Harnessing the power of the sun

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Dear Reader,

This issue of In Control is about how ABB technologies and solutions are helping to make solar power affordable and reliable all over the world.

ABB has a long and pioneering history in solar power that goes back all the way to the industry’s origins in Europe and the United States.

In Europe we developed the automation platform for the world’s first test facility for concentrating solar power technologies at the Plataforma Solar de Almería (PSA) in Spain. And on page 14 of this issue you can read how we recently extended the operating life of turbine control systems that we supplied 22 years ago to the 160 MW Harper Lake solar thermal power plant in California - the largest and oldest solar thermal power plant in operation in the world.

We are now in our third decade as a leading player in solar energy, which is probably longer than any other company. As a world leader in power and automation technologies, ABB offers a diverse and proven portfolio of products and solutions for the entire solar power value chain. For the power generation business, we offer turnkey EPC solutions for photovoltaic and solar thermal power plants, as well as full service and operations and maintenance support for both ABB and third-party commissioned plants.

You can read about many of these solutions in these pages. We have selected some of our most recent turnkey EPC projects from various parts of the world to give you an indication of how we are living up to our claim of making solar power affordable and reliable in Europe, the United States, India, North Africa, South Africa and Australia.

Two of these articles describe how ABB was selected by national electric utilities in two countries – by Eskom in South Africa and SPE in Algeria – to supply the first photovoltaic power plants ever to be built in their respective territories. In both instances the plants are pilot facilities to determine the best way to achieve the ambitious renewable energy programs that the governments of both countries have set for the next two decades.

Operations and maintenance and the development of new solar technologies are key differentiators of our offering. On page 17 we highlight the latest addition to our hugely successful O&M service centers for photovoltaic power plants, and on pages 18 and 22 we describe how ABB technologies and innovations improve the performance of photovoltaic and solar thermal power plants.

Most important of all are our customers themselves. In this issue we are delighted to feature interviews with Mr. Alfredo Gonzalez, operations manager for Gestamp Solar, Mr. Massimiliano Salvi, chief executive officer of Emmessenne Solar, and Mr. Tobias Andrist, who is a member of the management board of Elektra Baselland and head of its Power business unit.

With kind regards,

Franz-Josef Mengede
Head of ABB Power Generation
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ABB is your one-stop partner in solar power.

ABB’s turnkey EPC (engineering, procurement and construction) solutions cover the entire scope of supply for solar power plants – from feasibility studies and site analysis to site clearance and civil works, plant design and engineering, manufacture and procurement, erection and commissioning, and grid connection.

To each project we bring the following strengths and attributes:
- More than 125 years’ experience in the power generation business
- More than 300 successfully completed projects as an EPC contractor
- Market and technology leadership in power and automation technologies
- A unique expertise in solar-critical applications like long-distance HVDC and HVAC power transfer, and the integration of renewable energy into micro and remote grids
- A global footprint with operations in more than 100 countries
- An annual R&D spend of more than $1.3 billion
- Bankability and a worldwide reputation for reliability

And, most importantly of all, a proven track record in delivering on time, on budget and at the contracted efficiency level.

Solar thermal power plants
ABB offers the most efficient and cost-effective solar thermal/concentrating solar power (CSP) technology on the market. Working in cooperation with Novatec Solar, a company in which ABB is a strategic shareholder, our turnkey CSP power plants require 30 percent less land, use 70 percent less material and consume 80 percent less water for cleaning than parabolic trough designs. They are also significantly more efficient. With a power block efficiency rate of 38 percent, they produce more energy and have the potential to generate higher revenues than alternative CSP designs.

The ABB-Novatec Solar CSP concept is centered on a patented and award-winning modular solar boiler and a unique solar field design based on linear Fresnel collectors. The technology uses direct steam generation and does not require heat exchangers and oil-filled absorber tube networks for heat transfer. Instead this highly economical concept utilizes compact almost flat glass mirrors. The uniquely efficient solar boiler produces directly superheated steam at a temperature of up to 500 degrees Celsius and a pressure of 100 bar. The steam is connected direct to a steam turbine for power generation or used for industrial heat applications, desalination or solar cooling.

ABB solar thermal power plants are available as turnkey solutions from 50 MW to more than 250 MW, and are ideal for a wide range of applications: solar augmentation of fossil fuel power plants, enhanced oil recovery, solar desalination, solar cooling, and to provide process steam or heat for mining and other industries.

Photovoltaic power plants
ABB has long played a leading role in the growth and development of the photovoltaic power market, providing turnkey solutions that reduce the cost and risk of investing in and operating PV power plants. Our capability includes extensive experience as an EPC contractor, rapid project execution within the shortest possible delivery times, a modular and scalable concept, optimized solutions that achieve the highest level of efficiency, and operations and maintenance support with remote monitoring from dedicated ABB control centers.

Over the past few years alone, ABB has delivered around 50 turnkey high-efficiency PV plants worldwide,
with capacities ranging from roof-top industrial installations of around 1 MW to utility-scale plants of up to 100 MW or more.

Remote O&M

ABB takes full responsibility for the operation, maintenance and management of all types of solar power plant.

We offer a fully proven operations and maintenance concept for the remote operation of PV power plants. From central control rooms, we can monitor and control the plant via secure high-speed data transmission connections. This enables us to pick up the first sign of a potential problem and to rectify it by remote, or dispatch a service team if required.

For solar thermal power plants ABB offers full onsite operation and maintenance services.

Integration with remote and micro power grids

Solar power plants are often located in remote areas or integrated with conventional power plants or connected to remote micro grids serving local communities. Power surges and short-term lulls are a constant threat to the stability of any power network relying on intermittent energy like solar and wind. ABB has the tools, know-how and services for all types of renewable energy integration. These well-proven solutions are designed to integrate up to 100 percent of the renewable energy generated with the conventional power system, while stabilizing voltage and frequency at utility quality standards.

To learn more about our solar offering, contact your local ABB office.

Our turnkey EPC solutions cover the entire scope of supply for solar power plants – from feasibility studies and site analysis to site clearance and civil works, plant design and engineering, manufacture and procurement, erection and commissioning, and grid connection.
Making photovoltaic power plants profitable

In 2011 ABB delivered two photovoltaic power plants, with a combined generating capacity of more than 50 MW, several weeks ahead of schedule on behalf of special purpose entity, Emmessenne Solar. We spoke to the company's chief executive officer, Massimiliano Salvi, to find out more about ABB’s performance as a turnkey supplier of PV power plants.

Interview with Massimiliano Salvi

Please describe your company’s business activities and your involvement in the solar power market.

Emmessenne Solar is a special purpose entity part-owned by Byom, an Italy-based advisory company that provides consultancy services for companies and investment funds that wish to invest in the energy and infrastructure markets. In 2010 and 2011, our activities were mainly focused on the renewable energy sector (photovoltaic plants and wind farms). In 2012, we extended our range of services to include infrastructure and capital research for small and medium-size companies. At present, Byom is managing solar power plant and wind farm assets in Italy with a combined generating capacity of 130 MW.

In 2011 your company selected ABB to provide a turnkey EPC solution for the De Nittis and Macchia Rotonda photovoltaic power plants. Why did you select ABB as your EPC contractor for this project?

