Success Story

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CENTUM VP Controls BOP of 100-MW CSP Plant in South Africa

Xina Solar One RF (Pty) Ltd.

Location:	**Northern Cape Province, South Africa**
Plant type:	**Concentrated solar power (CSP) plant + molten salt thermal energy storage**
Capacity:	**100 MW | 5.5 hours of storage**
Project type:	**Greenfield**
Completion:	**2017**
Scope:	**DCS for balance of plant (BOP)**
Industry:	**Renewable Energy**

Executive Summary

The project
The Xina Solar One project is the third project executed in South Africa by Abengoa, S.A., a world leader in CSP technology. This solar power plant generates clean energy for 95,000 homes while aiming to reduce its carbon dioxide footprint by 348,000 tons per year.

Xina Solar One is a state-of-the-art project using parabolic troughs and a five-hour thermal energy storage system using molten salt. The parabolic trough technology employs parabolic-shaped mirrors mounted on a structure that tracks the movement of the sun and concentrates the solar radiation onto a receiving tube. A heat absorbing fluid flows inside the tube, reaching a high temperature. The fluid transfers the thermal energy to a heat exchanger, which is used to heat water and convert it to steam, which then drives a turbine to generate electricity.

For the BOP, power generation is completed with a steam rankine power cycle comprising a steam turbine and dry cooling system. Thanks to its molten salt thermal energy storage system, Xina Solar One can reproduce its throughput for 5.5 hours or more.

Xina Solar One RF (Pty) Ltd. is owned by Engie SA, France (40%), the Industrial Development Corporation of South Africa Ltd. (20%), South African state-owned Public Investment Corporation (20%), and Xina Community Trust funded by the Industrial Development Corporation (20%). The plant is operated and maintained by another special-purpose vehicle held by Abengoa and Engie.

Outline of the project
CSP systems use the radiant heat from the sun to heat a thermal oil (heat transfer fluid) and produce steam, which is the source of energy that drives the steam turbine. The issue with this type of project is how to produce 100 MW of power based on steam production in areas where water is scarce. Thus, the challenges for a CSP plant are water and solar radiation.

A meticulous study of radiation was performed during the Front-End Engineering Design (FEED) phase of the project, and the complete operation of the plant was modeled for some years into the future. With this model, the selected design defines how the plant will be structured and how it will need to be operated. The patterns of radiation, historical data and other environmental data are considered during the design and implemented in the project.

During operation, the latest weather forecasting and advanced weather stations installed in the plant for controlling the solar field are key factors for sustaining the high performance of the plant.

The other critical resource for CSP plants is water. The current design of CSP plants has a very accurate water balance, because there are usually only limited water sources near the plants. After the specified treatment and demineralization, the water is fed to the steam-water system of the plant. The challenge is not only sourcing and treatment but also consumption.

A proper water balance of the plant is critical for cost-effective operation. Not only the correct treatment of raw water and controlled effluent, but also efforts to optimize and reduce the quantities of both have reduced the CO_2 footprint.

The Challenges and the Solutions

High reliability and availability of control are two main objectives that the control of a power plant must satisfy. High availability was a critical requirement for proper control and supervision of the plant when designing the control system. Yokogawa selected the CENTUM VP distributed control system (DCS) as the core of the entire control system, and priority was given to assured flow of data to and from other devices and systems in all layers of the plant. Thanks to high integration with other subsystem and supervisory layers, the CENTUM VP realized structured connections and flow of data between all the control layers of the plant.

System of systems
For the Xina Solar One project, more than just a single control system was deployed. To meet the needs of the plant and requirements based on the engineering performed by Abengoa, Yokogawa developed a complete control system solution that integrates the subsystem controls and enables the operators to control the entire plant via the same user interface while providing plant statuses in real time.

The CENTUM VP at Xina Solar One not only controls the core equipment - the steam generator, steam turbine, aero condenser, and molten salt storage system - and utilities such as the water treatment plant, but also integrates the solar field control and monitoring system to enable the user to control the entire plant at a single place.

