New test bay for Bromborough

Reader survey – have your say about ABB’s communication

Delivering the converter stations for IFA2

Ofgem Electricity Network Innovation Competition success

Viewpoint: how DNOs are becoming DSOs
ABB's Power Grids division is the world's leading supplier of power and automation products, systems and service solutions across the power value chain of generation, transmission and distribution serving utility, industry, transportation and infrastructure customers directly and through channel partners. The division is focused on addressing key areas such as the integration of renewable energies, growing network complexity, grid automation and microgrids. The division also offers a full range of consulting, service and asset management solutions based on a lifecycle approach.

Dear reader,

We are living and working through times of unusual political, social and technological change. Digitalisation is opening up huge potential for greater efficiency and performance through the Fourth Industrial Revolution.

ABB is working hard to find new and clever ways to work with the power industry to make the most of digital technology and the Internet of Things, both by using existing technology in innovative ways to overcome new challenges and through integrating new technologies.

I’d like to highlight our work on E.ON’s Rampion Offshore Wind Farm, where our compact GIS will reduce land take and we have adopted parallel working and special environmental measures to deliver the project.

In terms of new technology, we succeeded in securing funding from Ofgem’s Network Innovation Competition (NIC) for two projects – learn more about the PowerFUL-CB and Phoenix project on pages 16 and 18.

As protection, control and automation schemes grow more sophisticated, it is essential to test and verify the logic behind them. Page 24 details how we are using offline testing on the Great Western Electrification Programme.

Integrating hardware with software is also central to the Fourth Industrial Revolution, so I hope that if you attended the Future of Utilities Conference you managed to learn about our Distributed Energy Response System (see page 41).

Although I can only highlight a few pages, I hope you’ll find plenty to interest you and that you will take a few minutes to share your feedback through our short online reader survey.

Complete the FFWD reader survey at www.abb.co.uk/ffwd

Best wishes,

Karen Strong, Marketing Communications Manager for ABB Power Grids
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Class of 2016 graduate

A graduation event took place on the 19th October 2016 to celebrate eight of ABB’s promising young employees, who achieved an Advanced Apprenticeship in Engineering. Craig Johnson, Josh Barber, Alistair Hares, Adrian Walker, Mitchell Gregory, Harry Street, Hayden Deaville and Ben Davies all succeeded in gaining their Level 3 EAL Extended Diploma in Engineering Technical Support.

The young professionals from Stone in Staffordshire joined ABB in 2012 and have combined classroom study at Newcastle-under-Lyme College (NULC) with engineering work experience. The scheme has developed their academic and technical skills in areas such as design engineering, construction and project working, as well as giving them insight into management and leadership skills. The event was attended by 50 people, including the Mayor and Consort of Newcastle-under-Lyme.

The head of ABB’s grid integration business unit in Stone, Jon Downs, said: “An apprenticeship is an excellent way to start a career as it gives a firm foundation for success in the world of work. Many members of ABB’s senior team started out as apprentices – so for those graduating today, the world is their oyster.”

B&R Automation acquisition

In April 2017 ABB announced the acquisition of B&R, a leading independent supplier of machine and factory automation. Based in Austria, B&R develops innovative products in PLC, Industrial PCs and servo motion as well as a software and solution suite.

"B&R is a gem in the world of machine and factory automation and this combination is a once-in-a-lifetime opportunity," said ABB’s CEO Ulrich Spiesshofer. "This transaction marks a true milestone for ABB, as B&R will close the historic gap within ABB’s automation offering. This is a perfect fit and will make us the only industrial automation provider offering customers the entire spectrum of technology and software solutions around measurement, control, actuation, robotics, digitalisation and electrification.”
Josh Barber named as IET Apprentice of the Year

One of ABB’s apprentices, Josh Barber achieved national recognition when he was announced as the IET’s (Institution of Engineering and Technology’s) Apprentice of the Year. The award celebrates the achievements of young engineers and technicians who have made exceptional contributions to their profession or operational area.

Josh was named as winner due to his outstanding work on Vattenfall’s Pen y Cymoedd wind energy project. He was nominated for the novel approach he took when designing the layout of a kiosk that integrates communications and power supplies for all substation equipment. Josh’s approach improved safety and efficiency and reduced installation errors. Having won approval from his supervisors and ABB’s customer, the design has now been adopted as standard. This means his contribution will be felt on every new substation project in the UK.

Josh commented: “It means so much to get recognition from the Institution of Engineering and Technology. I can honestly say I wouldn’t have achieved this without the support from my colleagues and supervisors at ABB who gave me the opportunity and the confidence to deliver the work which won the award.”

Step change for HVDC Light

ABB has more than doubled the capacity and significantly reduced the footprint of its HVDC Light (High Voltage Direct Current Light) technology. The news marks 20 years since ABB introduced Voltage Source Conversion-based HVDC Light.

The new generation of technology will have power capacity of up to 3,000 megawatts (MW). It will also introduce enhancements that will deliver 350 percent more power per square metre of space. This is a major benefit when limited space is available on offshore wind platforms or onshore converter stations. The advances were made possible through power electronic devices that provide greater control on a smaller scale.

Celebrating sustainability

The IET (Institution of Engineering and Technology) has opened nominations for its 2017 Innovation Awards and ABB is once again continuing its support for the Sustainability award. Textile manufacturer Samatoa Lotus Textiles won the ABB-sponsored Sustainability category at the 2016 awards for using a waste product from lotus stems to create a 100 percent ecological fabric that is also the world’s first natural microfibre.

Sustainability is close to the heart of what ABB represents as a business as it celebrates innovations that meet the needs of the present generation without compromising future generations. Past winners include developers of energy storage technology, refrigeration and biodegradable packaging.
Hubertus von Gruenberg research award

ABB has awarded a $300,000 research grant named in honour of its former chairman Dr Hubertus von Gruenberg. The award was received by Dr. Jef Beerten, a Belgian researcher in HVDC (high-voltage direct current) grids who works at the University of Leuven and the Research Foundation Flanders.

Dr Beerten was chosen from 69 applicants from leading institutions as his work offers a new look into the stability of HVDC grids interacting with existing HV alternating current (HVAC) grids. He researches new tools, models and methods for designing and controlling meshed HVDC grids. His research improves understanding of how today’s HVAC grids will interact with future HVDC grids.

ABB created the award to recognise outstanding academic work in energy and automation. It is awarded every three years and comes with one of the highest research grants of its kind.

ABB CEO Ulrich Spiesshofer said: “I congratulate Jef Beerten, whose work stands out for its applicability to real-world problems in the field of power and automation.”

Dr Beerten said: “I am proud and delighted to be able to accept this exceptional award. I would like to thank ABB for the grant and this unique opportunity to continue my work in the field of electric power systems.”

FITNESS in focus for SPEN

ABB’s digital substation experts contributed to an event hosted by ScottishPower Energy Networks (SPEN) in Glasgow with the goal of sharing knowledge and experience on the Future Intelligent Transmission Network Substation (FITNESS) project.

The project will be the UK’s first live multi-vendor demonstrator of a digital substation and it will see two bays of SPEN’s existing Wishaw 275 kV substation being equipped with digital protection and control systems. ABB will deliver digital substation components including IEDs, non-conventional instrument transformers, merging units and phasor measurement units that will interface with the IEC 62850-9-2 process bus and the wide area monitoring platform.

ABB delivered a presentation during SPEN’s event, which was held alongside a meeting of the influential IEC Technical Committee 57 (IEC TC 57), which oversees knowledge sharing in power systems.

The FITNESS project will deliver a digital protection and control scheme in parallel with the Wishaw substation’s conventional scheme before the digital solution is converted to live operation.
Community links

Engineers from ABB and Scottish and Southern Energy (SSE) and ABB raised a total of £3,000 for charity at a recent team-building golf day. The day was attended by members of the project team on SSE’s Caithness-Moray link and each half of the team nominated a charity to benefit from half of the funds raised. ABB nominated Highland Disability Sport, which it first supported when it sponsored the charity’s Junior Festival of Sport in 2015.

Lesley Jones, Administrator for Highland Disability Sport said:

“It is thanks to funds raised by people in organisations like ABB and SSE that Highland Disability Sport can provide the joy of sports training, athletic competition and shared identity for children and young adults with intellectual and learning disabilities from across the Highlands.”

Success for MeyGen

Atlantis Resources, the operator of the MeyGen tidal stream project in the Pentland Firth, has supplied almost 400 MWh of energy into the grid since it entered operation in November 2016.