From the beginning, we decided to take an industrial, rather than a speculative, approach. ABB came to us with a complete package, including not only its services as an EPC, but also the license to build the plant and the involvement of a qualified local partner. Due to my previous professional experience as CEO of Acea Distribuzione - the second largest Italian energy distributor - I knew ABB very well and have always considered the company a very serious and reliable industrial partner with a technology edge.

Speedy execution was crucial for the success of this project. Can you describe why speed was so important? As we understand it, the feed-in tariff was due to decrease and the Italian government unexpectedly brought forward the feed-in tariff deadline.

You are right, speed was crucial because the new decree impacted us during the construction phase and we faced - for almost two months - a nightmare caused by lenders who suspended the funding. We renegotiated some clauses in the original EPC contract to take into account the new rules of the game. In this scenario the financial strength of ABB has been very important, together with a proactive approach adopted by the management.

ABB managed to complete the project 40 days ahead of schedule. What did this mean for your company and the success and revenues of the plant?

It was crucial in order to avoid other reductions in the profitability of the investment and to complete the plant before new government legislation for large solar power plants came into effect in August 2011. If we hadn’t have done that we might not have completed the investment.

Did ABB execute and complete the project to your satisfaction?

Yes, without any major problems. It was a significant achievement due to the extraordinary circumstances we faced.

Does your company intend to retain its ownership of the plant or sell it as an investment?

For the time being we don’t see any reason to sell the De Nittis plant. We have already sold the Macchia Rotonda plant in 2010, and we have to admit that the good level of engineering architecture has been really appreciated by the buyer.
Customer interview

De Nittis PV power plant, Italy

Massimiliano Salvi
CEO of Emmessenne Solar

Beating the feed-in tariff deadlines

39 MW plant completed six weeks ahead of schedule

The De Nittis PV solar power plant in Foggia, southern Italy, comprises three units with a combined generating capacity of 39 MW. Two of the units are adjacent to one another, with the third located some 3 km distant.

ABB provided a turnkey EPC solution including design, engineering, civil works, procurement, installation and commissioning. The solution is highly optimized to ensure a high level of efficiency and low power losses. It includes ABB’s pre-assembled, factory-tested electrical balance of plant modules, as well as a state-of-the-art distributed control system and human machine interface.

As part of the contract ABB also provided a 150 kV substation, which links the three units via a 10 km cable to the high voltage transmission grid.

ABB was contracted to execute and commission the entire project within six months. The project was successfully completed and handed over 40 days ahead of schedule (including the substation), thereby enabling the customer to win a substantial gain in production and qualify for the targeted feed-in tariff.

ABB is responsible for remote monitoring of the plants from its dedicated O&M control center for PV power plants.

15 MW multi-plant project completed three weeks ahead of schedule

The Macchia Rotonda PV power plant in Foggia consists of four units of varying capacity located within a 10 km area.

ABB was appointed the EPC for all four units and was given six months to complete the project and ensure that the customer qualified for the targeted feed-in tariff. Despite heavy rainfall in the winter months of February and March, which caused delays in site clearance and plant erection, ABB was able to make up for lost time and complete the project an impressive three weeks ahead of schedule.

ABB’s scope of supply included design, engineering, installation, commissioning and connection via a 10 km cable to the Enel transmission grid. ABB also supplied the full range of power and automation equipment including switchboards, inverters, transformers, medium voltage cabinets, medium and high voltage cables, distributed control systems and control software.

ABB’s offering for PV power plants

ABB has long played a leading role in the growth and development of the photovoltaic power market, providing turnkey solutions that reduce the cost and risk of investing in and operating PV power plants. Our capability includes:

– Extensive experience as an EPC contractor
– Rapid project execution within the shortest possible delivery times
– A modular concept for PV power plants
– Optimized solutions that achieve the highest level of efficiency
– A fully developed operations and maintenance concept with remote monitoring from dedicated ABB control centers
Operations and maintenance at La Robla

In August 2010, ABB completed - within just 20 weeks - the delivery of a 13.3 MW turnkey photovoltaic power plant at La Robla, Spain, for Gestamp Solar. Following the successful completion of the project, Gestamp Solar awarded ABB a five-year operations and maintenance (O&M) contract to secure the performance and availability of the plant. We asked Mr. Alfredo Gonzalez, operations manager for Gestamp Solar, to comment on ABB’s execution of its O&M responsibilities.
Interview with Alfredo Gonzalez

Please describe Gestamp Solar’s operations in the solar power industry.

In the past two years alone, Gestamp Solar has built more than 25 photovoltaic power plants in Spain, Italy, France and the United States, each with a generating capacity of between 4 and 10 MW, and with a combined capacity of more than 140 MW.

Currently we are building the two largest solar power plants in South America at 20 MW each, and soon we will begin a 30 MW plant in South Africa and a 57 MW plant in the Dominican Republic.

Why did you select ABB as your supplier of PV power plants?

We chose ABB a couple of years ago because we needed a proven quality company that could support us anywhere in the world.

The long relationship between ABB and Gestamp in various divisions, especially in the robotics area, and the fact that ABB’s center of competence for solar power is located in Spain, also influenced our decision, giving us a reasonable degree of confidence to build the plants.

La Robla was completed two years ago in August 2010. How has the plant been performing during its first two years of operation?

The La Robla plant has been running according to our expectations since its start up, even exceeding the guaranteed performance, which demonstrates that it was well designed and constructed. The actual values obtained demonstrate that the plant is performing well and that ABB is performing its O&M tasks satisfactorily.

ABB has an operations and maintenance contract for La Robla. Can you describe the reasons why you awarded the O&M contract to ABB? How long is the contract for and what is ABB’s scope of responsibilities?

It is common practice in all EPC contracts we sign. The company that builds the plant is responsible for operations and maintenance, at least during the warranty period.

For La Robla, the duration initially agreed on for O&M was five years, renewable for another five thereafter. The length of this period is normally a consequence of financial conditions imposed in the project finance.

ABB is responsible for operations and maintenance at La Robla and for performing corrective, preventive and predictive maintenance at the plant, supported by its remote O&M control center in Madrid.

Is there anything in ABB’s O&M concept for solar power plants that you find particularly valuable?

I am impressed by ABB’s global expertise and capability in power and automation. It is an important differentiator for the construction and operation of the plants built by ABB.

It is also important for the support ABB has given us, through their local subsidiaries in those countries in which Gestamp Solar is promoting, building and operating its solar power plants.

Have there been any notable O&M incidents at the plant that have required a response from ABB?

No incidents of any significance. Damage to roads and civil works by the action of water is common after the construction of a PV plant, but once repaired do not occur again.

The first years of O&M are critical because they are a period in which any problems not discovered during engineering and construction must be identified and rectified to avoid the sudden degradation of the assets.

Looking back at the La Robla project as a whole (project development, project execution, plant operation and maintenance), what for you have been the most valuable lessons learned?

In order to secure the success of the project, it must be developed, built and operated with clear premises and in a coordinated way, even with the time pressure of a short delivery schedule like La Robla.

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Customer interview

Cutting the cost of CSP

The Puerto Errado 2 (PE2) solar thermal power plant is the world’s first utility-scale solar energy facility to generate power using linear Fresnel technology. Commissioned in March 2012, this groundbreaking facility uses ABB-Novatec Solar’s award-winning solar thermal technology to produce 30 MW of clean solar energy for the Spanish power grid. Swiss utility and telecom company, Elektra Baselland (EBL), owns a controlling interest in PE2. We asked EBL management board member and former project director for PE2, Tobias Andrist, for his assessment of the project.

