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Siemens AG
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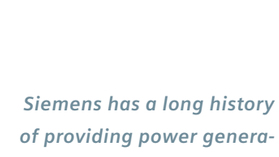
Power Blocks for Concentrated Solar Power Plants

Bringing power generation experience to CSP

Siemens has a long history of providing power generation solutions based on a wide range of technologies. Today, Siemens expands its experience to focus on concentrated solar power (CSP) power blocks with a combination of features and innovations that help lower the cost of CSP plants by improving their efficiency and operating flexibility.



Solar thermal plant technologies

Since the U.S. solar boom of the 1980s, solar thermal energy has been a proven technology. The most common type of plant is the parabolic trough collector, but alternative technologies are being deployed such as central tower plants with heliostats and linear fresnel collector plants with flat mirrors. The basic principle is the same for all three plant technologies: Mirrors concentrate the incident solar radiation onto a receiver where it is converted into heat that is used to produce steam to drive a steam turbine. Heat storage systems like molten salt tanks provide for power supply even during unfavorable weather conditions or in the evenings when the sun is not shining. Storage systems significantly increase the number of full-load operation hours with optimal power block efficiency, thus allowing the plant to be dispatchable.

Power blocks for CSP applications

Behind the solar field is the workhorse of a concentrated solar power plant, the power block. Regardless of the solar field technology, parabolic trough, tower or linear fresnel, the power block needs to provide reliable, efficient power. Siemens is uniquely positioned to provide not only state-of-the-art power block component technologies but also to integrate them into a more reliable, flexible and efficient power block that gets the most from the sun's energy with the guarantees and risk mitigants you expect from Siemens regardless if you are a utility, developer, a technology owner or an EPC company.

Reference Power Block design approach

Siemens' reference power plant design approach has been successfully implemented on a wide range of power plant applications, including combined cycles and large steam plants. Now, Siemens is applying this approach for CSP power block applications.

Reference power block design approach

A well-funded reference power plant program is the foundation that enables Siemens to provide cost-effective power plants with world-class performance and highly competitive project implementation schedules.

Our programs include an optimized and pre-engineered power block design based on key components manufactured by Siemens, including innovations such as the Siemens BENSON® boiler and efficient steam turbine generator designs. These programs also allow for detailed support from Siemens during early project development and for modifications to address site requirements, operation and maintenance. Finally, it is a tool for risk management because plant layouts and construction schedules are pre-defined based on experience from prior projects.

Potential benefits of Siemens reference power block approach for all CSP applications include:

- Better plant performance guaranteed by Siemens
- Features and innovations for improved operating flexibility with lower capital costs
- Incorporates Siemens' broad power generation experience
- Allows for a range of options and site requirements.

The focus of reference power block designs for CSP applications includes:

- Integrating CSP power block with solar field and heat transfer fluid system
- Optimizing interface parameters of power block and solar field to size the power block equipment for all possible load cases
- Optimizing start-up, shutdown, part load and overload operation of the power block
- Providing better performance because Siemens controls the design of key components and the power block cycle.

CSP power block scope

Siemens can provide just the power island equipment or up to and including the complete EPC of the CSP power block. Our power island includes the key components that allow Siemens to offer cycle performance guarantees.

The Siemens power block scope of supply, regardless whether implemented as equipment only or as a part of a Siemens EPC scope, can include the entire range of components from steam turbine generator, BENSON boiler, reheater, and condensing systems to pre-heaters, evaporators and cooling systems, as well as the entire electrical equipment, plant control systems, instrumentation, transformers and switchgear.

Innovative power block components for CSP

Steam Turbine Generators

For CSP applications, Siemens is uniquely positioned as the original equipment manufacturer of the key components in a CSP power block. By controlling the designs of the key components and the entire CSP power block, Siemens can provide better power block performance with less risk. Key components include the steam turbine generator, boiler and power block controls.

Steam turbines for CSP applications

CSP plants require steam turbines, which are optimized for their complex and challenging cycle conditions. Bearing in mind that efficiency and total cost of ownership are key to any investment decision, Siemens incorporates its operational experience into extensive R&D and engineering activities to adapt the turbines to the specific requirements of the CSP technology. As the CSP market leader in steam turbines with over 70% market share, Siemens commands a comprehensive product portfolio for solar thermal plants, covering outputs up to more than 300 MW.