ABB delivered the onshore power conversion and grid connection for MeyGen Phase 1A, which included a PCS6000 STATCOM (static compensator) to provide variable reactive power to compensate for natural variation in the tidal flows in the Pentland Firth, where four turbines have been installed. In February 2017, Ofgem awarded the project full accreditation under its ROC (Renewables Obligation Certificate) scheme.

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ABB’s engineers nominated Highland Disability Sport as their charity

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MeyGen has generated its first power from the tidal race in the Pentland Firth

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FFWD READER SURVEY

As a reader of ffwd, we’d love to know what you think about FFWD as a publication. We’ll use the results of the survey to improve how we communicate with customers – so whether you’d like more in-depth technical detail or more of a high-level overview, please let us know.

For every survey completed we will donate to our chosen charity, Macmillan Cancer Support, to help improve the lives of people affected by cancer by providing practical, medical, emotional and financial support.

Let us know what you think of FFWD at www.abb.co.uk/ffwd
INTERCONNECTORS

HVDC converter stations for the IFA2 link

National Grid and its French counterpart RTE (Réseau de Transport d’Electricité) have awarded ABB an order worth €270 million to deliver key HVDC (high voltage direct current) technology that will help to interconnect the electricity networks of France and the UK.

The link will run between Chilling, Hampshire, on the southern coast of England to Tourbe in northern France, covering a distance of 240 kilometres across the English Channel.

ABB’s role is to provide the two HVDC Light converter stations that will convert alternating current (AC) from the grid into direct current for transmission across the Channel and back again.

The key advantage of HVDC technology is that it enables efficient and reliable transmission of large amounts of electricity over long distances with minimum losses. Based on voltage source conversion (VSC) technology, ABB’s HVDC Light technology incorporates advanced features such as regulating grid fluctuations and power restoration in the event of an outage. These features provide economic benefits for the network operator and reliable electricity supply to electricity consumers.

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HVDC technology enables efficient and reliable transmission over long distances.
**IFA2 HVDC transmission link**

ABB enables interconnection of France and UK power networks

240 kilometre HVDC link to facilitate power trading and shared use of renewable energy

ABB to supply two HVDC Light converter stations – one in France and one in the UK

“This order further strengthens our leading HVDC position and provides momentum to our transformational drive for profitable growth, as a partner of choice for enabling a stronger, smarter and greener grid,” said Claudio Facchin, President of ABB’s Power Grids division.

**MACH™ control and protection**

The converter stations will be equipped with ABB’s MACH advanced control and protection systems, which acts like the brain of the HVDC link. It monitors, controls and protects the sophisticated technology in the stations, managing thousands of operations to ensure the reliability of power supplies.

The control and protection system is designed to operate on a 24/7 basis for thirty years or more and consists of control and monitoring servers, operator workstations, main computers, digital signal processors, I/O systems and control units for the HVDC valves. It is based on a modular approach and uses similar hardware and system software used in an HVDC Classic system (based on current source conversion) or a FACTS (flexible alternating current transmission system) installation – only the application software and valve control differs from these.

It also incorporates advanced fault registration and remote control functions and will protect the link from unexpected disruptions such as lightning strikes.

**Affordability, sustainability and security**

According to the IFA2 website, project partners National Grid and RTE plan for the Interconnexion France-Angleterre 2 to be operational by 2020 and will build on the existing IFA link that connects Folkestone and Calais by providing a second connection.

The link will reduce the cost of electricity for homes and businesses in the Great Britain, increase the security of supply for both the UK and France and help both countries to meet climate change targets by sharing renewable energy.

Preparatory work is planned to start in autumn 2017, with construction running from 2018 to 2020.
Vital role for advanced GIS as mammoth East Anglia ONE offshore wind projects gets under way

ABB’s state-of-the-art gas insulated switchgear (GIS) is set to play a vital role in what will be one of the world’s largest offshore wind farms; the 102-turbine East Anglia ONE project in the North Sea off the east coast of England.

Following eight years of planning, surveys and liaison, ScottishPower Renewables commenced pre-construction works for its £2.5 billion East Anglia ONE project in January 2017. The first turbines are expected to be installed by 2019 and the wind farm is scheduled to be fully operational during 2020.

When complete, the new wind farm will have up to 102 turbines, installed some 50 km offshore, covering an area of more than 300 square kilometres – the equivalent of 30,000 football pitches. Together these will provide an overall generating capacity of up to 714 MW – enough to power 500,000 homes annually. The new wind farm will also be the most cost-efficient of its kind and will make a significant contribution to the UK Government’s cost reduction targets for renewable generation.

State-of-the-art switchgear
ABB’s involvement in the project includes a £12 million contract to supply state-of-the-art the high-voltage GIS for the offshore substation that will serve the new wind farm. This will cover 72.5 kilovolt (kV) and 220 kV switchgear, as well as project management, installation and commissioning and local services.

The offshore substation – weighing 7,700 tons and covering a surface area of 1,144 square metres – will collect the electricity produced by the turbines and transform it to a higher voltage to send it ashore. It will be equipped with 22 bays of ABB’s ELK-04 switchgear to collect the electricity produced by the wind farm’s 66 kV inter-array cables, while two bays of ELK-14 220 kV switchgear will connect the substation to the export cables that will transmit the power produced to the mainland grid. Two seabed export cables, each around 73 km long, will transfer the electricity to shore.

Jonathan Cole, Managing Director of Offshore Wind at ScottishPower Renewables, said: “This is a huge year for the East Anglia ONE project. Preparations are now underway for the initial work onshore and we are in advanced planning stages for the offshore work, which will kick-off in 2018. We will deliver industry-leading levels of UK content, coupled with the fact that this is the best value offshore windfarm ever to go in to construction. We hope that further major contracts will be placed in the UK in the coming months, adding to the jobs and investment we are already creating in Great Yarmouth, Lowestoft, Hull, Belfast, Aberdeen and Hartlepool.”
Interfacing with third parties will be particularly important for this project, with an even higher than normal emphasis on community relations to support ScottishPower Renewable's commitment to inward investment into the UK. ScottishPower Renewables is on target to deliver more than 50% of UK content across the life of the project and is committed to stimulating growth in the East Anglia region and supporting thousands of skilled jobs.

David Hughes, former Director Marketing and Sales at ABB’s Power Grids business in the UK, said:

“The East Anglia ONE project is a perfect example of how ABB’s state-of-the art GIS technology is the ideal match for the performance and reliability demands of large-scale wind farms, especially as they make the step to higher voltage 66 kV inter-array cabling instead of the more traditional 33 kV technology.”

**Local stimulus**

Interfacing with third parties will be particularly important for this project, with an even higher than normal emphasis on community relations to support ScottishPower Renewable’s commitment to inward investment into the UK. ScottishPower Renewables is on target to deliver more than 50% of UK content across the life of the project and is committed to stimulating growth in the East Anglia region and supporting thousands of skilled jobs.

ABB itself is sourcing a significant proportion of the project resource locally within the UK, including manpower, site management, subcontractors and suppliers of all kinds. Wherever possible, it is involving the community in the project and making the most of local skills and resources.
The BESS way forward for active power chain management

Stuart Grattage, ABB General Manager T&D Infrastructure & Grid Integration Solutions, outlines how ABB has developed Battery Energy Storage Systems (BESS) technology for active management of various issues across the power value chain.

Dynamic frequency control
The capability to maintain grid frequency within pre-set limits is now one of the most pressing issues for UK power networks to avoid power supply interruptions. This is because the increasing level of renewable energy does not offer the spinning mass and inertia provided by traditional, large generation plant – which has historically enabled our grid to maintain its frequency within the tight limits essential for stability.

The strategic deployment of BESS installations can help bridge this growing inertia gap by delivering vital grid frequency support. The battery absorbs power when the frequency is too high and injects power when the frequency is too low.

Load levelling
In load levelling the battery is used to store excess energy produced when demand is low and then make it available when demand is high. This approach is particularly useful in industrial applications where there is usually sufficient energy to meet the load but occasionally insufficient power at peak times. In this case, rather than reinforcing the plant feeder, a BESS can be a more cost-effective and faster to implement solution.

Peak power shaving
For peak shaving, the BESS delivers stored energy to the grid during periods of high demand, reducing the burden on the distribution network. This effectively reduces the gap between peak and average demand, improving the overall efficiency with which the electrical energy is used.

Using a BESS for peak shaving can help a utility to defer the major investment that might otherwise be needed to reinforce the network infrastructure to meet peak demands.

Power smoothing
Another key advantage of our BESS technology is its power smoothing capability to prevent sudden surges or drops in power supply. The stored energy smooths out any erratic power from intermittent energy sources such as wind and solar power plants, so that the utility receives constant and consistent power.