Interview with Tobias Andrist

Please describe your job title and responsibilities at Elektra Baselland and with regard to PE2.

Until June 2012, I was head of business development at EBL and responsible for various projects in electricity retail and power generation. In this function, I was project manager or project director for the PE2 project from the first contact with Novatec until project completion in May this year. In July, I became a member of EBL’s management board and head of business unit Power.

Why did EBL decide to invest in a new solar power plant in Spain? Were there any reasons for the choice of location in Murcia?

Once the decision was made in 2008 to invest in CSP, we evaluated two potential investment opportunities in parabolic trough and linear Fresnel. Our aim was to acquire a stake in a developed project. Once that decision was taken the location of the investment was mainly dependent on where the available projects were located.

Why did you select the Novatec solar thermal solution for the site?

When evaluating the two options of parabolic trough and linear Fresnel, we became convinced that linear Fresnel is a technology with potential for the future because of the reduced material use per output. Furthermore, the approach of Novatec and its key personnel inspired us to support a technology that was barely off the ground at the time. It has always been a quality of EBL to engage in leading-edge technology projects, another example of which is a deep heat mining project in Basel, Switzerland.

Did your company consider any other solar power technologies or solution providers for the plant? If so, how did they compare with the Novatec solution?

As indicated above, we have also evaluated parabolic trough. However, the project under discussion was less clearly developed and, therefore, did not fit our target profile. In our view parabolic trough technology was already quite optimized and thus has less potential for future cost decreases.

Is there anything that particularly impressed you with regard to Novatec’s execution of the project?

The design and engineering phase of this project was a challenge in its own right, mainly because a standard power block had to be integrated with cutting-edge solar field technology for which no long-term expertise or experience existed. At the beginning, we were naturally more concerned about the delivery and performance of the solar field scope. However, Novatec’s delivery of the solar field worked exceptionally well. Until the very end, the solar field installation was on track, and this was very promising for the overall success of the project.

The plant started production in August this year. Although this was just a few weeks ago, how has the plant performed during these opening few weeks?

The project has clearly fulfilled its aim of using less land and building materials - without a doubt. And I am convinced that in the future, there is much more potential for further reductions in both. The performance of the solar field is in the range of our expectations. However, a detailed performance evaluation will be carried out during the course of the first operating year.
What do you expect the main benefits to be for your company in owning and operating this plant?

With this project, EBL demonstrates that it can implement large projects. We have also gained a lot of valuable new experience that benefits the whole organization. Now, as we enter the operational phase, we are optimistic that we will have a long-term generation asset that will benefit our portfolio.

Does EBL have any plans to invest in additional solar power plants in Europe? Would you consider selecting a Novatec-ABB solution again?

Generally, EBL is interested in investing in additional solar power plants in Europe to diversify its generation portfolio. For this to happen, further progress in the technology, cost reduction and re-emergence of certain support schemes is necessary. In the meantime we will focus on the optimization of PE2 and gain more operating experience.

**Turnkey EPC solutions**

ABB and Novatec Solar, a company in which ABB is a major shareholder, together offer scalable turnkey solutions for solar thermal power plants - solutions that are extremely quick, easy and cost-effective to build and operate.

Based on Novatec Solar’s patented Fresnel-based CSP technology, the plants use 70 percent less material, require 30 percent less land and consume 80 percent less water per megawatt generated than parabolic trough designs.

This is achieved through an innovative solar boiler design for direct steam generation based on linear Fresnel collector technology. Instead of the curved mirrors of a parabolic trough, the collectors use flat glass mirrors to reflect solar energy onto a receiver in which water is vaporized directly to produce superheated steam at temperatures of up to 500 degrees Celsius and a pressure of 100 bar.

By using standard materials such as sheet plates and glass mirrors, the automated mass production of key components in locally erected production facilities, a fast and accurate assembly process, highly efficient land use, and a robotic cleaning system that uses very little water, the cost of building and operating the plants is kept exceptionally low - features that offer huge potential for global deployment.

PE2 is the third commercial installation of the ABB-Novatec Solar linear Fresnel technology. A 1.4 MW plant has been delivering power to the Spanish high voltage grid since 2009. In May 2012, ABB-Novatec Solar completed a 9.3 MW plant at the 2,000 MW Liddell coal-fired power plant in New South Wales, Australia – integrating CSP technology with conventional coal-fired power generation for the first time ever.

The ABB-Novatec Solar concept can be used to generate energy in a wide range of applications including standalone or hybrid power plants, as fuel savers in existing power plants, in desalination and district cooling plants, and in industrial processes that require steam, such as enhanced oil recovery.

“When evaluating the two options of parabolic trough and linear Fresnel, we became convinced that linear Fresnel is a technology with potential for the future because of the reduced material use per output.”
Protecting fish from the birds

One of the biggest problems facing a fish farm is how to prevent predatory birds from feeding on the fish. Loud noises and flashing lights are two methods of prevention. A more innovative one is a roof-top photovoltaic plant that protects the fish and earns the farm revenues.

Seen from the air – through the eyes of a bird - an expanse of water means fish, and fish means food. Birds can dive from the air, attack from the surface, or wade through the shallows. Whatever their method of approach, they go to the water to dine.

For a fish farm, predatory birds are a pest. They kill and damage the farm’s fish stocks. The fish have to be protected. Perhaps the most effective way to do this is to camouflage the water with a structure – like a photovoltaic power plant.

This is precisely what ABB has done at the Mézos fish farm in southwestern France.

The PV plant is owned by Soleil des Landes, a special purpose company, which sells the power to the grid operator, while providing the fish farm with the protection it needs from predatory birds. It also provides the farm with revenues from renting the space above the water to Soleil des Landes.

ABB provided a complete balance of system solution, including design, engineering, project management, installation and commissioning. The solution comprises all the electrical and automation equipment - inverters, DC and AC cabinets, transformers, switchgear, cabling, equipment housing, control and SCADA with remote access - as well as system optimization to ensure a high yield from the challenging surface dimensions of the water. ABB was also responsible for providing a substation that is engineered to meet the grid requirements of the medium voltage transmission system.

Rapid project execution was a key customer requirement to ensure qualification for a higher feed-in tariff that was then available for roof-top PV plants. ABB was awarded the order in June 2011, began site work in the same month, and commissioned the plant and the substation in October.

The farm is owned by Viviers de France, one of the country’s leading seafood and land-based fish farming companies. Soleil des Landes is part of Groupe UNITe.
Algeria’s first photovoltaic power plant

ABB is supplying a turnkey power and automation solution for Algeria’s first photovoltaic power plant. The 1.1 MW pilot facility will comprise several different PV technologies to enable the plant owners – the Algerian national electric utility, Société Algérienne de Production de l’Electricité (SPE) – to determine which technology is best suited to harness the country’s huge solar power resources.

The plant represents an important first step in Algeria’s new long-term national energy strategy to diversify the country’s power generation technologies and make optimal use of its vast renewable energy and solar power resources.