One of the challenges for the CENTUM VP system was to implement all the control system blocks for all units and pieces of equipment and the integrated subsystems such as packaged units. Integration of all processes into the CENTUM VP system has greatly benefited the operators thanks to full visibility of all the components of the plant with a real distributed control schema. The unsurpassed reliability of the CENTUM VP distributed control system, which has been proven in many industry sectors and cannot be attained by PLCs, gives operators greater flexibility in plant operation.

Electrical monitoring
Another challenge for the control system is to enable proper real-time monitoring of all the electrical signals. Yokogawa Unified Gateway Station (UGS), which is deployed wherever necessary, unifies the subsystem controllers on the redundant control network of the CENTUM VP. These UGSs gather all the electrical signals via diverse communication protocols, realizing a full monitoring application required by the power plant control system, such as for process alarms, annunciations and system alarms.

The UGSs provide electrical data to field control stations (FCSs) in each location. In critical locations, a model with dual-redundant CPUs is used to reinforce the availability. The capacity of 100,000 tags and 1,000,000 data items per UGS makes it ideal for supervising electrical devices and subsystems when integrating electrical devices in the CENTUM VP.

Steam turbine monitoring via Matrikon® OPC server
For complete integration, the CENTUM VP in this project allows steam turbine monitoring via a UGS and Matrikon turbine controller OPC server. All turbine control data is thus gathered, allowing the operators to monitor both the turbine and BOP operation on the same user interface.

Business layer (PI System) integration
Xina Solar One is part of the extensive renewable power plant portfolio in South Africa as it is connected to the grid, helping to strengthen the balance of the electricity demand of the country. Due to the high integration level of the plant, the control system needs to deliver sufficient data to the business layer to ensure proper operation of the plant in compliance with the power demand of the grid. For this business layer integration, the CENTUM VP uses the OPC protocol, which is widely used for integration with PI Systems (OSIsoft).

The OPC station delivers structured data necessary to update the databases of the PI System. The data gathered and delivered is taken directly from the control network and CENTUM VP FCSs, so the PI System obtains reliable data in real time, thus enabling digital transformation with high-quality and reliable operations data. This integration facilitates the analyst's work and potential for correct market control and delivery.

Central and remote operation
The plant is operated from the main control room, where two operator workstations are used to control and operate the whole plant. Operators are given a complete view of the plant statuses via the Plant Visualization Station (PVS), while a system operation station shows a complete overview of the main process, events and alarms of the plant.

The operation is supported by Plant Resource Manager (PRM), which is crucial for ensuring proper, timely maintenance of the plant. The PRM helps to improve equipment maintenance plans and optimize equipment maintenance costs.

For the purposes of monitoring and management, the control room is connected to a remote operator workstation located in the meeting room, which provides full control of the plant via a remote connection under a secure engineered connection.

Customer Satisfaction

The solution delivered by Yokogawa to Xina Solar One is characterized by robustness, reliability and resilience. The control system, one of the key parts for the operation of the plant, meets the requirements and exhibited the high performance for which the CENTUM VP is renowned.

System Details

General
- CENTUM VP DCS for all BOP control and integration of the Solar Field SCADA
- Integration of subsystems and remote access
- Connection with PI System for asset management
- Optimized subsystem integration to eliminate many points of failure

CENTUM VP
- Field control stations, including integration of two local HMIs for field control and supervision
- Turbomachinery modules
- Operator stations (with four monitors)
- Remote DCS station
- Supervisor station
- UGS stations (single- and redundant-CPU models)
- PRM server
- Third-party subsystem integration (via Modbus, IEC 60870 or IEC 61850):
    - Steam turbine
    - Solar steam generator (SSG)
    - Heat transfer fluid (HTF) system
    - Steam boiler
    - Thermal energy storage (TES) system
    - Chemical dosing
    - Solar tracking system
    - Siemens VF/SS
    - Siemens SICAM-TM
    - Siemens D20
    - Siemens SICAM-PAS
- OPC communication with PI System

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