Islanding for microgrids
Operating within a grid-connected microgrid, a BESS can enable seamless islanding. This ensures that should there be any interruption to the main power supply then the microgrid can disconnect from it and rely on the energy stored in its battery to maintain security of supply. The BESS might even help in black-starting the main grid.
ABB has the proven capability to design, develop and implement fully integrated BESS solutions to suit every need from kilowatts to megawatts. Furthermore, since our technology is also used extensively for the management of reactive power, the addition of a BESS provides a further dimension – the management of active power. Our power converter systems have the capability to meet both reactive and active power needs, providing the grid with the flexibility to manage any situation, at any time in the daily demand cycle and for prolonged periods of time.

Successful demonstration
Between 2010 and 2014 ABB worked with UK Power Networks to install a 200 kWh BESS based on lithium-ion (Li-Ion) technology at Hemsby substation in East Anglia. The purpose was to demonstrate that an intelligent system that combined a battery with power electronics could support an existing distribution network and allow more renewable generation to connect by smoothing its intermittent output, reducing voltage fluctuations and shifting load.

The project showed that a BESS is like a Swiss army knife – it can provide multiple benefits and are not just a way to store energy generated from renewable sources for use at times of low generation. The communications infrastructure, providing real-time network measurements as control inputs and the automated control algorithm, managing peak loading to allow more renewable generation on a constrained network, were successfully installed and commissioned.

The main findings were that the Hemsby BESS:

• stored surplus energy when the wind was blowing or the sun was shining
• was adaptable enough to predict when local demand will peak and pick the best time to discharge its energy on to the network
• measured the negative effects on the network and performed an equal and opposite reaction to cancel them out
• ensured voltage remained consistent and lights don’t dip, when the wind suddenly dropped or clouds covered the sun
• used remote sensors to identify and correct problems on other parts of the network
• switched between two different 11kV circuits and even transferred surplus energy between them, this would normally require a back-to-back AC/DC/AC converter.

New range of Energy Storage Inverters
ESI range include features that enhance power quality

ESI inverters are suited to medium and low voltage applications

ABB has further extended its range of BESS solutions with the new ESI range of bi-directional inverters. They can be used with different types of battery technology and in both low voltage (LV) and medium voltage (MV) applications by connecting through a step-up transformer. The ESI is also packed with powerful features to enhance power quality issues such as harmonic mitigation, load balancing and reactive power compensation. This means that the ESI adds significant value to any BESS by doubling up as a power quality improvement device.

The ESI range offers three type of inverters- ESI-I up to 315 kW in one unit, ESI-M up to 100 kW in one unit and ESI-S up to 85 kW in one unit. ESI-I and ESI-M are free standing cubicles while the ESI-S are designed for wall mounting. The choice of the inverter depends on the power requirement, type of network connection and various other parameters.

Projects involving ESI projects will be coordinated by ABB’s specialized Power Quality facility at Bromborough. Steve Joyce, ABB Power Quality Business Manager, said: “The ESI range is ideally suited to address the reactive power and harmonic issues of wind and solar farms as well as providing effective energy storage. It is an efficient one-solution tool to address both BESS and Power Quality requirements for our growing number of customers with small to medium size renewable energy installations including industrial facilities, academic campuses, large supermarkets and warehouses and residential blocks.”
The PowerFul-CB project, which is funded by the Network Innovation Competition (NIC), administered by UK regulator Ofgem, addresses the growing fault current challenge being faced by London’s power distribution networks as they connect an increasing number of distributed generation (DG) resources.

Currently, most of London’s power is generated outside the city in power stations where large quantities of heat are lost to the atmosphere. One of the aims of the London Plan is for one-quarter of London’s heat and power to be generated in the capital by 2025, which could reduce carbon dioxide emissions by more than 2.5 million tonnes annually.

This is likely to lead to significant growth in CHP schemes, which are highly efficient in generating heat and power simultaneously and so consume less energy than conventional energy systems in meeting the same energy demand.

Many large offices and housing developments in London already have their own CHP units, which capture the heat created as a by-product of electricity generation and circulate it around the buildings instead of using separate boilers. CHP units are up to 30 percent more efficient than having separate electricity generators and boilers, potentially leading to significant cost savings for consumers, as well as cutting emissions.

Fault level constraints
Achieving these aims, however, is challenging given the fault level constraints that a rapid introduction of CHP schemes would place on the distribution network without prohibitively expensive infrastructure upgrades, or advances in technology. In London, the already limited headroom in substations would soon be exhausted. In one scenario, with the capital seeing a greater than six-fold increase in connecting CHP by 2031, some 73 percent of substations in the capital would require fault-level reinforcement.

Fault current occurs when there is a fault on the network (normal current is a steady flow of electricity through the network) and is characterized by an instantaneous surge of electrical energy, which flows towards the point of the fault.

Fault level is the potential maximum amount of fault current that will flow when a fault occurs. Additional demand and generation – including CHP schemes – connecting to the network increase fault level. Fault level fluctuates...
throughout the day depending on the network configuration and customers’ load or generation. The ability to actively manage and mitigate fault level is a valuable tool for Distribution Network Operators (DNOs).

**Fault current technology breakthrough**

UK Power Networks established the PowerFUL-CB project to evaluate innovative fault current limiting technology on 11 kV distribution networks. The company estimates that by 2050, this new technology could save UK customers around £400 million in reinforcement costs (in net present value terms). These savings would be associated with around 460MW of additional DG connections nationwide.

Moreover, the increase in distribution connected CHP has the potential to deliver up to 3,800 kilotonnes of cumulative reduction in carbon dioxide emissions by 2050 – equivalent to the annual improvement of taking around 800,000 vehicles off the road.

The PowerFUL-CB project is funded by the NIC, which is open to applications from UK mainland distribution and transmission networks, including independent network companies, offshore transmission owners and the national system operator. Network companies submit and deliver projects in partnership with the wider energy industry, such as energy suppliers, universities or technology providers.

PowerFUL-CB will see ABB deploy the world’s first fault current limiting solution based on compact power electronics. This innovative device will respond to a fault current within 0.35 milliseconds – 300 times faster than a Formula 1 driver – with the added benefit that it can be reset as soon as the fault current is cleared to ensure security of supply.

In the first two years of the project, which started in January 2017, ABB will use its existing 2,000 A power electronic fault current limiter technology to build a full prototype for a trial installation at a primary substation. The aim is to demonstrate its suitability as a smart, cost-effective long term solution for multiple DG connections.

Commenting on the project, Peter Jones, ABB Technology Strategy Manager, said: “Fault currents are a major barrier to the connection of DG. But while a number of smart solutions are already available, they do not meet London’s unique physical and operational constraints in terms of lack of space for new substation equipment and the need to ensure total security of supply. This project will enable us to demonstrate an innovative approach that offers a compact option to achieve a quicker and more cost-effective connection to fault-level-constrained networks.”

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The combined heat and power energy centre built for the London Olympic games in Stratford, East London
The transmission system in Great Britain (GB) is facing a growing stability challenge due to the loss of spinning reserve as it embraces renewable energy. Ofgem’s Electricity Network Innovation Competition (NIC) is leading the quest for possible solutions and has funded SP Transmission’s Phoenix project to deploy the world’s first Hybrid Synchronous Compensator.

Renewable energy resources are now responsible for some 25 percent of Great Britain’s electricity generation, demonstrating steady progress towards a greener grid. That’s good news for the environment. However, it also represents a challenge for transmission network operators (TSOs) who have always relied on spinning reserve from traditional large-scale fossil-fuel and nuclear plants, which have the system inertia that ensures grid stability.

**Spinning reserve**

In simple terms, spinning reserve is unused generating capacity that is connected to the grid and is ticking over, making it available at a moment’s notice to meet a sudden change in demand. Also known as ‘inertia’, it keeps the grid voltage and frequency within tightly controlled limits. If the grid strays outside these limits it can become unstable, potentially leading to outages or blackout.

Momentum in the large rotating equipment used in thermal power stations has lots of inertia. It literally keeps spinning for a long time even when unpowered.

In contrast, renewable energy has little or no inertia. For example, a passing cloud can cause the output from solar panels to decrease by 70 percent or more in only a minute. This is why the growing grid penetration of renewables now presents challenges to grid stability.
Today, no single technology solution is available to solve these rising challenges. Future power grids will need to include a number of complementary technologies. These include Synchronous Compensators (SCs), which are large rotating generators that have been used on networks for many years, as well as power electronic based FACTS (Flexible AC Transmission Systems) devices.