Between 2011 and 2030 Algeria intends to install around 22,000 MW of renewable energy production, most of which will be in photovoltaic and solar thermal power plants. Stage 1 of the program involves the testing of pilot projects and the assessment of various technologies.

Earlier this year ABB was awarded the contract to supply Algeria’s first photovoltaic power plant and the first pilot PV installation in the national renewable energy program. The customer is Société Algérienne de Production de l’Electricité (SPE), the national utility responsible for the production of electricity. ABB was selected by SPE for providing the best technical and most economical solution in a competitive tender.

The plant will have a generating capacity of 1.1 MW and will comprise various PV technologies in order to assess which ones produce the best results for Algeria’s long-term energy needs. The technologies include monocrystalline and polycrystalline panels (some of which will be on fixed structures and others on tracking systems), as well as amorphous silicon and cadmium telluride solar cells.

ABB is also responsible for design, engineering, project management, procurement, supervision of erection works, optimization of all the technologies to ensure maximum yield, and commissioning of the plant. Civil works and erection will be performed under the supervision of ABB by a local partner in Algeria.

The plant is located about 20 km from the city of Ghardaia, which lies in the Sahara Desert about 600 km south of the capital, Algiers. Completion of the plant is scheduled for 2013.

ABB also played a significant role in the delivery of Algeria’s first integrated solar combined cycle power plant at the Hassi R’Mel gas field. The 150 MW plant comprises a conventional 120 MW combined cycle unit and a 20 MW parabolic trough solar field. ABB supplied a complete electrical balance of plant solution for the entire facility, which at the time – in 2010 – was one of the first ISCC plants to be constructed in the world.
Extending the life of the world’s largest CSP plant

ABB has upgraded with state-of-the-art features the 22-year-old turbine control systems at the Harper Lake solar thermal power plant in the Mojave Desert, California.

Built in 1989 and 1990 respectively, the two 80 MW units that make up the 160 MW Harper Lake solar thermal power plant have been the largest solar thermal generating units in the world for well over two decades.

Along with five 30 MW units at Kramer Junction, and a 14 MW and 30 MW unit at Degget, Harper Lake is part of the vast 354 MW Solar Electric Generating Systems (SEGS) solar power facility, which was built between 1984 and 1990 and is the biggest and oldest solar thermal complex in the world.

ABB supplied the original Procontrol P13 turbine control systems for the two Harper Lake units and for two of the 30 MW solar thermal units at Kramer Junction, all of which are equipped with ABB steam turbines and generators from the same period.

Although the original turbine control systems were still in perfect working order, they were no longer at the cutting edge. Plant owner, NextEra Energy, the largest generator of solar and wind power in the United States, required a cost-effective state-of-the-art upgrade with minimal disruption that would improve plant operations and reliability.

ABB began work on upgrading the four units in 2010 and executed the project in stages over the course of two years during scheduled outages and without additional downtime. In line with ABB’s control system strategy of protecting as much of the customer’s investment in hardware and software as possible, ABB retained the existing cabinets and I/Os to avoid new wiring and commissioning.

The processor was upgraded to the latest 70PR05 processing module, the bus traffic director was upgraded to enhance the system’s diagnostic capabilities, and the old HEX code-oriented program was converted into a graphic-oriented tool.

The result is a cutting-edge turbine control system that provides NextEra Energy with faster fault finding, better diagnostic capability, safer and more reliable operation, up-to-date documentation, fewer spare part requirements, and a built-in capability for the future addition of a redundant processor.

The Procontrol P13 platform is now in its fourth decade of providing safe and reliable power plant operation. ABB continues to actively maintain Procontrol P13 to safeguard the previous investments of its customers in the platform, ensuring seamless evolution to Symphony Plus.
In late 2011, ABB completed the fast-track delivery of two turnkey high-efficiency photovoltaic solar power plants for Eskom’s Kendal and Lethabo coal-fired power stations in South Africa. The plants were the first photovoltaic power plants in the country.

The two high-efficiency PV solar power plants represent the opening phase of Eskom’s long-term strategy to use renewable energy for internal power consumption at its fleet of coal-fired power stations in South Africa.

The energy generated at the two pilot installations provides electricity during daylight hours for the auxiliary systems of the two power stations. By reducing in-house consumption of the power generated from fossil fuel at the stations, Eskom is able to deliver more electricity to consumers, generate higher revenues and lower its carbon footprint.

Each of the two PV solar power plants occupies a 1 hectare site next to the power stations at Kendal and Lethabo. The plant at Kendal consists of fixed-tilt panels, and has a production capacity of 620 kilowatts. Lethabo comprises single-axis trackers, and has a capacity of 575 kilowatts.

Once Eskom has assessed the lessons learned from the two pilot projects, it expects to install additional solar power plants at its coal-fired power stations in South Africa.

ABB was selected by Eskom for its ability to deliver turnkey solutions for both sites at efficiency levels that no other competitor could match, and within a very challenging timeframe of under three months.

The solutions are based on ABB’s widely proven concept for PV power plants, which combines a high level of customization, rapid turnkey delivery, and system optimization technologies that enable each plant to generate the maximum amount of energy.

Solar thermal to take off

Earlier this year, ABB signed an agreement with FG Emvelo, an independent solar power plant company, to develop high-efficiency solar thermal power plants for a huge 340 kilometer site at Karoshoek Solar Valley in Northern Cape province. The plants will use the ABB-Novatec Solar turnkey concept for solar thermal power plants - which has a higher power block efficiency and requires 30 percent less land, uses 70 percent less material and consumes 80 percent less water for cleaning than parabolic trough designs.

The South African government estimates that the country requires an additional 56.5 GW of power generation by 2030 to meet projected demand. Of this new capacity, 10,000 MW has been allocated by the government to photovoltaic and solar thermal technologies.

Eskom generates approximately 95 percent of the electricity used in South Africa and around 45 percent of the electricity used in Africa.
ABB successfully completed construction activities on a 20 megawatt solar power plant in June 2012 on behalf of SunEdison, a leading global solar energy services provider.

Known as the Apex Solar Facility, the plant consists of an array of more than 87,000 polycrystalline solar modules on a 154-acre site at the Apex Industrial Park in North Las Vegas, a city that adjoins its famous neighbor in the Las Vegas valley.

ABB was selected by SunEdison for its ability to provide a complete solution, including a high voltage substation that connects the plant to the local transmission grid. The substation is pre-engineered by ABB to meet a projected increase in transmission rating from 69 kV to 138 kV.

ABB’s scope of supply includes design, engineering, supply, construction and commissioning of the PV power plant and substation. The solution comprises a wide range of ABB solar power and transmission technologies, including the DC collection system, AC transformation center, 69 kV switchyard and connection to the NV Energy transmission line. ABB also supplied 2000 kVA pad mounted transformers, medium voltage switchgear and the central plant SCADA system.

Supervisory control is based on ABB’s AC500 programmable logic controller using the Power Generation Portal human system interface. This advanced SCADA control system provides remote monitoring, control and diagnostics to maximize plant availability, productivity and efficiency.
High solar penetration in hybrid micro grids

Marble Bar, western Australia

The world’s first high penetration, photovoltaic-diesel power stations have been successfully operating in the towns of Marble Bar and Nullagine in Western Australia since 2010.

