A new lease of life for transformers  32

Creating a smarter energy market  8
DCB preparing for its UK debut  12
National Grid evaluating shunt reactor refurbishment  4
ICP adopts ABB distribution transformers  19
Fast-track relay retrofit programme  28
Dear Reader,

I was pleased to hear in July that ABB’s work and innovation has paid off in Canada, where we have won a major order to supply an HVDC Light system for the Maritime Link power project. The contract win is further evidence of ABB’s leadership in HVDC technology, which ABB pioneered 60 years ago and leads today. Read more about the project on page 11.

Back in the UK, I am following political matters with interest, particularly the recent ministerial appointments in energy and transport and activities in Scotland. As the UK’s political landscape shifts, ABB remains committed to delivering power infrastructure that is sustainable, reliable and cost-effective for the UK’s consumers.

Many of the projects and products within these pages showcase how ABB’s innovative technologies can improve performance, extend asset life and minimise both footprint and cost of infrastructure. For example, the disconnecting circuit breaker (DCB) on page 12 is a high-voltage switch that can save 60 percent of space when compared to a traditional switchgear bay, improving availability without compromising performance.

Elsewhere, ABB’s project to deliver the grid connection at Pen y Cymoedd (page 10) is giving us the opportunity to invest in the Welsh supply chain and by refurbishing and re-engineering National Grid’s shunt reactor at Willesden (page 4), the operator will be able to identify the most economically viable route to upgrading service-expired assets.

And looking ahead, I will continue to share ABB’s continued technological success stories and give the inside track on how to apply technology for resilient and cost-effective power networks.
Contents

03

News

04 The latest news on ABB’s projects

Smart grids

08 Creating a smarter energy market in the UK

Site management

10 Safe working is key to Pen y Cymoedd success

HVDC

11 Maritime Link success

High voltage

12 DCB prepares for ENA review

International project focus

14 Gotland smart grid

Power quality

16 Combating harmonics with active filters
17 Introducing the QCap

Renewables

18 Fast track 100 ICP selects ABB transformers
19 UK Power Networks adopts PASS M0

Power conversion

20 A user’s guide to frequency conversion technology

Transformers

22 Ready to meet or exceed new EU ecodesign requirements

Rail

24 FACTS for modern railways

Medium voltage

26 SafeRing Air ring main units
27 UniPack-G compact secondary substations

Protection and control

28 Relay retrofit programme
30 Digital substations

Service

32 Transformer tapchanger and bushings replacement

Arc flash

34 DNV approval for REA relays

Events

35 Forthcoming events
Good as new

National Grid has placed a £1 million order with ABB to refurbish a shunt reactor that was installed at Willesden substation in London in 1967.

The project is being funded under the Network Innovation Allowance (NIA) provided through Ofgem. It aims to demonstrate that refurbishment is an economically viable methodology for upgrading service-expired 13 kV (kilovolt) shunt reactors to modern standards of performance and energy efficiency.

The new RIIO (revenue = incentives + innovation + outputs) funding framework means that National Grid is keen to explore the relative merits of refurbishment and replacement of key assets such as shunt reactors, which improve the efficiency of the transmission and distribution network.

Recent innovations in materials science mean that modern transformers are built with steel that has lower losses than a 40-year old design. As such a refurbishment based on the old design would not meet today’s high specifications for transmission equipment.

ABB will transport the 13 kV 2 x 30 MVA (megavolt ampere) shunt reactor to its transformer centre of excellence in Drammen, Norway, where a detailed inspection and appraisal will establish options for redesign and remanufacture of a new active part, as well as refurbishment of the tank and cooler bank. The refurbished unit will then be subjected to factory acceptance testing (FAT) to the very latest standards before being returned to Willesden 275 kV substation for installation and commissioning on its original plinth, saving extensive civil works.

“The Willesden project is a very significant breakthrough for ABB’s Transformer Service team in the UK that enables us to deliver a practical real-world demonstration of how a non-ABB shunt reactor asset over 40 years old can be remanufactured cost effectively in its existing tank, while upgrading it with state of the art design and materials” says Matthew Pownall, Divisional Manager ABB Power Products Service UK.

National Grid has a fleet of around 70 shunt reactors in the UK

Grid connection for MeyGen

Atlantis Resources Limited has awarded ABB a major contract to create the onshore grid connection for the first phase of the flagship MeyGen tidal energy project.