**Hybrid Synchronous Compensator**
In response to the growing stability challenge, ABB joined forces with project partners Scottish Power Energy Networks, National Grid, The University of Strathclyde and the Technical University of Denmark. The partners made a successful application in the Electricity Network Innovation Competition (NIC) organized by Ofgem, the UK regulator for electricity and gas markets.

The team won funding for the Phoenix project to create the world’s first Hybrid Synchronous Compensator (H-SC). Its innovative approach combines two technologies, a Synchronous Compensator (SC) and a static power electronic compensator (STATCOM, FACTS device).

The H-SC will be deployed at a strategic point on the Scottish Power transmission network. The project’s objective is to demonstrate the technical and economical capabilities of an H-SC to enhance system stability and security while maintaining power quality to minimize the risks of blackouts and delivering significant benefits to the GB network and its residents.

“We have the technological know-how and the experience within ABB,” said Per Eckemark, Global Product Manager for FACTS. “We are very happy that customers like Scottish Power, National Grid, together with Ofgem, once again put their faith in ABB. It’s a validation that innovation and persistence really pays off!”

**Partnership working**
Peter Jones, ABB Technology Strategy Manager, said: “These Network Innovation Competition (NIC) submissions demonstrate how ABB finds success by working very closely with our customers to bid jointly for innovation funding.”
ABB has introduced a new breed of distribution transformer for a long life in the most severe operating environments. The TXtreme has a special coating that is designed to withstand tough conditions that contain salt, moisture and chemicals that can cause premature corrosion.

While the core and coils typically last up to 20 to 30 years, around 80 percent of distribution transformers fail due to rust, corrosion or leaks. Such harsh environments can lead operators to replace units prematurely or develop alternatives using stainless steel, which can be more costly as well as heavier and larger.

Recognising the need for an alternative, ABB has mastered the process of applying a unique coating that protects the distribution transformer and ensures its ongoing operation. The formulation is resistant to corrosive substances and extends the service life of the transformer.

As well as being applied to the transformer tank, it also protects the joints and cooling system, helping the unit to survive the elements and reduce operation and maintenance costs by eliminating the cost of frequent repainting.

The TXtreme is ideally suited to delivering asset resilience and reliability for utilities and grid operators, which are measured by regulators against uptime and continuity of supply.

The new transformer can also help industrial operators, including operators of offshore oil and gas platforms, which experience continuous exposure with wind and salt water.

“We are delighted to provide this innovative product to support increased grid resilience and reliability for utilities and optimized performance and improved uptime for industries,” said Markus Heimbach, Managing Director of ABB’s Transformers business unit, a part of the company’s Power Grids division.

“The special coating formulation protects against chemical and water ingress.”

Markus Heimbach, Managing Director

“TXtreme is an integral part of ABB’s Transformer Resilience initiative designed to help utilities protect assets and is another example of our Next Level strategy to enable a stronger, smarter and greener grid.”
Transmitters

World’s first digital distribution transformer

In March 2017, ABB launched TXpert™ as the world’s first digital distribution transformer at ABB Customer World, an automation and power event in Houston, Texas. TXpert integrates digital sensing and monitoring technology. It is designed for customers in utilities and industry to maximise reliability, optimise operating and maintenance costs and enable operators to manage their assets more efficiently.

TXpert is part of ABB’s Transformer Intelligence portfolio that includes state-of-the-art sensors, monitoring platforms and software tools. As a digital product it also falls within ABB’s unified, cross-industrial digital capability called ABB Ability that covers everything from devices to the cloud. ABB Ability uses cloud computing and connected devices to generate actionable data for a broad range of customers.

The TXpert solution is capable of monitoring key indicators such as ambient and top-oil temperatures, as well as the level, pressure, moisture and hydrogen content of oil and finally voltage and current levels.

Performance data collected from the transformer’s sensors is stored and analysed within the transformer for up to 20 years or be transferred via an encrypted link using standard communications protocols. When connected with a wide area communications network, operators can tap into real-time data to gain insight into network conditions.

Power grids are undergoing a transformation both on the supply and demand sides. Intelligent products such as the TXpert that can communicate are an essential component in the convergence of information and operational technologies.

“Distribution transformers are vital components in the electrical value chain. This latest innovation extends our digital portfolio and ABB Ability based offering and reinforces our position as the world’s leading transformer manufacturer,” said Claudio Facchin, President of ABB’s Power Grids Division.

Within the utility world, ABB Ability provides tailored digital solutions and products across power generation, transmission and distribution. These include digital substations, advanced diagnostics, communication, DERMS (distributed energy resource management systems) and lifecycle management, as well as the new TXtreme digital distribution transformer.
Bushings are a critical component of power transformers. They connect the windings of the transformer to the overhead line or busbar while providing an insulated barrier between the live conductor and the transformer body. They also perform as a mechanical support for the overhead conductor.

Oil-filled porcelain bushings
Traditionally, bushings are made of a central brass or copper conductor surrounded by a stack of porcelain insulators separated by protective gaskets. Between the conductor and the porcelain, a void is filled with insulating oil that increases the electrical withstand. In addition, a fixing system holds the stack together and consists of a collar flange and some pressure components that also connects a metallic cover.

Failure can have major consequences in terms of loss of service. If and when oil-filled porcelain bushings fail, it tends to be through sudden explosive shattering of the porcelain. This leads to risk from porcelain projectiles as well as leakage of the synthetic or ester insulating oil and the potential hazard of an oil fire.

The operating environment can impact the life of outdoor equipment and bushings are particularly open to the elements as they are exposed to wind, rain, harsh UV, pollution, heat and cold on top of the transformer. In addition, they experience thermal and electrical stresses during their lifetime.

Many thousands of such bushings are in place on the UK’s aging transformer fleet, creating a major challenge for operators in how to best maintain the bushings and their individual components.

Moving towards combined insulation bushings
Rather than replace time-served bushings with brand new oil-filled porcelain replacements, operators are increasingly opting for combined insulation bushings as they achieve higher levels of safety, reliability and environmental sustainability.

Sagnik Murthy, Regional Marketing Specialist Northern Europe, for ABB’s Transformer Components explains how utilities are increasingly turning to combined insulation bushings as the proven material of choice for replacing bushings.
Inside a combined insulation bushing, an organic insulation resin layer is directly moulded onto the conductor rod at the core. A silicon rubber insulator is then moulded on top to protect the resin and create the final shape, also known as the shed profile, in one single self-contained piece. This delivers a bushing that has the lowest possible level of partial discharge and the highest mechanical strength.

While both types of bushing have the capability to withstand the stresses experienced in service, combined insulation bushings have better performance across the board in terms of mechanical, thermal, dielectric and leakage characteristics.

**Advantages of combined resin and silicon**

Combined insulation bushings have several major advantages over their oil-filled predecessors, mainly because each bushing is a single component formed from tough and resistant resin and silicon. Ultimately, the choice of modern engineering materials has created a hard working product with simpler handling, installation and maintenance requirements and fewer operational risks.

At a stroke, by removing porcelain and oil, the design eliminates the potential for oil leakage and the potential for shattering. Second, whereas porcelain is delicate and fragile, handling and transport of a combined insulation bushing is more simple and straightforward, with no need for special storage and handling measures and the capability to install them at any angle from horizontal to vertical. In service, they are resilient in spite of temperatures as low as -60°C.

Third, as a single piece, assembly is easier and faster. Technicians need to clamp together individual porcelain pieces and gaskets when assembling and maintaining oil-filled porcelain bushings and the process calls for measures for handling of oil. By removing the oil and all gaskets other than the ones that separate the bushings from the transformer tank, combined insulation bushings eliminate the need to maintain the gaskets.

The last advantage is related to the silicon rubber surface, which is self-cleaning, flexible and sturdy. This makes them a no-maintenance option that is even suitable for use in heavily polluted and offshore environments.

**Practicalities**

ABB’s combined insulation bushings are available from 24 to 72.5 kV and 630 to 6,300 A and are manufactured to the IEC 60137 standard at our Comem unit in Montebello, Italy. They are designed to be fully interchangeable with conventional porcelain bushings made to the historic EN 50180 standard and can be optimised for utility, renewables and industrial applications.

In 2015 the ABB Comem combined insulation bushings passed a challenging environmental test when South African utility ESKOM tested units at its Koeberg Insulator Pollution Test Station (KIPTS), which is recognised as the world’s leading site for testing the natural aging of outdoor components due to extreme seasonal wet and dry conditions, UV, high winds, salt, sand and pollution.