Historically, the towns generate their own electric power in diesel power plants and distribute it via local micro grids. In both towns, the existing diesel plants dated back to the early 1970s and were no longer compliant with regulations.

In 2010 the plants were replaced by the local power network operator with photovoltaic-diesel hybrids, which included integration, stabilization and control technologies provided by Powercorp, a company that was acquired by ABB in 2011.

The solution comprises PowerStore grid-stabilizing technology and a specially designed distributed control system. When the sun is shining the solution can provide up to 100 percent peak penetration of solar energy into the power network by lowering diesel generation to the minimum load requirements of the generators. When the sun is obscured, the solution covers the loss of solar energy by ramping up diesel generation, thereby ensuring uninterrupted energy supply.

PowerStore is a flywheel-based, short-term energy storage system designed to achieve up to 100 percent integration of intermittent and often erratic renewable energy into micro grids. Without Powerstore grid stabilizing technology, the instantaneous penetration of renewable energy is limited to about 30 percent of the total system load before the renewable component starts to destabilize it. In micro grid networks, this is a frequently experienced problem.

Each of the new solar-diesel hybrids at the two towns generates more than 1 GWh of renewable energy a year, supplying 60 percent of the town’s annual energy, saving 405,000 liters of fuel and displacing 1,100 metric tons of greenhouse gas emissions annually.

EPC contract for PV plant in India

ABB has been selected by Aatash Power to provide an engineering, procurement and construction (EPC) solution for a new 5 MW photovoltaic power plant in the state of Gujarat, western India. The plant is located in Sabarkantha district, about 100 km northwest of the state capital, Gandhinagar, and is scheduled for commissioning in November 2012.

In addition to supplying a complete engineering solution for the plant, ABB is also responsible for the supply, installation and commissioning of the AC and DC electrical equipment, SCADA system and connection to the high voltage power grid. ABB is also providing Aatash Power with a plant performance guarantee to ensure that the plant’s performance ratio remains consistently at a high and agreed level.

The contract is the latest of several that ABB has won in recent months to supply EPC and electrical balance of plant solutions for PV power plants in India. The plants range in size from 1 to 25 MW and are located all over the country.

O&M operations start in Bulgaria

ABB has won contracts to provide operations and maintenance (O&M) services for four photovoltaic power plants in Bulgaria.

The plants have a combined generating capacity of around 85 MW, with the largest producing 50 MW of power and the smallest 6 MW. All four plants are investment projects of Hareon Solar, the leading China-based manufacturer of PV modules. Some of the panels in the projects were supplied by Swiss-based ILB Helios.

ABB monitors the plants from a dedicated control room in Sofia that uses high-speed and secure data transmission connections and is manned solely by accredited technicians.

Besides collecting and storing real-time and historic data on all the critical equipment at the plants, the control center continuously analyzes the data to ensure that the plants are operating at their stipulated performance ratios. If a plant isn’t meeting its production target, the control room is automatically notified. A technician then performs a detailed diagnosis to identify the cause of the problem and either rectifies the fault by remote, or dispatches a service team to the plant if necessary.

Most importantly for the customer, all the plant data can be accessed remotely from any part of the world to produce comprehensive reports that are freely configurable. This enables the customer, among other things, to forecast plant output for the following day.

All four plants are equipped with an extensive range of ABB power and automation products and systems, including PVS800 inverters, cast coil dry-type transformers and medium voltage switchgear, as well as monitoring and control systems.

ABB operates dedicated O&M remote control centers for PV power plants in Italy and Spain, and offers similar O&M services for solar thermal plants as well.
Maximizing production at PV power plants

As an EPC contractor ABB has delivered more than 50 photovoltaic power plants with around 400 MW of generating capacity and has contracts for an additional 250 MW in the pipeline. Part of ABB’s highly successful concept for PV power plants is the attainment of very high levels of plant performance ratio and equipment availability.

The main challenge facing the EPC (engineering, procurement and construction) contractor after the completion of a photovoltaic (PV) power plant is to meet the performance and availability levels stipulated in the contract. This is when the plant design has to be validated in a real operational setting and over a defined period of time. In PV projects the plant design is the result of several engineering disciplines – civil, mechanical, electrical and electronic – which have to be harmonized with the construction and commissioning capabilities of the EPC contractor to secure the production targets of the plant.

The quality of the plant design is measured by two main values:
- Performance ratio (PR)
- Equipment availability

These two values measure the quality of converting solar irradiation into electrical power and confirm that all the plant equipment - from the panels to the grid connection - is working at maximum efficiency and with minimal losses during the sun hours of the day. They measure the quality of the conversion in watts per square meter into the energy delivered to the grid in watts per hour:

\[ PR = \frac{E_i}{P_{p,\text{plant}}} \cdot \frac{H_i}{G_0} \]

where:
- \(E_i\) = Energy generated at the measuring point (inverters, grid, etc) in the period \(i\) [kWh]
- \(H_i\) = Irradiance measured by the calibrated cells of the installation in the period \(i\) [Wh/m²/year]
- \(P_{p,\text{plant}}\) = Peak power of the panels installed [kWp]
- \(G_0\) = Irradiance at standard test conditions [1000 W/m²]

In actual fact the maximum electrical energy that the panels have the potential to deliver is never attained because there is always equipment or plant conditions that prevent it, such as dust deposits or optical loss because the sun’s rays are not perpendicular to the glass surface of the panels.

These losses, which are derived from the physical characteristics of the plant equipment, can be summarized in the following sets of factors:
- Losses associated with the panels
- Losses associated with DC power
- Losses associated with the DC/AC conversion
- Losses associated with AC power

Factors that influence the performance of a PV plant

- Dust
- Shadings
- Reflection
- Low irradiation level
- Temperature losses
- Module degradation
- Mismatching
- LV wiring losses
- Inverter electrical losses
  - Efficiency
  - Mppt losses
  - VDC variable
- LV AC wiring losses
- LV/MV transformer losses
- MV wiring losses
- Substation losses
- ...
irradiation level and reflection of the light on the panel surface, as well as degradation of the panels in the initial phase of operation (light-induced degradation) and yearly degradation.

- Arrangement of the panels

Losses associated with the mechanical installation of the panels are shadow, dust, inadequate cleaning of the panel glass, and tracker gain. The mismatching effect is also relevant, as not all panels are physically identical and not all of them can be installed randomly in series and parallel connections to increase the voltage and current.

**Losses associated with DC power**

The DC electricity converted by the panels is conducted to the inverters by cables, which due to the high current they are conducting cause voltage drops and as a result electrical losses.

**Losses associated with the DC/AC conversion**

The DC power is converted into AC power by an inverter. The performance of this electronic device is dependent on many factors, such as load working point, tracking the operating point of the panels (MPPT maximum power point tracking), temperature, etc.

**Losses associated with AC power**

In order to transfer the AC power to the grid the voltage level has to be increased to medium voltage by transformers and connected to the grid by cables; this results in electrical losses.

All of these losses accumulate in the electrical path of the electrons and the end result is that they reduce the amount of power generated by the plant.

ABB has a deep knowledge and long experience of minimizing these losses in PV power plants. We have developed an advanced control system that calculates in real time the plant performance ratio, which it continuously reports via secure data transmission connections to one of several ABB operations and maintenance (O&M) centers. The data transmitted includes trends, deviations and other critical information. This enables the O&M center to take corrective action to increase the power output as fast as possible in order to avoid medium-term deviation trends that cannot be recovered during the year period.