During the first 6 MW (megawatt) demonstration phase (Phase 1A), four submerged turbines will be installed in the Inner Pentland Firth between Orkney and the Scottish mainland.

ABB is creating the onshore power conversion and grid connection systems that will feed electricity safely and reliably into the local distribution grid. ABB’s scope of supply includes state-of-the-art PCS6000 power converters, transformers, medium voltage switchgear and associated civil engineering and cabling works.

Phase 1 has consent to generate up to 86 MW and will see further turbines installed over the next few years and once completed, the MeyGen project is expected to deliver up to 398 MW.

“ABB is delighted to be working with Atlantis on this flagship project that will confirm the potential for marine energy to make a significant contribution to tackling climate change,” said Stephen Trotter, Managing Director for ABB’s Power Systems business in the UK and Ireland.
Have you taken the ABB Power Quality Challenge?

A new interactive app from ABB explains in simple terms how reactive power compensation and harmonic filtering solutions help in improving power quality of electrical networks.

Take the power quality challenge to see how harmonic pollution and low power factor can affect operations and profits in a hotel and a factory. You will see the impact of increasing loads on various electrical equipment such as fluctuating lights, flickering screens and machines and production slowing down or being interrupted. You will also experience enhanced efficiency, steady operations and lower downtime when Power Quality solutions are applied.

The challenge is available via the web at abb-powerqualitychallenge.com or via the iTunes App Store.

Visit abb.com for a definition of harmonics and power factor and to find out about ABB’s range of harmonic filter and capacitor products that improve power quality.

Switchgear retrofit for London

UK Power Networks has engaged ABB to deliver a 20+ year lifetime extension for legacy switchgear installed at London distribution substations. The retrofit programme covers class QA/QF oil-filled circuit breakers, many of which are now unsupported by their original manufacturer.

Rather than complete replacement at considerable cost and requiring long network outages, UK Power Networks has appointed ABB to project manage the installation and commissioning of an innovative retrofit solution developed by its OEM partner, P&B Switchgear.

Much of the original switchboard equipment remains in good condition and installing new state-of-the-art circuit breakers will bring the switchboards up to modern safety and reliability standards. Not only will this extend the life of the assets by 20 years or more but it will minimise outages as there is no need to disturb or replace cabling. Plus, the retrofit solution will remain within the footprint of the original installation.

Like the refurbishment of National Grid’s shunt reaction in Willesden, the project will help UK Power Networks meet Ofgem’s RIIO model.

The retrofit will be completed within a one-week outage
Bringing IEC 61850 to life

On 12th June, ABB’s System Verification Facility (SVF) in Stone, Staffordshire played host to a workshop attended by engineers from utilities, railways, industry, consultancy and academia. Part of a two-day networking and personal development programme, the workshop was hosted jointly by ABB and OMICRON, the leader in innovative testing, diagnosis and monitoring solutions. After a day of conference sessions, attendees visited the SVF on the second day for a series of four workshops on portable commissioning, and IEC 61850 demonstration, a tour of the SVF and a hands-on session with OMICRON’s equipment.

Danny Lyonette, Business Development Manager for Network Management said: “Feedback indicates that attendees gained insight and that the sessions helped to bring the topics to life.”

Solar power takes flight

A solar plane supported by ABB took its maiden flight in June.

The Solar Impulse aims to be the first solar-powered aeroplane to fly around the world non-stop and ABB is one of the project’s four main partners through a technology alliance. It supports a team led by Bertrand Piccard and Andre Borschberg. “Solar Impulse and ABB are technology innovators and pioneers,” said Andre Borschberg, Co-Founder and CEO of Solar Impulse. “We both want to motivate people to use clean technologies; ABB and Solar Impulse will work together on key technologies like power electronics for our mutual benefit.”

solarimpulse.com

Solar Impulse 2 on a test flight out of the Payerne aerodrome in Switzerland
Burbo Bank extension

In August, DONG Energy placed an order with ABB worth £30 million to supply a high-voltage cable system that will transmit power ashore from the Burbo Bank Extension Offshore Wind Farm.

The contract win builds on ABB’s project to supply the submarine cable for the first phase of Burbo Bank offshore wind farm in 2005.