Today, a fleet of Comem combined insulation bushings is in operation on transformers for various applications for UK customers including National Grid, UK Power Networks, Western Power Distribution, DONG Energy, Bombardier and other industrial customers.
Offline testing and verification for Great Western

Mohammed Tageldin, lead engineer for protection, control and automation projects explains how ABB used the latest technologies, tools and principles in offline testing and verification to de-risk the implementation of the protection and control scheme for Network Rail’s Great Western Electrification Programme.

ABB and its consortium partner UK Power Networks Services are delivering more than 30 traction substations along the 235-mile length of the Great Western tracks between London Paddington and Cardiff. An important aspect of the project is that ABB is using innovative technologies to de-risk the project by using equipment that arrives on site ready to plug and play, minimising construction and commissioning work.

Technology key to de-risking project

In terms of primary equipment, the project is using ABB’s SMOS Light (Structure Mounted Outdoor Switchgear Light) concept that cut the time required for on-site construction, testing and commissioning by as much as 30 percent.

De-risking and capital savings have also been found through the advanced protection and control system that ABB designed to suit Network Rail’s deployment of the IEC 61850 smart grid substation communications standard. Called the Rationalised Autotransformer Scheme (RATS), it uses a sophisticated protection, control and communications concept to reduce the number of circuit breakers required and uses less costly load break switches instead.

While circuit breakers can tolerate and break a high fault current, load break switches cannot. Therefore, the key to RATS is that it uses IEDs (intelligent electronic devices) to open circuit breakers in the case of a fault, preventing the load break switches from ever experiencing a fault current. RTUs (Remote Terminal Units) are also utilized to relay signals from across the route in order to communicate the system state to the top end control centre.

Network Rail was keen to make the most of its investment, so when it selected ABB technology for the line’s electrification and the power distribution system, it also opted for a sophisticated protection and control scheme that would limit the amount of high-value equipment needed to control the supply power to the line.
Bench testing
One of the most important and critical targets of the delivery of this protection and control scheme was getting it right before deployment on site.

To achieve this, the scheme is undergoing rigorous testing at ABB’s system verification facility in Stone. In 2015 ABB’s protection and control engineers set up more than 110 IEDs in specially created test racks to replicate the six substations that make up the first section of the line to be energised between Maidenhead and Foxhall Junction.

The test bench also integrated eight Omicron test sets to inject currents and voltages to replicate conditions on the network. ABB engineers used the Omicron RelaySimTest software to ensure that the test sets simultaneously injected the currents and voltages that they would experience in real life fault conditions.

Finally an ABB MicroSCADA workstation was installed to monitor and control the whole rig and was used alongside other tools for troubleshooting and debugging during the test cycles.

Ninety-six scenarios
Once the test bench was established, engineers simulated a total of 96 possible scenarios to record and review the performance of the protection and control system before and during a sequence of tripping, reconfiguration and restoration.

When analysing the results of each test, the team had to analyse a huge amount of data to check that the system was performing as designed. This included checking at least tens of SCADA events and GOOSE (Generic Object Oriented Substation Event) messages, as well as multiple data files, IED records and other records. Testing and analysis was then recorded through a structured system of documents and checklists.

During testing the scheme performed as expected in all 96 test scenarios, showing that the RATS scheme was able to complete all steps from automatic fault detection to power restoration on unaffected sections within six seconds. The test and verification programme also identified potential improvements in the scheme’s logic.

Bench testing mitigates risk
Offline testing is serving its purpose of verifying the design and logic of the protection and control scheme on the Great Western RATS IEC 61850 implementation, giving ABB’s project managers the confidence to install the AEEs on site and minimising testing and commissioning on-site.

Following the successful testing of the first section, the project reached a major milestone when the first substations were energised to provide power for the first electric train running on the line in June 2015.

ABB is now continuing its AEE testing programme for other sections of the Great Western line in preparation for electrification.
ABB has extended its range of capacitor shelves to enable panel builders to pack more Power Factor Correction capability into a smaller space. Engineers at ABB’s power quality facility in Bromborough developed the new QS4 modular capacitor shelf to meet the specific needs of panel builders who need to reduce the overall footprint of their panels, while helping their customers to improve power factor (PF).

PF is a measure of the effectiveness of the power supply. It is the ratio of the ‘real’ power that does the work to the ‘apparent’ power that needs to be generated and supplied by the electricity supplier to overcome the electric charge that is stored by inductive loads that are connected to the network. Such loads include rotating equipment such as motors, pumps and fans, as well as fluorescent lighting and computer equipment.

During operation these build up electric charge in the system, causing the power factor to drop and taking up ‘head room’ in the power distribution system, effectively reducing capacity, reducing equipment life and potentially leading to financial penalties from utilities. Installing Power Factor Correction (PFC) equipment alleviates this.

**QS4 is next step in the series**
The new QS4 capacitor shelf is the next natural step in ABB’s QS range of modular capacitor shelves for panels builders to integrate into low voltage distribution panels and switchboards that operate under the IEC 60831-1 standard. It joins the Q1, Q2 and Q3 models and like them it is based on ABB’s well-proven QCap capacitors and is designed for straightforward installation and to ensure exceptional reliability and efficiency during operation.

The QS4 packs 100 kVAR of capacity into a 600 x 600 mm footprint, helping to reduce the overall panel size by up to 200 mm.

“We were approached by a switchgear manufacturer that liked the reliability and efficiency of the QS3, but needed to save space. Hence the QS4 design. As well as generating an immediate order for 42 units we are now rolling the QS4 out as a solution for all our customers and it is already generating interest from export customers.”

Steve Joyce, ABB Power Quality Business Manager
ABB has invested in a new test bay at Bromborough to test all the power quality equipment manufactured at the site, including power factor correction equipment such as the QS series of capacitor shelves, QCap capacitors and also active harmonic filters that eliminate the troublesome harmonics (electrical noise) that affects some electrical supplies.

The new bay, which was commissioned in January 2017, includes the latest computerised testing technology and has been designed and optimized for ABB. Before products are shipped, the new facility will ensure consistent high quality by testing in an automated bay to the highest levels of repeatability and accuracy, including systematic data storage. Testing will include high voltage, insulation and continuity tests.

Since moving its power quality facility to a new purpose-built facility in Bromborough, ABB has been able to provide a better power quality service to its customers in the UK, improving the flexibility and capability for special project work.

This has included developing new products like the QS4 modular capacitor shelf, which can handle up to 100 kvar compensation capacity. This will allow our panel building customers to bring to market more cost efficient integrated solutions, while being backed up by highly reliable ABB base technology.

Steve Joyce, ABB’s Power Quality Business Manager, said: “Our new test bay is very impressive and now that it is complete, we can invite customers to Bromborough to witness testing on their equipment, giving them extra insight and background knowledge.”

Power quality is becoming increasingly important for business continuity. For example, harmonic distortions can cause unexplained shutdowns, damage to equipment and premature failure, whereas poor power factor can lead to loss of capacity and reduce life of equipment and some utilities also charge a penalty to sites that have a low power factor. Power quality equipment can overcome these issues.
Tales of the unexpected

Fahd Hashiesh, head of ABB’s power consulting business for the UK, Middle East and Africa, explains why a changing environment means that operators need to consider the many competing priorities that can affect the balance between supply and demand and how system studies can help operators to anticipate the unexpected.

In the past, grid operators would use frequency as the measure of balance between electricity supply and demand. However, the picture has become significantly more complex as penetration of renewable energy has grown.

Today, many competing factors can affect the balance. From the demand side, these include growth in demand, changing behaviour and introduction of electric vehicles, whereas the environment and mix of generation can affect the supply side. In addition, system inertia, losses and power quality can all affect the grid, as can trading behaviour.

The unpredictable nature of renewable energy means that grid operators must be able to manage voltage fluctuations and instabilities, balance reactive power and filter harmonics. In addition, as renewables have replaced traditional rotating mass generators, there has been a significant loss of system inertia.

Today, operators lack tools that can precisely monitor the changes in frequency, more importantly its rate of change in order to take proper actions in a timely manner.

Challenges of grid expansion
As the grid expands to integrate wind and solar generation, there have been consequences for grid operators.

One is the change in the level of short circuits. Another impact is the potential overloading of equipment to accommodate a higher than normal level of generated power across the grid, for example when a wind farm is operating at peak capacity. In addition, there have been issues related to fault ride through, reactive power balance, system inertia and power quality.

Changing load profiles can also introduce challenges for grid operators. When industrial consumers connect new loads such as variable frequency drives, furnaces and rolling mills, they also introduce harmonics that might damage the electrical infrastructure.

