PROJECT SUMMARY

200 MW PIONEER SOLAR CONCENTRATED SOLAR POWER PROJECT CONCEPTUAL DESIGN, COST ESTIMATE AND SPECIFICATIONS

PROJECT SUMMARY

Bridgestone Associates prepared a complete conceptual design, preliminary layouts, preliminary specifications and a detailed cost estimate for a planned 200 MW concentrating solar power (CSP) plant with minimum 3 hours of thermal storage located at high elevation in Colorado, USA.

PROJECT STATISTICS

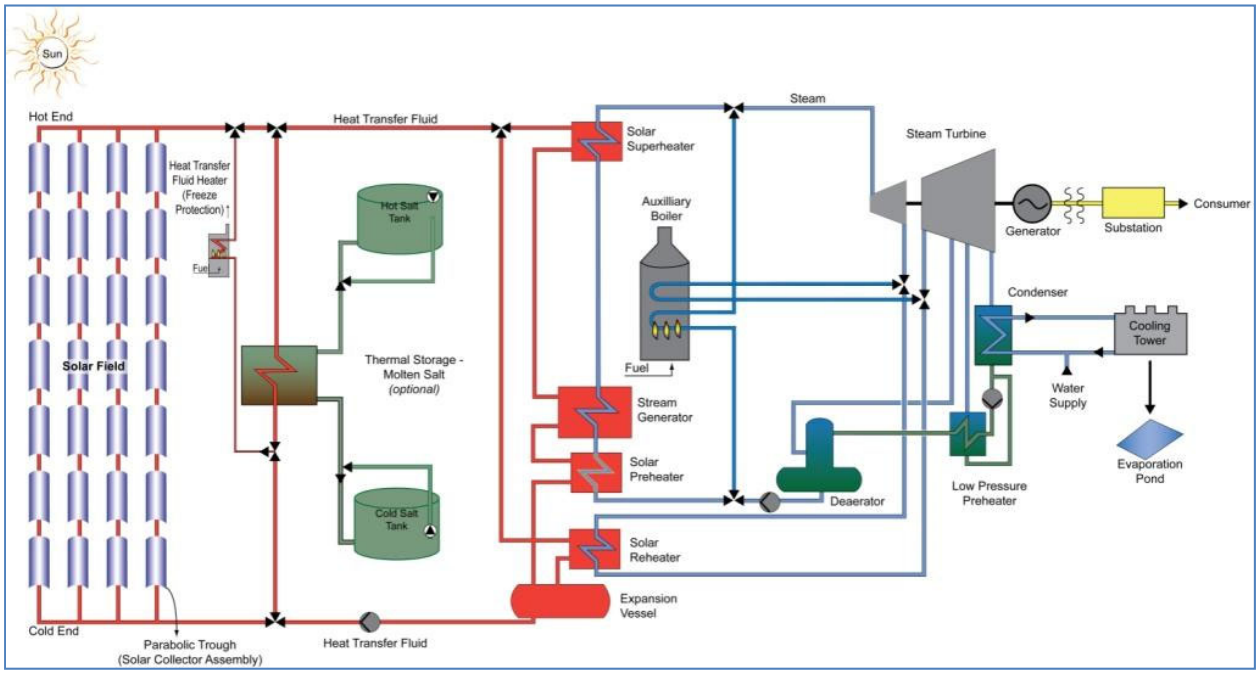
Client:	Renewable Energy Systems Americas
Project Type:	Parabolic Trough CSP Plant Conceptual Design, Cost Estimate, Specifications
Size:	200 MWe at interconnection point
Design Conditions:	85 ^{o}F and 40% RH
Unit Sizes:	2 x 100 MWe to allow phased construction
Thermal Storage:	3 hours minimum at full load using molten salts (60% $NaNO_2$, 40% KNO_2)
Estimated Turnkey Cost:	US$1.208 billion (with evaporative cooling with thermal storage) US$786 million (with evaporative cooling without thermal storage) US$1.238 billion (with dry cooling with thermal storage) US$816 million (with dry cooling without thermal storage)
Plant Location:	Southern Colorado, USA
Plant Elevation:	7,576 feet above sea level
Interconnection Voltage:	230 kV
Auxiliary Back-up:	Natural gas < 25% output
Cooling:	Evaporative with Dry or Hybrid option
Thermal Transfer Fluid:	Therminol VP-1
Parabolic Trough Supplier:	SykTrough by SkyFuel
Heat Exchanger Supplier:	Foster Wheeler
Thermal Storage Supplier:	Yuba Heat Transfer/Alfa Laval/Foster Wheeler
Steam Turbine Generator:	Siemens