During the project, ABB will design, engineer, supply and commission the 25 km 220 kV AC submarine cable and 32 km of underground cabling, as well as cable joints, accessories and terminations.

Located on the Burbo Flats in Liverpool Bay, the wind farm receives the full force of the wind from the Irish Sea, making it an ideal site for offshore wind generation. The extension will be located to the west of the existing operational wind farm and will generate enough electricity to power more than 170,000 homes.

“Offshore wind is making an increasing contribution to boost the share of renewables in Europe’s energy mix and this project will support the UK government’s efforts in this area,” said Claudio Facchin, head of ABB’s Power Systems division. “ABB has considerable experience in executing such projects and the technologies to support the efficient integration of renewables into the grid.”

RoSPA gold medal

The Royal Society for the Prevention of Accidents has awarded ABB’s Power Service and Power Systems businesses its Gold Medal Awards. The medals are awarded only to organisations that have achieved nine consecutive Gold Awards. The Gold Awards recognise very high levels of performance, demonstrating well developed occupational health and safety management systems and culture, outstanding control of risk and very low levels of error, harm and loss.

Michael Parker, RoSPA vice chairman presenting a Gold Medal Award to Gareth McDonnell, HSE advisor for ABB Power Service.
Smart grids

Smart energy markets
We have the technology

Global energy markets are evolving as countries strive to address the ongoing trilemma – to ensure security, affordability and sustainability of our energy supplies.

ABB is ready to respond to these challenges with a broad portfolio of smart technologies, including distribution automation and demand side response, as Colin Green, ABB’s Head of Regulatory Affairs and Technology, explains.

In the UK, the implementation of Electricity Market Reform (EMR) is a major step in facilitating the tens of billions of pounds investment in new low carbon power generation. Nevertheless, the key question at the heart of our energy policy is how can we best deploy smart technology to ensure that we develop and use our national energy resources efficiently? By 2020, 30 million UK homes and small businesses will have smart meters installed enabling consumers to be more engaged. This is though just one example of how technology is supporting the development of a smarter energy system - one that gives greater control over how we produce, transport and use energy.

There is perhaps a tendency to think that the technology we need is not fully ready. But in fact, ABB has already developed and made commercially available many of the vital building blocks such as:

– Power technologies to increase the efficiency of existing assets;
– Advanced network automation;
– Demand response management systems;
– Building control infrastructure;
– Consumer control interfaces.

Smart grids

Smart grids have an important role to play in a smart energy system. Many smart grid technologies are already applied across the global energy sector – e.g. FACTS (Flexible Alternating Current Transmission Systems), WAMS (Wide Area Monitoring Systems), IEC 61850 intelligent electronic devices (IEDs), and intelligent control systems.

Information is crucial to the success of a smarter energy system, as we need to understand and control – in real-time – the relationship between energy production and consumption; and the interaction with network operation and performance.

Distribution Grid Automation

Distribution Grid Automation solutions have been developed to enable network operators to manage day-to-day local grid operations efficiently and reliably through a combination of operational technology (OT) and information technology (IT) that delivers advanced applications such as:

– Outage management to identify system faults and manage work crew response
– Automated switching to reconnect customers during storms
– Automated controls to optimize the grid in real time to improve reliability, reduce losses, and improve grid efficiency.

Customer engagement - DRM

Customer engagement (industrial, commercial, residential) is also crucial to the development of the smarter energy market. This includes consumer interaction with the market through demand side participation and more efficient energy use through intelligent building controls.

Demand response management (DRM) offers substantial opportunities for future energy markets. In general, DRM provides a way for end customers to make short-
term changes in their energy consumption in response to specific criteria. These can be changes in pricing or incentive payments designed to induce lower electricity use at times of high wholesale market prices, or when system reliability is jeopardized.

DRM is not actually a new concept, but we are now seeing a new generation of DRM that creates a more direct and interactive relationship between the consumer and energy management systems to help optimize the consumption of energy. Moreover, energy management systems are now starting to integrate DRM with the management of local renewables, energy storage, electric vehicles and major new loads such as data centres.