Steam turbine adaptations for CSP include:

- Steam path and casing re-designed for typical CSP parameters
- HP exhaust designed for saturated steam
- Shaft and blade glands designed for high temperature gradients
- Rotor and blade roots designed for daily start and stop
- Side exhaust options for direct connection to condenser.

Efficiency

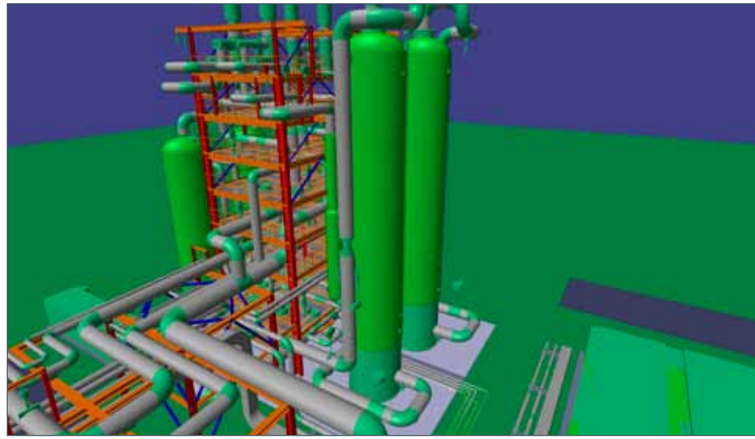
Siemens has cooperated closely with leading solar thermal EPC companies, project developers and operators to develop and fine-tune its steam turbines for solar thermal applications. Highly efficient turbines enable a smaller solar mirror collector field with associated reduction in investment cost for generation of the required electrical power output. Alternatively, the surplus heat can be put into thermal storage to extend the production time for the plant. Innovative single and double reheat solutions help improve efficiency and reduce problems with erosion/corrosion and moisture in the LP turbine.

Daily cycling

Daily cycling requires special attention because of the large number of starts and fast daily startup capabilities needed from the CSP steam turbine. When focusing on annual power production, a short turbine start-up time is of great benefit to the CSP plant owner.

Innovative power block components for CSP

BENSON® once through boiler



Within Siemens' CSP power block scope is the boiler. Options include kettle, natural circulation and Siemens unique BENSON "once through" boiler technology.

Siemens BENSON technology has been used successfully in a number of power generation applications, including combined cycles designed for daily cycling and large steam plants for base load generation. When used in CSP applications, BENSON technology can provide the following potential benefits:

- "Once through" design allows for steam cycles with higher main steam conditions resulting in better plant efficiency
- A single vessel for the economizer, evaporator and superheater reduces the amount of internal piping and valves and reduces HTF side pressure loss with less complex controls
- Reduced erection and commissioning cost and time with less piping and vessels
- Larger capacity of each steam generator reduces plant complexity compared to kettle or natural circulation steam generators
- Header-type design provides excellent thermal flexibility allowing faster daily start-ups resulting in increase annual power production
- Sliding pressure operation down to low loads
- Active control of steam generation and steam temperature with feedwater flow.

Innovative power block components for CSP

Siemens SPPA-T3000 controls

Siemens SPPA-T3000 control system is state-of-the-art in controls for power generation applications. It has been implemented in a wide range of power generation applications and will control one of the largest CSP plants being built in the world.

The SPPA-T3000 control system architecture can be extended to integrate the operation of the entire CSP plant, including the turbine, BOP and solar field/storage/HTF controls, regardless of the type of solar field.

For CSP applications, Siemens SPPA-T3000 provides the following potential benefits:

- **Harmonized process control**

  Improves the transparency of the installations and thus improves the quality of operator control

- **Optimize project realization time**

  Reduce customer project management efforts by combining instrumentation, controls and electrical

- **Lower EPC costs**

  Having a single I&C system results in less interfaces and less project execution risks, resulting in savings in purchasing, engineering, erection and commissioning

- State-of-the-art control systems to IEC 61850 are well-established in the market

- Designed with higher levels of automation to reduce the number of required operators.