PROJECT DESCRIPTION

A complete conceptual design, plant specification, plant performance and cost estimate for this 200 MW CSP plant was developed for the client. The plant design included molten salt thermal storage capable of providing full rated power for over 3 hours with no solar input. The plant design also included

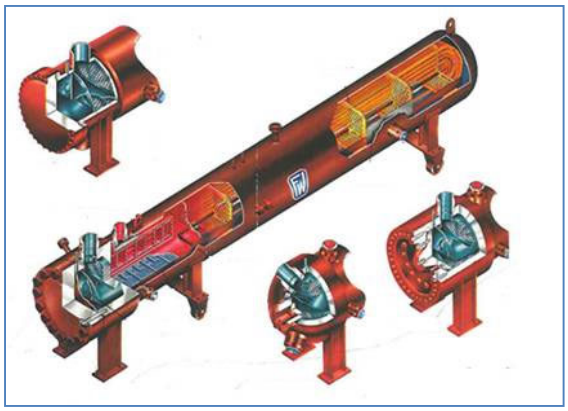
alternatives with traditional water cooled cooling towers; hybrid (water/air) cooling towers; complete waterless cooling; multiple and a single steam turbine-generator. The favoured design was based on two identical 100 MW power islands capable of being developed and constructed in phases.

The plant will be connected to the local utility at 230 kV via a 4 mile 230 kV transmission line included in the plant design prepared by Bridgestone Associates. Also included were the 230 kV interconnection substation, 16/230 kV generator substation, and plant auxiliary substation designs.



The plant will be located at a high (7,500 ft approx) elevation in the Rocky Mountains. This elevation results in specific issues relating to low nighttime temperatures. The thermal heat transfer fluid (Therminol VP-1) freeze point is well above the average nighttime ambient temperature throughout much of the year, so freeze protection and back-up thermal sources were an integral part of the design. Detailed evaluation was required on thermal insulation alternatives, freeze protection, thermal fluid drainage systems and back-up thermal sources in order to understand freeze risks and develop appropriate mitigation measures.

The plant design includes thermal storage for a minimum of three hours at full rated output. The thermal storage selected was molten salts using 60% Sodium Nitrate ($NaNO_2$) and 40% Potassium Nitrate (KNO_2). As there are very few examples of this technology in successful operation, a great deal of investigation was required to develop the best approach and reasonable estimates of cost and performance. Specific activities included identification of manufacturers capable of providing the equipment,



system design, estimation of system performance, system operations and maintenance, initial startup (75 days to melt the salts), and safety issues.

Detailed performance runs (heat balances) were prepared for all different design scenarios, as well as full and partial loads and nighttime operation. These heat balances and performance runs were used as the basis for economic feasibility analysis.

Because of the location, water availability and usage is of key importance. Considerable investigation was undertaken on dry versus evaporative versus hybrid (including Heller) cooling systems for the steam turbines as well as minimization of other water uses (including re-cycling) for such things as mirror cleaning. A detailed evaluation of water treatment alternatives was undertaken.

A detailed capital cost estimate with over 750 line items was prepared. This estimate was based on budget proposals and costs from equipment vendors for all major components as well as estimates based on industry data adjusted for local conditions, productivity and prevailing labour costs. Capital costs were compared against the limited data available in the solar industry for other CSP plants.

In addition to the detailed cost estimate and performance, layout drawings, general arrangement drawings, electrical one-line drawings and P&ID's were all prepared. Also prepared were a write-up of the plant design and major component specifications, an outline plan for plant operations and maintenance, an outline construction plan, a project construction schedule, and an operations and maintenance cost estimate. All were to be used by the client in a proposal being prepared.

The work performed by Bridgestone Associates was completed on time and on budget.