The grid operator’s own infrastructure can also impact other grid-connected equipment. For example, an operator might install a series compensator to overcome reactive power over a long AC transmission line.

However, an unanticipated result can be felt inside the wind generators when the grid frequency happens to coincide with the resonant frequency of the turbine generator shaft, causing catastrophic failure and literally blowing the generator apart in a phenomenon called Sub Synchronous Torque Interaction (SSTI).

Even changes to the grid’s protection and control system need to be studied carefully to
avoid introducing mal-operation as the grid expands. As new generation, loads and relays are installed, protection and control schemes become more sophisticated. Automation engineers should take care to avoid loss of synchronism, which can lead to instability within the system. In turn, this can represent non-operation of primary protection and ultimately equipment failure and blackouts.

Cyber security
When Ukraine’s power grid was infiltrated in late 2015, hackers targeted substation communication devices to open feeder circuit breakers at different substations. While the operator recovered power within hours by manually over-riding primary equipment, the hackers had updated firmware in the relays, meaning they had to be replaced with new equipment.

The experience has taught grid operators around the world the value of enhancing cyber security but also the importance of considering and analysing scenarios that would once have been unthinkable, such as loss of communications in the control centre, changes to functionality of key equipment and loss of operational data.

System studies
In light of the changing world we live in, system studies and analysis are growing in importance. They have become an essential tool for operators to understand all the potential consequences of changes to the grid, whether initiated by the changing nature of generators and consumers, new technologies or external factors.

The starting point for assessment methodology is to properly model the current system with consideration of the future energy scenarios.

These break down into generation and demand’s modelling. In terms of generation, auditing grid-connected generation will evaluate the types, installed capacity and load factor of grid-connected generation. Similarly, analysis of loads, real and reactive power demand and daily profile will establish the demand background. In addition, the geographical location of both generation and loads will need to be considered.

As well as considering future energy scenarios, the other major element of a system study is to take into account the potential impact of network upgrades. This shows the potential impact of new overhead lines, cables, transformers and switchgear on the grid.

Today, operators around the world are using system studies to evaluate the best solution to their challenges, when weighing up the relative advantages of technologies such as FACTS, microgrids, WAMS (wide area management systems) or energy storage.

In support of this, we have a 125-strong team of power consulting experts that can combine their know-how to deliver feasibility studies, simulations, grid studies and renewable integration consulting. Their objective is to maximise the value of an operator’s assets and achieve optimum value from investments.
Transitioning from DNO to DSO

Operators are increasingly having to manage complex power flows arising from distributed generation, intermittent renewable energy resources, as well as electric vehicles, heat pumps, energy storage, microgrids and demand response mechanisms.

Responding to the growing complexity, distribution network operators have been trialling and now implementing active network management systems. These enabled them to integrate the many points of supply and consumption, control the multi-directional flows of electricity between these sources and also interface with the wider grid.

Some of the UK’s DNOs have set out their vision for the evolution of the grid towards a smarter more flexible system.

In effect, these plans set out how DNOs are planning to transition to the role of Distribution System Operators (DSOs). New technologies will be central to the change, as will operating principles that coordinate all the different producers and consumers they serve. The objective for distribution systems is to build a flexible network that can manage the flow of electricity at many points to deliver security and quality of supply, improved energy efficiency and reduced costs.

Flexible Power Links balance supply and demand
One example of a technology that has great potential for DSOs is the Flexible Power Link, which is a back-to-back (AC-DC-AC) converter. It enables the control and transfer of power between two previously incompatible distribution grids and allows the operator to balance generation and demand more effectively.

Flexible Power Links offer an alternative to traditional grid reinforcement by building new connections between each grid and the nearest substation. They have potential to free up 1.5 GW of capacity by 2050.

Western Power Distribution is the first operator in the UK to introduce the technology under the Ofgem-funded Network Equilibrium project in Devon. The project will trial a 20 MW converter that will connect two separate 33 kV distribution network groups. The link will use an ABB static frequency converter based on proven power electronic technology.

Line Voltage Regulation aids integration of renewables
The transition towards renewable energy has introduced new challenges. Traditional grids were designed on the basis of a voltage drop along the distribution line from the substation to...
Operators can use Line Voltage Regulators on medium and low voltage grids to avoid curtailing renewable energy for the consumer. However, the introduction of distributed generation means that today’s grids can experience voltage rises near these sources.

If supply exceeds demand, there is potential for such voltage rises to exceed the statutory limits. In this case, DSOs may need to curtail generation to maintain stability or even invest in a new connection to maintain voltage levels in the permitted band.

Technology has an answer to the challenge of voltage variation in the form of line voltage regulators (LVRs), which ‘recalibrate’ voltage to maintain it in the allowed range. They can be installed anywhere on a medium-voltage or low-voltage distribution grid and can regulate a single feeder or a bus with several feeders. Operators can use an LVR to decouple a feeder from the rest of the network if it has a large infeed from renewable generators – this allows the DSO to avoid curtailing the incoming power and continue to meet the voltage limits of the grids.

**Interoperability**

Interoperability underpins the ability of DNOs to transform into DSOs. Distribution systems will require many different types of equipment from different manufacturers to work together seamlessly, including metering, switchgear and transformers as well as new introductions such as LVRs and Flexible Power Links.

Many operators are already trialling the enabling technologies for interoperability. What is worth remembering is that the key to successful integration will be integrating monitoring, control and communication as part of an over-arching actively managed flexible network.

The DSO model offers huge benefits in terms of more resilient and flexible network operation, greater integration of renewable energy and changing patterns of supply and demand represented by demand side management and electric vehicles. One example of a benefit worth highlighting is the ability to aggregate resources dispersed across the network, allowing multiple generators to operate as a single virtual power plant (VPP) that can help to balance supply and demand both at the local level and the interface with the wider distribution and transmission network.

So the future for distribution grids does not necessarily mean just putting more wires into the ground, but it will be an evolution to help existing infrastructure work harder, smarter and with more flexibility.
Prioritising investments in substation retrofit

Steve Pickering, General Manager for Substation Services, explains how ABB has the capabilities to support the task of maintaining electrical networks in optimum condition to minimise the risk of unexpected and costly outages.

Our service supports customers in utilities, industrial and commercial sites, food and beverage, transportation and offshore and onshore substations. We emphasise quality and value, with an overarching goal of helping customers get the best out of their network assets – whether that is through adding intelligence, avoiding unplanned downtime or supporting equipment from any manufacturer.

We cover the full gamut of service from installation to end of life on equipment from 11 to 400 kV, including AC and HVDC. Service is always provided by a team of highly skilled, experienced and accredited power network experts who account for health, safety and environmental performance throughout.

Today, we have around 150 active service contracts in place around the world across hundreds of sites, including blue-chip customers and a high proportion of return business, which demonstrates that our customers know we add value.

Substation LifeStretch
We introduced a new addition to our service portfolio in 2016, when we developed LifeStretch as a methodology to inform decision making on the operation, maintenance and life-extension of critical substation infrastructure.

ABB service aims to get the best out of network assets

The technique can help operators establish the correct and most cost-effective action at the right time. Because it takes both asset condition and criticality into account, it helps decision makers find a balance between economic, technical and reliability.

Under LifeStretch, each substation component is assessed as an individual component, as part of the system and by considering both the operator’s and ABB’s experience. Assessment covers criteria such as financial performance, technological capabilities and KPIs such as lifecycle cost, failure rate, expected cost of power interruption, environmental and safety performance.

The key to our substation LifeStretch methodology is working in collaboration to identify the optimal solution to extend an asset’s lifecycle or functionality.

Balancing condition and criticality
The condition and importance of each component is rated under LifeStretch. Each asset is then plotted in a risk matrix with condition on the y-axis against performance on the x-axis.

Whereas traditional condition based maintenance (CBM) prioritises only by condition, LifeStretch uses reliability centred maintenance (RCM) that takes both condition and asset importance into account.

This shift of focus can radically shift the priority of maintenance activity. Whereas CBM focuses on assets in relatively poor condition, RCM prioritises assets that may be in better health but which could have a greater impact.
Substation Assessment
Prioritized actions based on RCM

Condition-based maintenance – takes account of the condition of assets c1 – c6

Reliability centred maintenance – balances the condition and importance of assets 1 – 6 to identify the overall risk profile (r1 – r6)

Comparing refurbishment, modernisation and extensions
LifeStretch can also be applied when comparing the merits of different options for refurbishment or retrofit of a substation.

