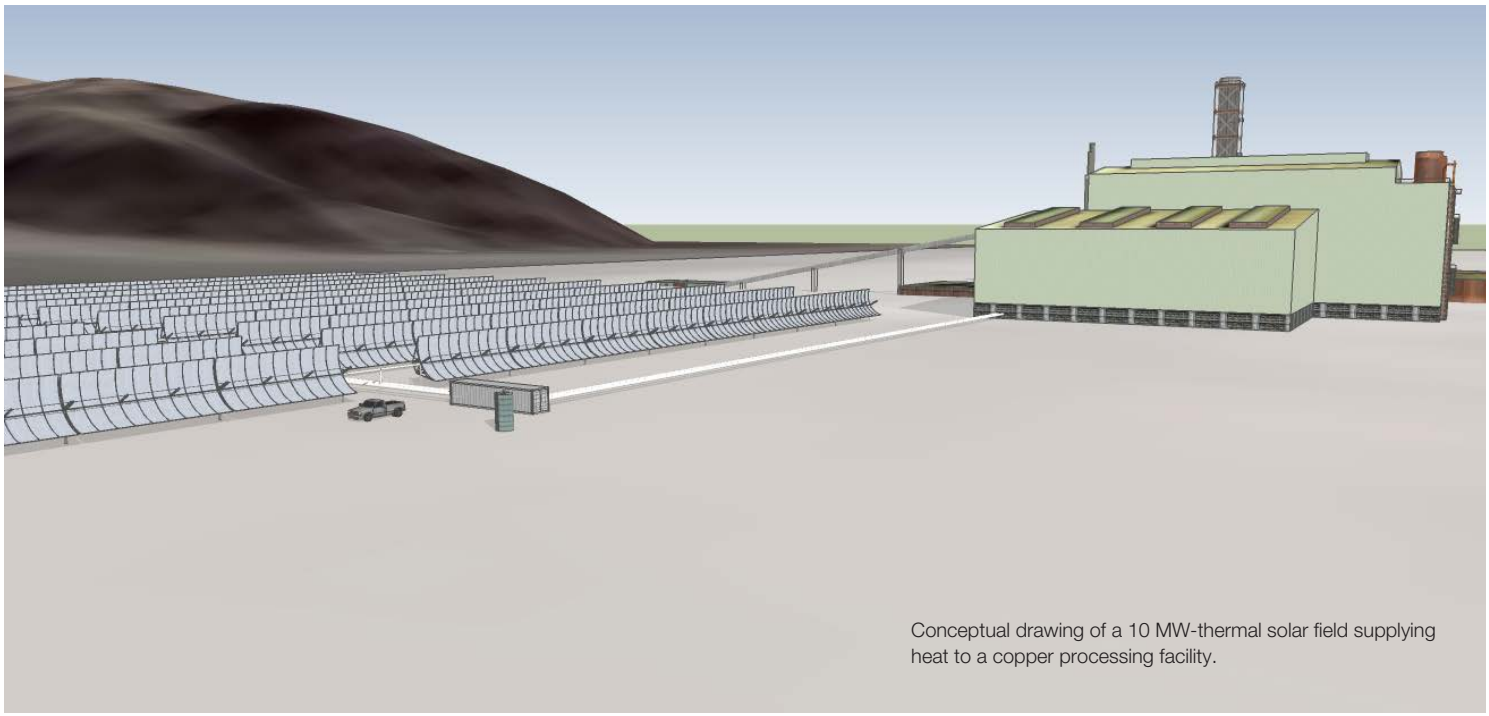
SkyFuel White Paper

Mining FuelSaver™

Solar Thermal Integration Into Mining Processes



Conceptual drawing of a 10 MW-thermal solar field supplying heat to a copper processing facility.

Solar Heat and Power for the Mining Sector

Parabolic trough solar concentrators have been used to make steam for utility electric generation for over thirty years. Solar thermal energy can also be used in the evaporation cycles of desalination plants, enhanced oil and gas recovery systems, and heated industrial processes. SkyFuel's parabolic trough technology, the SkyTrough®, is uniquely suited to such diverse applications due to its high performance, low cost, and simple assembly which makes it effective at any plant size.

How it works

The curved SkyTrough® reflectors follow the sun through the sky and concentrate sunlight onto a thermal receiver. A heat transfer fluid (HTF) is pumped through the receivers and collects heat which is then transferred to the system's working fluid (often water) in a heat exchanger. The heated working fluid can then be used to drive a turbine generator and/or for industrial process heat. Thermal storage can be added to the system for generation at night or during cloudy periods.

Parabolic Trough Solar Concentrator (SkyTrough®)

Organic Rankine Cycle (ORC) Turbine Generator (Turboden)

Advantages for Mines

Mines are often located remotely where fuel must be delivered at high cost, and sometimes with poor reliability. Remote operations replacing a portion of their energy needs with solar can benefit from:

- Clean, independent, and stable power
- Reduced reliance on local energy sources
- Less exposure to fuel price volatility
- Uncomplicated and automated operation