In addition to the environmental impact of reducing electricity consumption, implementing DRM:
- Helps utilities save money by deferring upgrades of the distribution system
- Provides financial benefits to customers
- Makes the overall electricity market less volatile in spot prices (i.e., prices for immediate payment and delivery)

DRM is often initiated at the utility where data, based on a demand forecast is used to estimate the capacity margin for future time intervals. A decrease in this capacity margin or a negative margin would cause the utility to trigger a DRM event. However, demand response can also be used to support grid stability in response to a network constraint or fault.

Clearly, DRM relies heavily on IT and communications infrastructure. Ventyx, the software business inside ABB, has developed a total distribution response management concept based on this principle. It combines real-time and near-real-time data, system modelling, visualization, simulation and integration of all major systems used in distribution operations, to provide a new way of managing and operating distribution networks.

Intelligent buildings
ABB is also particularly active in the smart home and intelligent building sector through our state of the art i-bus® KNX systems. By providing automated control of key services such as heating, lighting and ventilation, they are proven to deliver double-digit improvements in energy efficiency by:
- Only using energy when it is really needed
- Only using the exact amount of energy actually needed
- Applying the energy that is used with the highest possible efficiency

A time of profound change
The world of energy networks already looks very different to how it was just 18 months ago. Looking ahead by 2 or 3 years we can anticipate the start of profound changes. The good news is that much of the foundations are already in place. What is needed is the shared vision to bring them all together.
Safety is key at Pen y Cymoeddd

With work now well underway at Vattenfall’s Pen y Cymoeddd wind energy project, ffwd caught up with Mick Walls, ABB Site Manager, substation and grid connection.

ffwd – what does the project involve?
MW – ABB is the main contractor for the grid connection of a 228 MW onshore wind farm that will be the largest in England and Wales. Together with Balfour Beatty we are building two high voltage substations and the underground cable connection between them.

ffwd – what are your responsibilities as Site Manager?
MW – I am responsible for the planning and organization of work on site to ensure that everything progresses according to programme. We can have upwards of 40 people working on site and one of my key roles is providing an effective interface between all the various contractors. And most importantly, I have to maintain the very highest levels of health and safety.

ffwd – can you tell us about the health and safety initiatives?
MW – We believe that safe working in everything we do is the key to effective progress on this project. To show just how important it is, I have a full-time health and safety advisor, Harry Shaw. I am very pleased to say that all our suppliers and contractors have bought-in to the idea that the site must set the very highest standards for safety. This covers many different aspects such as the total use of complete PPE (personal protective equipment) and thorough induction briefings for everyone on site, ‘toolbox talks’ – short briefing sessions that cover a specific safety issue, use of plant segregation and barriers, right through to effective planning, coordination and reporting to ensure that every risk is anticipated and minimised.

ffwd – how are you engaging with the local community?
MW – Our aim is to minimize disruption and inconvenience for the local community. So for example a great deal of thought and planning went into managing traffic flows when carrying out cabling works along the main roads.

The site is also a popular local amenity, used by walkers and cyclists. So we are doing everything we can to maintain access – with of course no compromise on safety.

ffwd – how are you engaging with the local community?
MW – Our aim is to minimize disruption and inconvenience for the local community. So for example a great deal of thought and planning went into managing traffic flows when carrying out cabling works along the main roads.

The site is also a popular local amenity, used by walkers and cyclists. So we are doing everything we can to maintain access – with of course no compromise on safety.

ffwd – how are you engaging with the local community?
MW – Our aim is to minimize disruption and inconvenience for the local community. So for example a great deal of thought and planning went into managing traffic flows when carrying out cabling works along the main roads.

The site is also a popular local amenity, used by walkers and cyclists. So we are doing everything we can to maintain access – with of course no compromise on safety. In fact, even managed to have the site available for use by 4,500 cyclists attending the Dragon race in early June.

ffwd – What are the main project highlights so far?
MW – The main highlight is the routing of the high voltage underground cable that will connect the two substations. This has seen around 950 metres of ducting installed on the A4061 route with a further 850 metres installed on the Hirwaun industrial estate.

Three km of ducting has also been installed in the Forestry region.

The compound for the Rhigos substation is now established, and the compound for the Pen y Cymoeddd substation up on the hillside will follow shortly.
ABB is taking a major role in the development of the Maritime Link, a 500 MW high-voltage direct current (HVDC) connection between Newfoundland and the North American grid. NSP Maritime Link, a subsidiary of international energy and services company Emera, appointed ABB to supply an HVDC power transmission solution that will form the basis of the link.