The convenience of single point responsibility

Generating reliable output in the shortest possible time after financial closing and notice to proceed (NTP) is the key to realizing an early return on your investment. To support this, Siemens ensures that on-time completion is the driving force behind our integrated project approach.

Financial strength

To set the project clock in motion, Siemens financial strength and stability helps you secure the financial backing necessary to bring your project to successful completion. With sales of over € 80 billion in 2010, a historically strong and stable financial profile, more than 405,000 employees and about 300 manufacturing locations worldwide, Siemens is one of the most successful companies today and will continue to be for years to come.

Integrated project approach

Regardless of whether Siemens is providing equipment only or a turnkey solution, at the heart of a successful project is a competent experienced project manager with access to world-class project implementation tools that pull together all of the documentation and processes required to bring a plant online. Secure Web-based systems connect us with our integrated, multi-disciplinary team of suppliers, engineering and construction partners, contractors, and the plant owner to provide the basis for real-time collaboration on design, construction and operation, including documentation and integrated scheduling.

Experience and competence

We can go further than just setting up a professional on-site team. We bring strong capabilities and competencies 'beyond-the- site.' In the last five years, we have successfully completed more than 110 turnkey projects with a total output of over 30,000 MW. Overall, we have built more than 300 turnkey power plants. Based on our experience with simple cycle, combined cycle, steam and industrial power plants, we have the expertise and competency to take charge of building your CSP power block wherever the project may be.

Our network of engineering expertise goes well beyond typical OEM component design capabilities. With nearly 1,000 power plant design engineers and a global project organization of over 800 people, we possess the in-house competency to handle every project need.

Driven by on-time completion

Armed with experience, resources and tools, we can offer competitive project schedules and guarantees that these schedules are met. With a dedicated program to closely monitor and analyze each and every project, product designs and processes are continually improved to world-class levels. This results in one overriding theme – our commitment to complete your project on time to your total satisfaction.

For the entire life cycle of your CSP plant

We provide OEM knowledge, operation and maintenance experience, global `off-site' infrastructures and engineering capabilities, and financial strength to support flexibly the entire asset management of your CSP plant.

At Siemens, we want to develop an ongoing partnership to ensure your project's long-term success. We are committed to serving our customers well after plant commissioning and during the entire asset life.

We recognize that the industry and financial community expects strong commitment by the technology provider to support project economics, secure overall project viability and financing. As the OEM supplier of core components, we are prepared to deliver it.

Moreover, with strong experience and know-how in operations and maintenance of power plants, of a wide range of complexity, type and capacity, we can provide integrated solutions - beyond the Power Block - which deliver a streamlined, efficient service.

We can go further than just setting up a professional on-site team. We bring strong capabilities and competencies 'beyond-the- site.' The on-site team is just a part, although essential, of the whole value-chain. Any operations and maintenance service stands on off-the-site infrastructures, their access and availability, logistics, training, knowledge management and engineering capabilities, and financial strength.

We have established a powerful and responsive service network with more than 3,500 field engineers and technicians in regional offices around the globe. So wherever you are - wherever your plant is located - we speak the language, we know the market and we are available to provide customer service and support 24 hours a day, seven days a week.

Our global service engineering, operation and maintenance training and support capabilities ensure we can support your team worldwide and with local knowledge.

And we are flexible. We recognize that each customer and each project has their own requirements, preferences, perceptions.

This is why we offer a comprehensive portfolio of service options, including corrective maintenance, preventative maintenance, performance-enhancing programs, service agreements, complete CSP plant operations and maintenance. And this is why our engineering and financial teams are engaged daily to tailor make each solution and to develop new concepts.

We believe that we can offer a level of integrated solutions, which are challenging to find in the market, and that are recognized and proven to help our customers from the development phase, when a sound business case is necessary, to and during the asset management phase...when being competitive, profitable and secure are keys to success.

We believe in the benefits to the environment and the society that our business can bring, and strive on our own and together with our customer to develop solutions with tangible positive impact.