**Operational results**

Tables 1-2 on page 20 present the monthly performance ratio results of six different PV plants in Spain and Italy that ABB monitors from its O&M centers in both countries. The performance of all six plants is substantially better than the owners expected, even though plant production was subjected to all manner of incidents, including grid blackouts, cable theft, fires, storms, high winds, and so on.

Continued on page 20

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**Control and supervisory system**

**Real-time PR calculation**

<table>
<thead>
<tr>
<th>Panels (String)</th>
<th>Tracker</th>
<th>DC cabling</th>
<th>Inverter</th>
<th>Transformation center</th>
</tr>
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<tr>
<td>- Temperature</td>
<td>- Tracking efficiency</td>
<td>- Voltage DC input</td>
<td>- Control for:</td>
<td>- CT control for:</td>
</tr>
<tr>
<td>- Sun irradiation</td>
<td>- Tracking accuracy</td>
<td>- Current DC input</td>
<td>- Voltage DC</td>
<td>- Temperature</td>
</tr>
<tr>
<td>- Current string monitoring</td>
<td>- Tracking gain</td>
<td>- Protection status</td>
<td>- AC voltage</td>
<td></td>
</tr>
<tr>
<td>- Panel location</td>
<td>- Control for:</td>
<td></td>
<td>- AC current</td>
<td></td>
</tr>
<tr>
<td>- Algorithm for:</td>
<td>- Sun position</td>
<td></td>
<td>- AC power</td>
<td></td>
</tr>
<tr>
<td>- Panel degradation</td>
<td>- Tracker position</td>
<td></td>
<td>- Restarting</td>
<td></td>
</tr>
<tr>
<td>- Panel failure</td>
<td>- Motor movements</td>
<td></td>
<td>- MPPT analysis</td>
<td></td>
</tr>
<tr>
<td>- Dirt</td>
<td>- 2 axis tilt sensors</td>
<td></td>
<td>- Switching system</td>
<td></td>
</tr>
<tr>
<td>- PR panels</td>
<td>- Shadow calculation</td>
<td></td>
<td>- Neuronal algorithm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Backtracking</td>
<td></td>
<td>- Inverter efficiency</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Emergency position</td>
<td></td>
<td>- PR inverter</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Maintenance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- PR tracker</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
where:

- **D** = Availability for the period (%)
- **P** = Total nominal installed power of the plant (kW)
- **T** = Irradiation for the period (ie, total hours that the panels are receiving irradiation during the period of calculation) (h)
- **p_t** = Power affected by a breakdown (kW)
- **t_t** = Time of a breakdown during irradiation (h)

Availability is highly affected by the following factors:

- The quality of the equipment
- High level of automation to enable the plant to be operated by remote operators in a fast, intelligent and intuitive manner
- Diligent attention to alarms and events at the plant
- Stock of spare parts for the replacement of defective parts
- Correct level of training of local maintenance crews
- Periodical cleaning of panels and cutting of vegetation

### Table 1 - Monthly performance ratio value

<table>
<thead>
<tr>
<th></th>
<th>SPAIN 1</th>
<th>SPAIN 2</th>
<th>SPAIN 3</th>
<th>ITALY 1</th>
<th>ITALY 2</th>
<th>ITALY 3</th>
<th>ITALY 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>October 2010</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>November 2010</td>
<td>89.01%</td>
<td>90.95%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>December 2010</td>
<td>89.43%</td>
<td>89.90%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>January 2011</td>
<td>88.84%</td>
<td>92.81%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>February 2011</td>
<td>85.31%</td>
<td>85.75%</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>March 2011</td>
<td>88.88%</td>
<td>81.73%</td>
<td>98.90%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>April 2011</td>
<td>78.14%</td>
<td>79.25%</td>
<td>76.11%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>May 2011</td>
<td>75.73%</td>
<td>78.90%</td>
<td>76.40%</td>
<td></td>
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<tr>
<td>June 2011</td>
<td>97.33%</td>
<td>98.04%</td>
<td>71.44%</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>July 2011</td>
<td>88.21%</td>
<td>88.91%</td>
<td>78.86%</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>August 2011</td>
<td>77.04%</td>
<td>76.85%</td>
<td>79.76%</td>
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</tr>
<tr>
<td>September 2011</td>
<td>78.87%</td>
<td>79.41%</td>
<td>81.23%</td>
<td>67.84%</td>
<td>83.54%</td>
<td>82.34%</td>
<td>85.35%</td>
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<tr>
<td>October 2011</td>
<td>82.86%</td>
<td>83.77%</td>
<td>82.89%</td>
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<td>71.52%</td>
<td>83.17%</td>
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<tr>
<td>November 2011</td>
<td>85.92%</td>
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<td>85.62%</td>
<td>80.54%</td>
<td>78.59%</td>
<td>85.92%</td>
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<tr>
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<td>84.92%</td>
<td>85.14%</td>
<td>86.35%</td>
<td>87.13%</td>
<td>87.09%</td>
<td>84.69%</td>
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<tr>
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<td>86.77%</td>
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<td>82.01%</td>
<td>77.51%</td>
<td>86.35%</td>
</tr>
<tr>
<td>March 2012</td>
<td>79.26%</td>
<td>80.94%</td>
<td>86.49%</td>
<td>86.73%</td>
<td>83.69%</td>
<td>85.91%</td>
<td>85.61%</td>
</tr>
<tr>
<td>April 2012</td>
<td>81.71%</td>
<td>82.58%</td>
<td>88.69%</td>
<td>86.15%</td>
<td>79.31%</td>
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<td>81.13%</td>
</tr>
<tr>
<td>May 2012</td>
<td>80.30%</td>
<td>80.36%</td>
<td>92.36%</td>
<td>85.14%</td>
<td>88.69%</td>
<td>92.36%</td>
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<tr>
<td>June 2012</td>
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<td>81.13%</td>
<td>89.27%</td>
<td>80.02%</td>
<td>81.85%</td>
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<td>July 2012</td>
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<td>88.87%</td>
<td>80.39%</td>
<td>83.66%</td>
<td>83.87%</td>
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</tr>
<tr>
<td>August 2012</td>
<td>78.32%</td>
<td>78.79%</td>
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<td>85.37%</td>
<td>83.53%</td>
<td>84.27%</td>
<td>74.80%</td>
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</table>

### Table 2 - Yearly summary of performance ratio

<table>
<thead>
<tr>
<th></th>
<th>Year 1</th>
<th>Year 1</th>
<th>Year 1</th>
<th>Year 1</th>
<th>Year 1</th>
<th>Year 1</th>
<th>Year 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contractual value</td>
<td>80.19%</td>
<td>80.19%</td>
<td>81.38%</td>
<td>80.58%</td>
<td>78.58%</td>
<td>80.81%</td>
<td>80.85%</td>
</tr>
<tr>
<td>Achieved value</td>
<td>84.39%</td>
<td>85.88%</td>
<td>82.41%</td>
<td>82.71%</td>
<td>81.86%</td>
<td>83.33%</td>
<td>82.65%</td>
</tr>
<tr>
<td></td>
<td>Year 2</td>
<td>Year 2</td>
<td>Year 2</td>
<td>Year 2</td>
<td>Year 2</td>
<td>Year 2</td>
<td>Year 2</td>
</tr>
<tr>
<td>Contractual value</td>
<td>79.19%</td>
<td>79.19%</td>
<td>80.38%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Achieved value</td>
<td>80.93%</td>
<td>81.85%</td>
<td>87.29%</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

