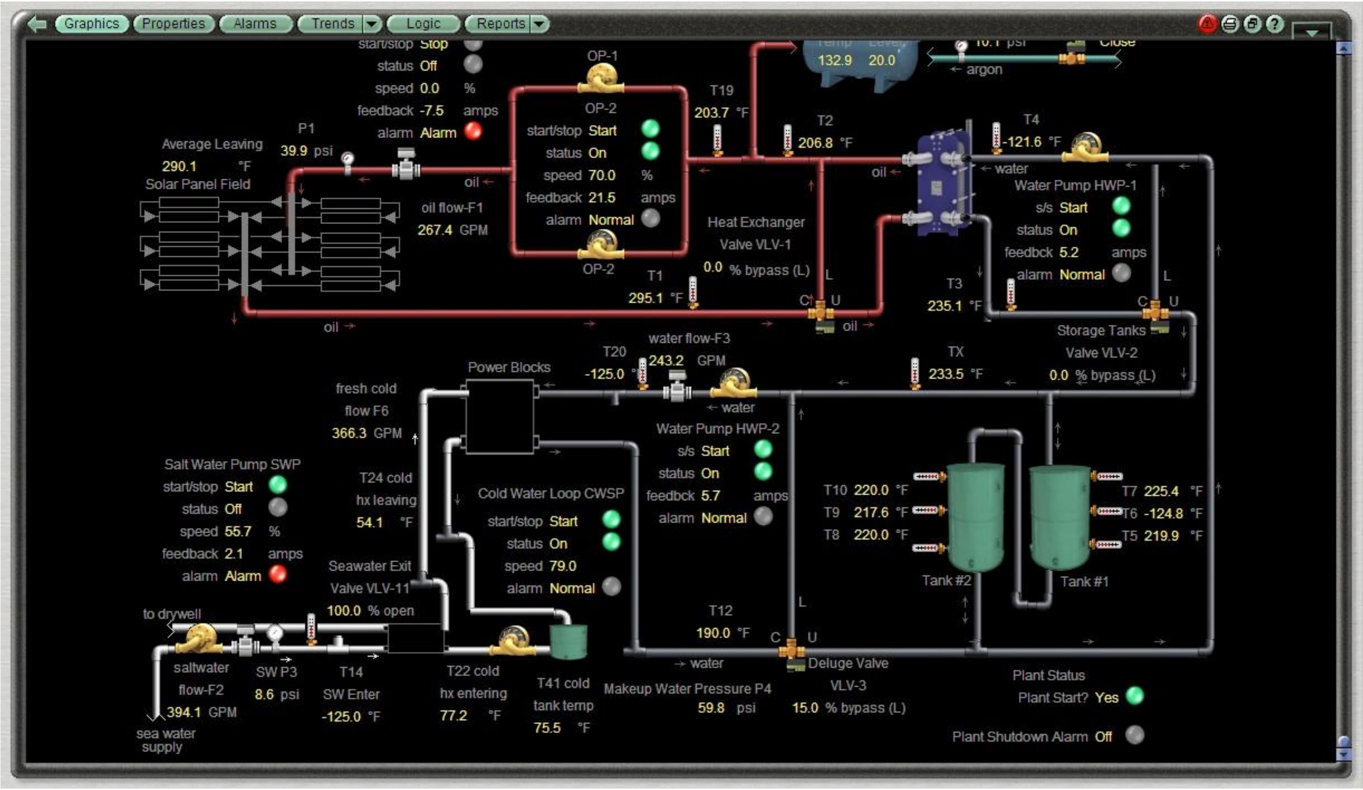
As with traditional CSP collectors, MicroCSP tracks the sun and concentrates the sun's rays onto a receiver tube. Transfer fluid inside the tube absorbs the solar energy and increases in temperature as it passes through a series of collectors. This hot transfer fluid is clean, renewable fuel. Instead of burning fossil fuels, MicroCSP uses solar power to generate electricity, air conditioning and process heat.

1.2. Tracking and Control Software

Sopogy's tracking and field control software, SopoSoft, optimizes field operations by tracking the sun to maximize the sun angle for any location, simplifying integration of the solar field with the balance of plant, and guarding against wind, rain, power loss, no flow and over temperature issues. SopoSoft also produces and aggregates operational data.

SopoSoft's interface provides a holistic view of solar field operations in a user friendly manner. Sopogy trains users to understand the conditions that will impact the solar field, the importance of the sensors that monitor the system and where they can find the sensors on the physical installation. The operator gains a full grasp of the controls available to optimize energy production.