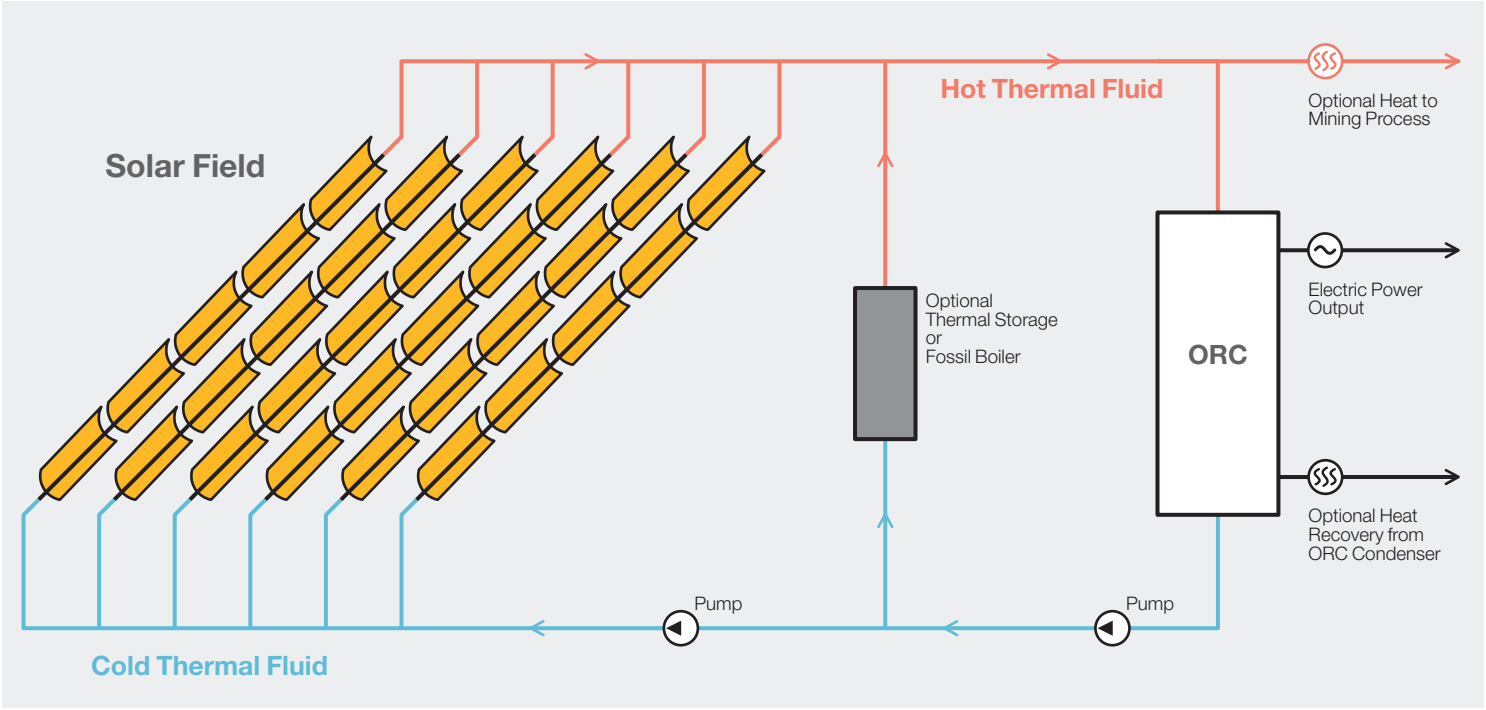
Solar thermal systems can be integrated seamlessly with existing mining processes with no disruption to standard operation.

Example: Chilean Mining Operations with Solar Thermal Systems

- Minera El Tesoro – Parabolic trough System with three 100m^3 storage tanks, replacing 55 % of existing diesel use
- Minera Gaby – Parabolic trough system expected to reduce energy costs by $7 mm annually
- Minera Constanza – Flat plate collectors generating 540MWh annually.

Mining Application Example

Mining operations have requirements for both electricity and heat to run equipment and accelerate extraction processes. Heat can be supplied from SkyTrough® solar collectors at temperatures up to 400° C, and this heat can be used directly in the extraction process or to generate electricity by means of a modular Organic Rankine Cycle (ORC) turbine generator. A thermal fluid (water, mineral oil, or synthetic oil) is circulated in a closed loop through the SkyTrough's receivers, and the heat collected is transferred to the process fluid through a heat exchanger. Additional heat can also be recovered from the ORC's condenser.

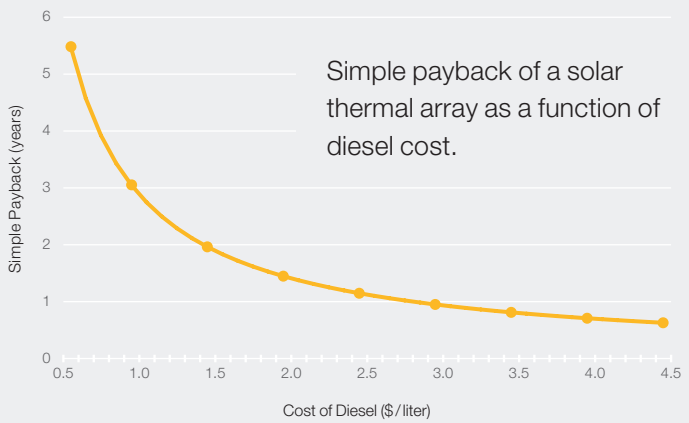


Schematic of Solar Thermal Integration with Mining Operation

In the example illustrated above, heat from the solar field could be stored for later use; augmented by a fuel fired boiler; or supplied to an ORC turbine generator to produce electricity. The curve to the right represents how many years it takes for a 14 MW-thermal solar system to pay back the cost of investment when offsetting the purchase of delivered diesel fuel.

Example System Specification

Solar field size (MW-thermal):	14
Diesel-fired boiler output per year (MWh):	120,000
Solar field output per year, 12 hours of thermal storage (MWh):	80,000
Ratio of solar field output to boiler output:	67 %
Diesel saved per year (liters):	7,500,000



Simple payback of a solar thermal array as a function of diesel cost.

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