### Table 3 - Average yearly equipment availability

<table>
<thead>
<tr>
<th></th>
<th>SPAIN 1</th>
<th>SPAIN 2</th>
<th>SPAIN 3</th>
<th>ITALY 1</th>
<th>ITALY 2</th>
<th>ITALY 3</th>
<th>ITALY 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contractual value</td>
<td>98.00%</td>
<td>98.00%</td>
<td>98.50%</td>
<td>98.50%</td>
<td>98.50%</td>
<td>98.50%</td>
<td>98.50%</td>
</tr>
<tr>
<td>Achieved value</td>
<td>99.40%</td>
<td>98.80%</td>
<td>99.35%</td>
<td>99.43%</td>
<td>99.13%</td>
<td>98.23%</td>
<td></td>
</tr>
<tr>
<td>Including grid events</td>
<td>98.50%</td>
<td>97.90%</td>
<td>98.80%</td>
<td>95.38%</td>
<td>97.72%</td>
<td>96.95%</td>
<td>93.12%</td>
</tr>
</tbody>
</table>

### Plant availability

The availability value measures equipment performance by measuring the number of hours the equipment is in operation against the number of hours expected, which in the case of PV plants is the number of sun hours per year for the location of the plant.

The equation for measuring equipment availability is:

\[
D = 100\times\frac{\sum_{i} p_{t}t_{t}}{PT}
\]

where:

- **D** = Availability for the period (%)
- **P** = Total nominal installed power of the plant (kW)
- **T** = Irradiation for the period (ie, total hours that the panels are receiving irradiation during the period of calculation) (h)
- **p_t** = Power affected by a breakdown (kW)
- **t_t** = Time of a breakdown during irradiation (h)

Availability is highly affected by the following factors:

- Early detection of faults by means of an O&M center
- Real-time supervision by the control system and the O&M center, and the ability of both to present information to operators in a fast, intelligent and intuitive manner
- Diligent attention to alarms and events at the plant
- Stock of spare parts for the replacement of defective parts
- Correct level of training of local maintenance crews
- Periodical cleaning of panels and cutting of vegetation
– Thermographic control of electrical equipment and panels

For the above mentioned six plants in Spain and Italy, equipment availability between October 2011 and the present (September 2012) consistently outperformed the contracted values. The results are shown in table 3.

It is important to mention that in the level of availability guaranteed by ABB, there are events that impact availability that are not the responsibility of ABB. These refer mainly to grid problems that have to be managed by the plant operator in order to reduce the impact of the outages and the loss of plant production. A key tool in doing this is remote monitoring of the plant in order to clear the fault and reclose, or to have reclosing routines in the automation system to start up the equipment safely and as quickly as possible. Normal outages are mainly due to the electrical protection trips caused by ground defects as well as overvoltage trips due to grid perturbation.

The prerequisites for maximum plant performance

ABB delivers exceptionally reliable and high performance PV power plants. As can be seen above, their performance is based on high-quality electrical equipment, a high level of automation, and a plant design that optimizes the plant’s performance ratio and equipment availability to deliver as much energy as possible while minimizing losses and outages.
Concentrating solar power (CSP) plants represent a new challenge for automation. The ratio of about 400 I/O signals per MW is one of the highest in power generation. The system tags also have an extremely high ratio of about 3,500 tags per MW. A parabolic trough CSP plant is one of the most automated types of power plant in the industry, comparable to a nuclear power plant.

In addition, the overall architecture is highly distributed, covering thousands of square meters in the solar field, a factor that increases the complexity of plant communications.

The automation of the balance of plant is based mainly on maintaining the working fluids (oil, heat transfer fluid, molten salt or water/steam) within narrow operating margins of temperature and pressure control, as well as on controlling unstable steam conditions due to the nature of the sun’s irradiation.

CSP internal bus communications are also a challenge. About 150,000 tags are communicated through the system buses, which are typically Modbus TCP or PROFINET DP. Communication from the solar field to the central power plant database has to provide a complete solar field update in less than 5 seconds.

The DCS has to be highly reliable (with 99.99% availability). For this reason, redundancy has to be provided for the control processors, the I/O cards for all analog I/Os for critical control loops, the communication and interface processors, the data storage devices, communication networks and power supplies - so that single component failures will have minimal effect.

The software communication system (SCS) is responsible for managing the huge volume of data traffic and for controlling some of the solar field functions related to the overall behavior of the plant - such as the emergency modes, startup modes, etc. - and it is fully integrated with the plant distributed control system (DCS) hardware. Depending on customer specifications, the SCS can be equipped with the same hardware processor as the DCS or with an industrial PC. This subsystem is critical for securing any kind of point to point, event-driven or broadcast communication.

**Local automation controllers**

In the case of CSP linear technologies (parabolic trough or linear Fresnel), the solar field of each solar thermal plant consists of a system of long pipes, in which the fluid is heated by the reflection of the sun’s rays and concentrated by an optical mirror system onto the pipes. The average number of local automation controllers (LOCs) per 50 MW is around 450 to 640 units, depending on the solar field design and whether the plant has thermal storage. These several hundred devices are connected to a communication bus system that is managed by the SCS in order to avoid communication collapse and to secure data integrity and the time cycle.

The LOCs should accurately calculate the expected position of the sun, as per the NREL (National Renewable Energy Laboratory) model, and drive the mirror system to track the sun for closed-loop control.
Control of the solar field and its coordination with the balance of plant processes and electrical systems is provided by the LOC, in order to ensure that the temperature and pressure are optimal for each moment of the day and that safety conditions like high winds, hail and overpressure conditions are taken into account.

LOC design principles

The control part of the LOC is performed by proven standard industrial microprocessor-based programmable logic controllers (PLCs).

The LOC should have a modular design to facilitate easy system adaptation to future requirements and achieve an operating life of at least 20 years. The system should have the capability and facility for expansion through the addition of controller modules, I/O communication cards, etc, as well as for future software modifications.

The LOC should be easy to maintain. Each hardware part of the LOC should be supplied by an industrial standards manufacturer and be able to be replaced within a reasonable time anywhere in the world.

Each component and system part should be of proven reliability. The minimum reliability of each item of equipment – such as the electronic modules/cards, power supply and peripherals - should be such that the availability of the complete system is assured for 99.7% or higher.

The design of the LOC and related equipment should adhere to the principle of fail-safe operation, wherever the safety of personnel and plant equipment is involved. Fail-safe operation means that the loss of a signal or the loss of excitation or failure of any component should not cause a hazardous condition. It also means that the occurrence of false trips is avoided.

Control functionality

As pointed out earlier, the control part of the LOC should be performed by proven standard industrial microprocessor-based PLCs, not by a low-cost dedicated electronic board that is likely to create operational problems for maintenance.

The LOC is responsible for detecting and controlling the angular position of the mirror system by means of sensors based on an incremental encoder or inclinometer.