Figure 2. SopoSoft interface from Holaniku, Kona, HI.



1.3. Thermal Storage

Instead of using batteries or grid consumption as back-up, MicroCSP relies on low cost thermal storage. How does this storage work in practice? On a typical sunny day, with clouds in the late morning, the solar field heats up water to fill a storage tank and begins production. When clouds roll in, the field operator opens the storage tank to release hot water 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.

Low cost thermal storage is a prime advantage of MicroCSP. It sets MicroCSP apart from photovoltaic, traditional CSP and wind systems.

Figure 4. Thermal storage at Holaniku, Kona, HI

1.4. OEM Thermal Equipment

Readily available original equipment manufacturers' heat exchangers, power blocks, desalination units and absorption chillers, traditionally reliant on thermal energy from fossil fuels, work well with MicroCSP collectors. Sopogy's installations have relied on OEM equipment from Broad, York, Yazaki, Turboden, Electrotherm, Calnetix and MAGE. Instead of burning fossil fuels, MicroCSP delivers clean solar energy to power these machines.

1.5. "Fabless" Manufacturing & Local Labor

Sopogy uses conventional manufacturing processes and materials—70% of the product can be made anywhere. This "fabless" manufacturing enables indigenous production, creating local jobs, reducing tariffs and freight costs, and encouraging political good will.

Sopogy trains local, unskilled workers to assemble MicroCSP solar installations on site. A Sopogy project engineer spends a week installing one row of MicroCSP collectors alongside the work force. This has proven sufficient for completion of entire fields. Once a solar field is complete, Sopogy returns to inspect the work, install controls and commission the field.

1.6. Portable

Sopogy designed a mobile data acquisition system to assess the quality of solar resources at a particular site. By measuring and tracking temperature gain, flow velocities, DNI, wind speed, rainfall and ambient temperature, SopoLite—for SOlar POwer satelLITE—enables analysis of the site's energy potential.

2 MicroCSP INSTALLATIONS

Since 2008, Sopogy's MicroCSP collectors have harnessed solar heat for solar air conditioning, electricity, process heat and desalination projects around the world.

Project	Energy	Application
Holaniku, HI	2 MWt	Electricity+Desal
Kalaeloa, HI	4MWe	Electricity
Mutah Univ, Jordan	80kWt	Electricity+A/C +Hot Water
Eckerd College, FL	40 kWt	Process Heat
Tokyo, Japan	40 kWt	Process Heat
Lae City, Papua New Guinea	1.3MWt	Process Heat
Masdar City, UAE	40 ton	Air Conditioning
Davis-Monthan, AZ	40 ton	Air Conditioning
Hermosillo, Mexico	75 ton	Air Conditioning
Fort Bliss, TX	50 ton	Air Conditioning
Palm Springs, CA	40 ton	Air Conditioning
Maui, HI	20 ton	Air Conditioning
Sempra, Downey, CA	10 ton	Air Conditioning
Eichler, CA	3 kWt	Pool Heater
Al-Raed, Egypt		Desalination
Energy Industries, HI	4 kWt	Thermal Energy
Rathdrum, ID	84kWt	Process Heat
Inypsa, Spain	5 kWt	Thermal Energy

2.1 Field Sizing

Land requirements for MicroCSP are more on par with photovoltaic panels than traditional CSP systems. Sempra Utilities installed a 9-collector MicroCSP array on the roof of their Energy Resources Center. (Figure 1). Sopogy's largest field to date is the 34-acre, 4-megawatt Kalaeloa Solar One electricity plant on Oahu, Hawaii, currently under construction.

The size of each solar field depends on the field's direct normal irradiance (DNI), OEM unit requirements, and other relevant factors. For example, a 40 kilowatt thermal field in Japan comprises 24 collectors, while a 52 kilowatt thermal field in Florida required 20 collectors.

2.2 Direct Normal Irradiance (DNI) and Other Environmental Factors

Direct Normal Irradiance, commonly measured in watts per square meter per day averaged over a year, is the single most important requirement for solar thermal energy. MicroCSP can generate energy withing a broad DNI range. One successful MicroCSP project has DNI as low as 256 watts per m^2 per day. Some other critical environmental factors that affect the DNI are aerosol (dust) and water molecules in the atmosphere. In addition to DNI, wind and ambient air temperature are the critical factors for MicroCSP energy production.

MicroCSP depends on direct normal irradiance, not diffused irradiance. One rule of thumb gauge of DNI is the clarity of shadows. If shadow lines are hard and clear, then direct normal irradiance is strong. If shadow lines are weak, than light is due to diffused irradiance.