Plotting all of a substation’s components onto a single risk matrix creates a visual representation of the overall risk exposure of that substation in terms of condition versus importance. We can then consider how different options for refurbishment, modernisation and extension would alter that risk profile.

One option could be to replace or refurbish all components that are in very poor condition. However, it may be possible to drive down the entire risk profile by retrofitting new control equipment. In addition to evaluating the condition and priority of assets, it is also important to compare the life cycle costs of each option in terms of initial investment, annual maintenance requirements and other operational costs.

Finding the optimal investment
To illustrate with an example, we considered how LifeStretch could be applied to find the optimal investment solution on a 40-year old 132 kV substation.

We developed and evaluated options for replacement of existing circuit breakers, including full replacement of circuit breakers or partial refurbishment and / or replacement of just the operating mechanisms and interrupters in all the circuit breakers.

Because reliability has a strong influence over costs, we then calculated the frequency and duration of outages for each option, as well as mean time between failures. This formed the basis of lifetime cost estimates for each option, built up from the costs of operations and maintenance, service disruption and failure, plus capital costs.

In the case of the 132 kV substation, in spite of having the second highest initial investment, the lowest lifetime cost option was to replace the existing circuit breakers with new state-of-the-art dead tank circuit breakers and retain the existing disconnect switches.

All of this can be achieved in five to 11 weeks, with ABB experts working in partnership with the operator. Effort will be focused around three workshops: project kick-off, technical evaluation and project conclusion. The information and guidance gathered at these will direct our service experts through phases for information gathering, defining and analysing alternatives and drawing conclusions.
Next-generation asset management to improve efficiency and optimise costs

The latest version of ABB’s asset performance management (APM) software, Asset Health Center 3.0 was launched in January 2017 as a cloud-based asset management system that enables operators to keep an eye on the health of infrastructure.

Asset Health Center 3.0 is the latest software-based solution. It integrates ABB’s knowledge and capabilities of asset management with Microsoft’s Azure platform. The combination enables asset data and analysis to be accessible via the cloud.

It is designed to help operators prioritise maintenance based on the probability of failure and criticality of assets. By doing so, it can improve efficiencies and optimise costs. It combines predictive and prescriptive analytics with customisable modelling.

**Lifecycle management**

The software follows the lifecycle management approach to cover the complete asset lifecycle.

By integrating it with Microsoft’s Azure platform, Asset Health 3.0 takes the form of Software as a Service (SaaS). It enables simpler and faster implementation, improved visuals and analytics and more straightforward integration of predictive models. It achieves this by using Microsoft’s Cortana Intelligence, a big data and advanced analytics suite.
Fleet optimisation
As with the previous versions of Asset Health Center, the new version integrates established condition monitoring solutions to monitor the status of assets.

In the era of big data and the Internet of Things, online condition monitoring can extend to connecting analytics and developing it as a foundation for strategic decisions that takes all assets into account. Asset Health 3.0 allows operators to combine real-time measurement of performance of individual assets with maintenance and historic data.

By presenting this visually, Asset Health 3.0 allows operators to gain insights about the condition of mission-critical assets and develop a lifecycle plan for optimal performance. Actions can include predictive maintenance and proactive replacements to prevent sudden catastrophic failures and unplanned outages.

“Our latest generation Asset Health Center combines the domain expertise embedded in ABB’s software based technologies with the global scale of Microsoft’s Azure cloud platform to deliver a powerful solution to help utilities gain new insights and drive faster decision-making to seize new growth opportunities” said Massimo Danieli, Managing Director of ABB’s Grid Automation business unit, a part of the company’s Power Grids division. “It is another illustration of how ABB is supporting the energy revolution as a partner of choice in enabling a stronger, smarter and greener grid.”

ABB Ability™
Asset Health Center 3.0 is an example of how ABB’s Ability™ digital solutions connect customers to the power of the Industrial Internet of Things, turning data insights into direct action that generate customer value in the physical world. It is also a key component of ABB’s digital substation concept where it collects condition data to optimize performance and improve the substation’s efficiency and cost effectiveness – reducing transformer and breaker downtime by up to 50 percent.

“This new release of Asset Health Center represents another successful collaboration in our long-standing alliance with ABB. Working together, ABB and Microsoft continue to empower digital industrial transformation by surfacing data-driven business insights in industries like transportation, power, water and gas utilities”

Caglyan Arkan, general manager, Manufacturing & Resources, Microsoft Corp
Spittal substation nears completion

Tom Smith, Project Manager for ABB shares the latest updates from the Spittal substation in Caithness. Once complete, the new substation will connect the local transmission and distribution grid with the new Caithness-Moray HVDC link and the first circuit is due to be energised Q4 2017.

ABB and its consortium partner Balfour Beatty are nearing the commissioning phase of the 275 kV Spittal substation near John o’Groats in Scotland for Scottish and Southern Electricity Networks (SSEN). ABB’s scope of works includes overall design and engineering and supply of air insulated and gas insulated switchgear (GIS) including HV cabling.

Compact GIS was chosen to save around 30 percent compared to full size equipment, saving on civil engineering, deliveries and construction work in the remote location.

Ninety percent of the equipment has already been installed, including 11 bays of 275 kV GIS and five bays of 132 kV GIS that will connect to the distribution grids in Mybster and Thurso, as well as the Spittal HVDC converter station in a neighbouring compound.

The HV pressure tests for 132 kV and 275 KV GIS will be completed in March 2017 with the first circuit due to be energised in November 2017.

To deliver the project on a fast-track basis, ABB deployed its largest ever GIS installation team for the Spittal substation project, including night shift work to decrease time to completion. Limited space on site meant temporary scaffold platforms were constructed to provide access for the works. These had to be modified throughout the build, with the scaffolding team at work during night shifts to avoid working over the heads of wiring technicians during day shifts.

Another innovation used to speed up work on site was a mobile gantry crane that was used for pre-assembly work and to free up the main crane for other jobs.

**Challenges for the substation**

The remoteness of the site was the biggest challenge. The Spittal substation is 25 miles from John o’Groats, near the towns of Thurso and Wick. If accommodation for the workforce isn’t available there, then the closest accommodation is Inverness, a three hour drive away.

As well as having to house some of the workforce in Inverness, some equipment including the GIS had to be stored in Inverness and called off as required. GIS equipment must be stored indoors so we used a covered facility further away.

Weather also proved a challenge for the project. The building was constructed during the winter when weather delayed some works. Large cranes can’t be operated in strong winds, so we had to wait for gaps in the weather to install GIS and gas insulated busbars (GIB).

With the site being on a slope, heavy rainfall created unexpected deluges. ABB implemented a water mitigation plan together with SSEN and the Scottish Environment Protection Agency. We constructed earth mounds to channel water away from working areas and provide shelter from the wind. We also planted trees as a landscape feature to screen strong winds.
Environmental protection has been a top priority throughout the project. Wildlife using the site includes hawks, pine martens, wildcats, deer and nesting birds so ABB employed environmental specialists to protect the animals without disrupting works, for example, using bird scarers to prevent ground nesting birds and a deer fence to keep them out of the work area.

Recycling local material was another important aspect of the job. Rock that was excavated for the building works was crushed and used as the working platform for both the HVAC substation and HVDC converter station. Surplus material was sent to nearby substations at Thurso and Mybster 4 kilometres away to be used to build further platforms.

Health & Safety is a top priority
Safety has always been the top priority for ABB during construction work because it is vital for people as well as good project delivery.

We are committed to planning ahead and ensuring the correct resources and safe systems of work are in place to minimise risk. For example, rather than using traditional hard hats, we issued our wiremen with bump caps, which are smaller and so don’t get in the way. We also used the Spittal project to trial safety features that reduce the risk of injury to operators.

We also used the project to introduce a new design for the trolleys that are used to pre-assemble and manoeuvre large and heavy GIS and GIB components around site. When connecting the 50 kg tubes together, we trialed a modified design with clamps to secure the wheels and the GIB or GIS tubes to stop them moving. We also used a Teflon coating to protect the tubes from being damaged.
Digitalising critical New York substation

In collaboration with leading energy utility Con Edison, ABB has completed a major upgrade to a key substation in New York City, where several conventional pieces of power equipment have been replaced with digitally-enabled technology. The bulk power substation is among the largest of its kind in the US and supplied electricity to hundreds of thousands of customers in lower Manhattan.

Con Edison has invested heavily to safeguard its infrastructure since the area experienced significant flood damage from the saltwater storm surge during Hurricane Sandy in 2012. This has included reinforcement of perimeter walls, gates and flood walls. Such measures will improve power reliability and mitigate outages in the case of super storms.