The LOC PLC is provided with the type of memory and capacity to store data and parameters permanently. The angular position of the collector should be stored in a permanent memory, even if an electrical blackout occurs.

LOC internal software must be able to calculate the expected position of the sun and the corresponding solar vector to which the mirror must be pointed. It should calculate the theoretical position of the sun, not just ‘see’ the position of the sun. The reason for this is to avoid misreading the sun’s position due to the presence of clouds or other disturbances. These calculations should follow the NREL system and have a control algorithm of ±0.0003º, which is extremely demanding for an industrial process.

The software architecture should be flexible to permit future modifications, so that dedicated hardware solutions will not be a problem for the maintainability of the overall system.

The LOC communicates with the plant DCS and must be able to deliver the following information to the DCS:
- Mirror identification
- Date and time
- Configuration parameters
- Calculated solar vector
- Alarm status
- Operation mode
- Mirror position set-point angle
- Fluid temperature
- Internal temperature of the LOC.

Extreme environmental conditions

The real challenges for the local automation of the solar field are heat, ultraviolet radiation and dust.

It is easy to imagine what the outdoor LOC equipment in a CSP plant in a desert location is subjected to. The heat from the sun’s irradiation is intense and equipment exposed to ultraviolet rays ages quickly. The electronics have to live with their worst enemies - the heat and dust. And, because customers require completely sealed solutions, ventilation holes and movable parts like fans are not permitted.

That is why ABB has designed a cubicle enclosure with double walls to withstand desert conditions and direct ultraviolet radiation. The external
enclosure of the LOC is IP65/ NEMA 4X plastic molded. It is attached to the metallic structure of the drive pylon (the central pylon of the collector) without any protective shadow.

The enclosures are designed for 25 years’ durability. The mechanical design can withstand extreme temperatures from -5ºC to 55ºC and relative humidity of 25% to 95%, including condensation and corrosive vapors.

For each CSP project our engineers design the optimal allocation of components in the LOC to ensure that the thermal behavior of the heat generated in the LOC does not affect the functionality, taking into account that the heat has to be dissipated only by means of passive solutions, without holes or fans in the cubicle.

Each LOC prototype is tested in the expected operating conditions and with the dimensions for the maximum ambient temperature of the site (typically 40 to 45ºC) and 1000 W/m² solar radiation, and with internal thermal dissipation. The internal temperature has to be at least 5ºC below the least heat-resistant component. Every design is verified and certified in an independent laboratory.

Communications

The LOC is provided with its own Ethernet communication port to the DCS by way of TCP/IP Modbus. Multimode fiber optic or copper RJ45 links connect each LOC to the next LOC within each network ring.

Communication with any LOC does not inhibit, delay or disturb communication with other LOCs, the DCS or other devices in the network.

The configuration program and configuration updates for each LOC are downloaded over the communication network.

A serial communication port is provided for local configuration and troubleshooting via the Ethernet communication port. For maintenance purposes, the LOC system includes a software tool to link a PC or handheld device with any LOC in the solar field from any point in the communication network. It includes control and communication software and human interface screens for any LOC or group of LOCs.

The LOC system has accurate time synchronization with the plant DCS. Real-time clocks in the control equipment are synchronized to within 1 ms by a GPS clock installed at the plant. A network time protocol (NTP) server synchronizes the clocks of all on-site LOC systems at regular intervals.

**ABB’s 1 GW installed base**

ABB has many years’ experience in automating linear system solar fields in Spain, the United States and Egypt, as well as active involvement in many CSP and ISCC (integrated solar and combined cycle) power plant projects in Morocco, South Africa, Australia, China, India, Chile, and other countries. Our large installed base in these projects now amounts to more than 20 installations with a combined generating capacity in excess of 1 GW. This, along with our vast operational experience of power plant automation systems and our global engineering footprint, provides our customers with substantial added value.
PowerStore
Innovative solution for grid stabilization

PowerStore™ is a flywheel-based, short-term energy storage system that includes state-of-the-art inverters and virtual generator control software. It is designed to enable integration of intermittent and often erratic renewable generation.

Advantages

- Can help achieve up to 100 percent penetration of the renewable source into micro grids
- Enables the utilization of renewable energy generators and ultimately protects remote communities from exposure to volatile oil prices
- Safeguards conventional micro grids and ensures the safe integration of large amounts of renewable energy
- Stabilizes both voltage and frequency and holds up to 18 MW of energy - can shift from full absorption to full injection in 1 millisecond to stabilize the grid
- Helps to significantly reduce greenhouse gas emissions
- Existing project references in solar, wind and hydro, as well as in hybridization with diesel units and consultancy services

New high-efficiency central inverter
Highly reliable, efficient and easy to install

Advantages

- Proven technology platform - high reliability and long operating life
- Compact and modular design - less space needed and fast and easy installation
- State-of-the-art industrial design - high total efficiency
- Wide range of remote and local communications - one supplier for all options
- Extensive DC and AC side protection - ensuring maximum uptime of the plant
- Life cycle service and support - rapid support anywhere in the world through ABB’s extensive global service network

ABB’s PVS800 central inverter sets the industry standard for high reliability, efficiency and ease of installation in large photovoltaic power plants.

The inverter is available in five ratings, from 100 kW up to the new 630 kW, and is optimized for cost-efficient multi-megawatt power plants. Using proven ABB components, the ABB central inverter delivers maximum energy in a compact, modular design with a wide selection of connectivity options.

The new 630 kW central inverter has a high maximum efficiency level of 98.6 percent and improved efficiency at partial loads, providing a Euro efficiency of 98.4 percent. It also offers a much wider operational temperature range, which makes it highly suitable for hot temperature conditions. In addition, the newly designed DC input section provides system integrators with a flexible and modular solution that is especially useful when considering the DC cable type and the number of junction boxes needed.
Product news

Substations for solar power plants

Scalable solutions

ABB offers a range of scalable substation solutions that help to efficiently integrate solar energy into the transmission grid and distribution network. Our in-depth knowledge of solar power generation technologies and comprehensive experience with grid codes and utility practices in use around the world enables us to provide turnkey grid connection solutions for all types and sizes of renewable power plants. The customized systems are based on proven and state-of-the-art technologies, and are designed to meet the requirements of customers with a global market presence as well as local specifications.

ABB’s worldwide presence ensures customer support throughout the life cycle of the substation, and our turnkey project capabilities enable us to support customers with permitting applications and system studies through to commissioning and maintenance.

Advantages

- Scalable grid connection substations for all types and sizes of solar power plants
- Optimized solutions with small footprint
- Cost-efficient systems based on domain knowledge of the power value chain and solar power generation technologies
- Short delivery time ensured by experienced system integrator with fast-track project handling capabilities
- Fast and well-documented proposals allowing simplified and shortened permitting process, concession application and utility negotiations
- Enhanced reliability and quality of power supply
- Dependable and optimal integration of the complete range of ABB substation equipment, including switchgear, transformers, substation automation, control and protection systems as well as ABB’s proven power converter system technology
ABB is a leading provider of integrated power and automation solutions for conventional and renewable-based power generation plants and water applications like pumping stations and distribution plants. The company’s extensive offering includes turnkey electrical, automation, instrumentation and control systems supported by a comprehensive service portfolio to optimize performance, reliability and efficiency while minimizing environmental impact.

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