2.3 Optional: Water for Cooling

The efficiency of power blocks, desalination units and absorption chillers largely depends on temperature differences in the production process. Holaniku , the 2-megawatt thermal plant in Kona, uses ocean water to cool ORC engines and desalination unit. Alternatively, cooling towers—often built within thermal machinery—are sufficient. The air conditioning system at Davis-Monthan Air Force Base uses a Broad absorption chiller with an inbuilt cooling tower.

2.4 Optional: Roof Top Installation

Sopogy's roof top installations save land, and can make strong architectural statements for sustainability. The Holcim Apasco building in Hermosillo, Mexico included MicroCSP in its design. It was sponsored by the Holcim Foundation for Sustainable Construction. The collectors fuel the building's 75 ton solar air conditioning system.

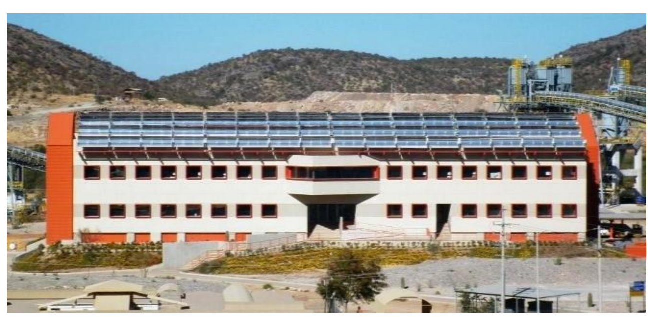


Figure 5. Holcim Apasco's roof top MicroCSP installation

Roof top installations require either a parapet or mechanical screen as a wind barrier.

3 APPLICATIONS

3.1 Electricity Generation

Sopogy's MicroCSP technology generates electricity through Organic Rankine Cycle (ORC) engines manufactured by Electrotherm, Turboden and Calnetix. ORC engines are similar to steam turbine engines but for the use of organic fluid in place of water. Fluids in ORCs are organic with high molecular mass, and boiling points lower than 100°C. In addition to solar thermal plants, ORCs generate power in waste heat recovery, biomass and geothermal power generation plants.

Holaniku, the 2 megawatt thermal plant in Kona, Hawaii has two 50 kilowatt Electrotherm ORC "Green Machines" (Figure 6) and a 150 kilowatt Calnetix ORC engine. Thermal storage enables control of energy delivered to the grid to help the utility maintain stability.

Fig 6. Electrotherm Green Machines, Holaniku, Kona, HI

The 4 megawatt Kalaeloa Solar I on Oahu will have two Turboden 2.75 megawatt ORCs, and thermal storage. Plant construction is underway for completion in 2012.

3.2 Solar Air Conditioning

The US Department of Defense is Sopogy's first repeat customer for solar air conditioning. A 40 ton air conditioning system will chill the Youth Center at Davis-Monthan Air Force Base this summer, while another 40 ton system chills the military dining facility at Fort Bliss in El Paso, Texas. In addition to the DOD, Holcim and Sempra Utilities, cited above, Mutah University in Jordan, Masdar City in the UAE, the Palm Spring Air Museum and the Maui Ocean Center in Hawaii have installed, or are installing, solar air conditioning systems using single or dual effect absorption chillers.

Absorption chillers rely on MicroCSP, or other source of heat, in combination with principles of evaporation, absorption and regeneration. The Southern California Gas Company has recently invested in Sopogy because natural gas is an ideal back-up heat source for solar air conditioning systems in Southern California.

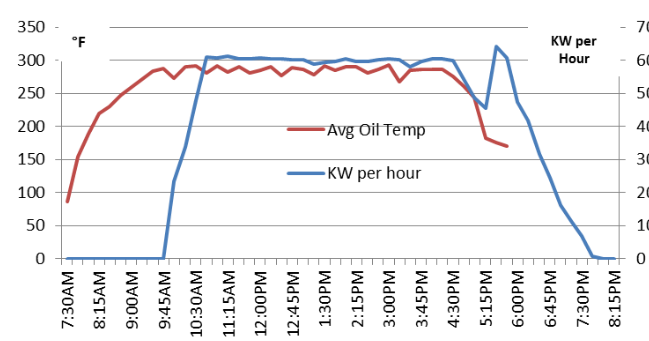
3.3 Industrial Process Heat and Hot Water

Sopogy's MicroCSP collectors capture 59% of the sun's energy [1]. 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.

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 7: 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



REFERENCES

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