The substation features modular 420 kV PASS (plug and switch system) hybrid switchgear that is elevated more than 10 metres above the original substation level. PASS switchgear is up to 50 percent smaller than comparable switchgear and has rotating bushings for straightforward transportation and commissioning.

Around 80 percent of the substation’s copper control cabling has been rendered obsolete as it has been replaced by a few fibre optic cables during the digital upgrade.

“The digital transformation of this critical substation and additional weather-fortification measures will bring greater grid resiliency and improve reliability of power supplies to Manhattan’s consumers,” said Claudio Facchin, President of ABB’s Power Grids division.

“Enabling digitalisation of the power grid is a core element of our Next Level strategy and we are committed to supporting our customers with the latest technologies to facilitate this effort.”

IEC 61850 communication
Con Edison’s adherence to the IEC 61850 communication standard has enabled the utility to interconnect a very large system with a multi-vendor installation base. Operators will be able to extract critical asset data in real time to make faster decisions in a crisis. Equally importantly, the digital substation will allow Con Edison to shift from traditional time-based maintenance to condition-based maintenance.

“We had to take great care in switching over from multiple layers of legacy control systems, some of which had been compromised by Hurricane Sandy’s floodwaters, to the new automated system. Our engineers maintained an ongoing dialog with ABB’s team throughout the design, testing and installation stages,” said Sanjay Bose, Con Edison’s Vice President of Central Engineering. “Collectively, with great attention to detail, we were able to put phase one into service on schedule, within budget, without accident or injury.”
Microgrid integrates renewables in Alaska

ABB is delivering microgrid technology for energy firm Chugach Electric Association in Alaska. The operator’s goal is to identify technology that will integrate more renewable energy, including the 17 MW Fire Island wind farm that is located about 4 km off the coast of the city of Anchorage.

“We are delighted to partner with a visionary utility like Chugach Electric, to build this microgrid which incorporates a hybrid storage solution to enhance reliability of power supply,” said Massimo Danieli, Managing Director of ABB’s Grid Automation business unit, a part of the company’s Power Grids division. “Integration of renewables is a key element of the Energy Revolution and a major focus area of our Next Level strategy.”

Integrating renewables and energy storage
ABB will supply its modular and containerised PowerStore microgrid solution that will integrate the renewable energy with two forms of energy storage technology in the shape of a flywheel and a battery system.

Whereas the flywheel will compensate for fluctuating wind power, the battery system will deliver longer term storage through its energy storage capacity of 500 kWh and peak power of 2 MW.

Microgrid Plus control system
Control and protection will be achieved through ABB’s advanced Microgrid Plus control system. It will monitor the hybrid storage solution and ensure proper load sharing between the two storage media. It is also equipped for remote service and maintenance.

“This innovative solution shows how energy storage technology can boost renewable energy penetration in Alaska and have far reaching implications for new renewable projects on the Railbelt as well as in smaller Alaskan communities,” said Paul Risse, Senior Vice President, Power Supply at Chugach Electric.
HEALTH AND SAFETY

Living the charter

A joint safety charter is enabling unprecedented levels of collaboration between ABB and the North Sea Link Interconnector (NSL) project team on the 1,400 MW capacity interconnector linking electricity markets in the UK and Norway.

The NSL Converter project team are collaborating closely to enable significant safety improvements while ABB delivers high-voltage direct current converter stations in Blyth, Northumberland and Kvilldal in Norway.

The close working relationship is a result of an initial safety conference hosted by the NSL management team. During the event everyone signed up to a Safety Charter. The approach has brought an open and inclusive approach with effective feedback loops between the operations and design team.

As part of the HAZID process (hazard identification) hundreds of hazards have been logged since the start of the project, with more than half closed out even though the design is only 30 percent complete. The HAZID process, carried out jointly with the NSL Converter team, has allowed ABB’s design team to hear about products in operation and improve them at the design phase. For the customer, sharing feedback at the design stage means significantly more cost-effective solutions. The charter even extends throughout the supply chain, with suppliers also signing up to the Charter and having access to the same logs as the clients, increasing transparency.

Each project or subcontractor meeting opens with a ‘Charter moment’, allowing team members to discuss communication and culture issues and a ‘Safety Moment’ where the team shares any hazards or problems they have spotted. This combination reinforces the project’s core values throughout the supply chain.

One example of the Charter in action came from a discussion between the designers and operations team regarding de-watering of valves. Because the converter valves are suspended, the operators get sprayed with water during de-watering operations. Following the Charter moment, ABB introduced a small design change to prevent this and make a big difference for the operations and maintenance team in terms of safety and comfort.

In another example, feedback prompted ABB to install a cable route through the transformer wall to carry cabling for test equipment and avoid the need for a long cable route from the reactor hall, reducing the effectiveness of testing.

Minimising risks at all stages of a project has always been a priority for ABB, but the Safety Charter has created a greater level of trust with the customer during the design phase. ABB uses lessons learnt and good practices from all projects to improve safety across the board.
**Software in focus at Future of Utilities Conference**

ABB attended the UK’s leading energy and water utilities summit on 29 and 30 March in London to share news about its Enterprise Software, which is used by more than 1,100 operators globally to ‘keep the lights on’, ensure reliability and enable commercial operations.

The event brought together more than 250 senior professionals from UK energy and water utilities for a two-day conference and networking event that explored the latest issues around power generation.

One area of focus for ABB was its Enterprise Software and Network Manager ADMS solutions that enable the efficient management of the sub-transmission, medium and low voltage distribution networks. The software solution can help utilities improve reliability and reduce costs while meeting the challenges of grid automation, communication, distributed energy resources (DER), changing consumption patterns, microgrids and markets that are driving grid modernisation and fundamentally changing the nature of distribution operations.

**Distributed Energy Response System (DERMS)**

ABB’s John Finney presented on Distributed Energy Response System (DERMS). He is Technology and Business Development Manager for ABB’s Grid Automation Business and is based in Zurich.

He introduced the DERMS software tool that enables the portfolio management, forecasting, monitoring, control and analysis of standalone and aggregated DER. Its goal is to optimise generation while maintaining safe grid operation.

DERMS can manage outages, taking into account aspects such as location, crew dispatch, field mobile response, restoration construction requirements, distribution operators and the role of analytics in the digital age. He covered how the solution fits into the traditional OMS/DMS/SCADA architecture and examined different types of customer who would benefit from DERMS.

He then joined a discussion panel alongside senior decision makers from UK Power Networks, ScottishPower Energy Networks and Northern Powergrid to debate how the UK’s distribution network operators should respond to an increasingly decentralised and unpredictable energy system.

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**Looking ahead to CIRED 2017**

ABB is preparing for CIRED in Glasgow on 12 to 15 June. The event is attended by decision-makers from distribution networks and system operators across Europe. ABB will be promoting its medium voltage technology at the event, including the eco-efficient AirPlus switchgear and UniGear Digital switchgear, as well as sensors, relays and communication equipment and solutions for asset management and condition monitoring.

Visitors will have the opportunity to register for a visit to ScottishPower’s Whitelee Windfarm, the UK’s largest onshore windfarm, which features low loss transformers and a high voltage substation supplied by ABB.

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CIRED 2017 will take place at the Scottish Event Campus in Glasgow
The Ability to make DERMS a reality

For utility providers across power generation, transmission and distribution ABB Ability provides tailored digital solutions and products for utilities providers across power generation, transmission and distribution. The aim is to enable our utility customers to know more, do more and do better.

Now the power of ABB Ability is being harnessed to address one of the most significant challenges facing utilities today, which is the integration of an increasing level of intermittent renewable and distributed energy resources (DERs). Utilities have to keep their grids balanced and optimized in real-time as the numbers of wind farms, solar power schemes and combined heat and power (CHP) installations continue to grow.

ABB is developing a new distributed energy resource management system (DERMS). This new solution will enable utilities to manage the entire lifecycle of distributed energy resources from registration to optimization, control and settlements, while ensuring safe, secure and efficient operation of their electricity distribution networks.

DERMS have typically been organized in two different ways: either top-down extensions of utility or grid operator controls out to customer endpoints, or bottom-up aggregations of customer loads into grid energy markets. In an innovative approach ABB is merging these separate philosophies into a seamless, fully-integrated solution.

In practice, DERMS will continuously capture and aggregate data from distributed energy resource assets and controllable loads on the distribution network to maintain network reliability and balance. The platform also dynamically optimizes these resources to respond to the real-time needs of the power system. It is expected to reduce distribution system operating costs significantly while enabling operators to optimize the hosting capacity for DERs on their network.