

## Optimising performance of integrated solar combined-cycle power plants

*Providing expert design and analysis services to proponents or operators of integrated solar combined-cycle power plants*

### Challenges

Proponents and operators of solar integrated plants face complex challenges in determining and optimising the performance of their plants. Location, time-of-day, weather and design of the solar collector system have an impact on plant performance.

A solar plant's effectiveness in improving a conventional power plant's efficiency also depends on how the two plants are connected. Supplying solar-heated steam at low temperatures will achieve very little increase in output. Supplying steam at higher temperatures, while more effective, can reduce the solar collector's efficiency and increase its cost. The challenge is determining the unique optimum arrangement for a particular installation.

### Solutions

HRL's Process Design Team provides expert design services to those proposing new integrated solar thermal power plants. The team also provides expert analytical services to operators of integrated solar plant. The team draws on many years of experience in using the ThermoFlow suite of software to design and analyse conventional and gas turbine combined cycle power plants. These skills can also be drawn on to model power plants that include solar thermal collector systems.

The ThermoFlow programs the HRL team uses in its expert design and modelled services for conventional and gas turbine combined-cycle power plants include Steam Pro, Steam Master, GT Pro and GT Master. Such designs can be imported into a ThermoFlex model containing solar collector and thermal storage models. Within the modelling software, solar devices can be connected to a power plant model and to determine overall performance under a wide range of conditions. If required, models can be designed using only ThermoFlex.



A field of parabolic trough solar collectors

### Benefits

In providing clients with expert design and analysis services – for assessing conventional and gas turbine plants with, or without, solar collectors – HRL Technology Group's Process Design Team provides numerous benefits including:

- expert services from experienced personnel
- fast design and analysis services
- accurate, authoritative and independent design and analysis services
- plant operation results that can be combined with EEO (Energy Efficiency Opportunities program) and greenhouse credits assessment to produce accurate financial modelling
- quick evaluation of the impact of adding solar collector systems to power plants
- assessing plant performance using biomass fuels.

## Modelling a gas turbine combined cycle plant coupled to a solar thermal steam generator capable of producing partially superheated high pressure steam

The parabolic trough solar-field heats a thermal oil which is pumped through a series shell and tube heat exchangers which preheat feedwater, generate steam, and superheat steam. The thermal oil temperatures are limited to about 400 °C thereby requiring final superheating of the steam in the heat recovery steam generator (HRSG). The solar generator receives partially preheated feedwater from the HRSG, and returns superheated steam which is mixed with high pressure (HP) steam exiting the first superheater (HPSO). The mixture is superheated to final steam turbine throttle conditions of approximately 550 °C.

Modelling suggests the solar field can contribute approximately 6.5 per cent of total plant power adding some 3.9 percentage points to plant efficiency. The modest improvements come with little impact on the combined cycle operation. Solar systems making a greater contribution add complexity to plant design and to plant operation in non-solar mode. In addition to calculating plant performance, the modelling also provides an estimate of plant cost.

## Modelling a solar collector with thermal storage integrated with a conventional steam plant

A field of parabolic trough solar collectors is used to heat thermal oil which is then stored in a thermally stratified tank. A 'solar boiler' generates steam by cooling thermal oil, drawn from the storage tank, in a series of tube and shell heat exchangers. The steam feeds a Rankine cycle power plant.

The tank's performance is modelled using sources and sinks. The solar field is fed from a source at 295 °C representing the cold bottom of the tank. Heated oil from the solar field is fed into a sink formed in the top of the tank. Hot liquid for the steam generator is drawn from the top of the tank and cool thermal oil is returned to the bottom of the tank.

The model, in conjunction with an E-LINK workbook, is used to analyse system operation over daily cycles throughout the year. The modelling also provides an estimate of the cost to construct the plant.

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The company's NATA Accredited Laboratories number is 561.

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