Vital interconnection commissioned

In July, ABB successfully commissioned an HVDC link for American Electric Power (AEP), which replaces an HVDC back-to-back converter station that was built in 1984. The converter station is an integral part of the Oklaunion HVDC transmission link and connects asynchronous grids in Texas and Oklahoma, both of which operate at 345 kV.

During the 22-month project, ABB’s scope included engineering, supply, installation and commissioning of an HVDC back-to-back transmission system capable of delivering 220 MW of power in either direction. Black-start capability enables fast restoration in the event of a power outage, allowing power to be imported from the other end of the link.

Key components of the turnkey solution include converter valves, converter transformers and ABB’s MACH 2 advanced control and protection system, which helps meet stringent system performance requirements.

ABB’s domain expertise and global experience enabled us to deliver this link in 22 months, and to minimise outage time for users, the converter station that was replaced remained in operation during construction.”
DCB preparing for UK implementation

Brian Cheung, Principal Technology Engineer gives an update on the potential for implementing the Disconnecting Circuit Breaker (DCB) in the UK.

When ABB introduced the DCB in 2000, it was a revolutionary concept for high-voltage air-insulated switchgear (AIS). By integrating the function of disconnector and circuit breaker into a single unit, the DCB opened up the potential to use a single piece of switchgear in place of three.

Then in 2013, we introduced the Fibre Optic Current Sensor (FOCS) to the DCB for current measurement that is accurate to 0.1 percent. This enabled the removal of current transformers from a switchgear bay. Combined, the DCB-FOCS has the potential to reduce the overall physical footprint of a substation by 60 percent compared with a conventional arrangement. And because the FOCS is equipped with a digital interface, it is compatible with the IEC 61850 standard.

The DCB is now a well-proven concept elsewhere in the world, and particularly Sweden, where installations have been in operation since 2000.

As part of their drive towards innovation, operators in the UK are now considering how they can use the equipment. ABB is preparing for the DCB to undergo review by the ENA (Energy Networks Association).
Once approved, operators across the UK will be able to adopt the switchgear for substations rated at up to 400 kV.

**What is the DCB?**
The DCB is based on ABB's well known LTB and HPL circuit breakers. Its basic functions are exactly the same as a conventional circuit breaker with the additional feature that the circuit breaker contacts also provide the disconnecting function. This means that once the breaker is open, the DCB uses the open breaker contact set as the disconnector and the isolation gap fulfills the IEC disconnector requirements.

To ensure the circuit is securely isolated for maintenance, the DCB is equipped with a mechanical blocking device which operates directly on the shaft that moves the circuit breaker main contacts. When the mechanical block is engaged and padlocked, it is impossible to close the breaker hence providing a secure point of isolation as a disconnector. An integrated earthing switch is also included as standard for DCB rated 245kV or below which provides another means of visual indication that the circuit is safe to work on.

**Optical current measurement**
FOCS is a type of sensor that measures DC current by viewing the changes made to a beam of light when it passes through the magnetic field generated by the current. It can measure currents of up to 600 kA (kiloamperes), providing readings that are accurate to 0.1 percent and it is equipped with a digital interface that is compatible with IEC 61850.

Because it measures changes to the physical properties of light, it does not require the regular re-calibration needed by a conventional current transformer, meaning that it is not just compact but also requires little maintenance.

**Performance and savings**
As a single piece of switchgear that replaces three, the DCB can deliver greater availability and grid performance as well as save 60 percent of the overall physical footprint of a substation compared to conventional technology, and enables significant cost savings for civil engineering and capital costs.

For new installations, a more compact footprint leads to reduced cost for land acquisition as well as civil works and installation costs and time. Indirect cost savings come from reduced energy losses and lower costs from outages and maintenance. And because the line has greater availability, the DCB can also protect revenues.

Designed for low maintenance, it can be delivered on a standalone basis or as a component part of a complete switchgear bay. It is also more environmentally friendly than its predecessor in terms of CO₂ emissions and material used for production and insulation.

---

**Try out the DCB on-screen**

ABB has developed a website where visitors can select the design parameters of a substation and compare a number of layouts. The tool allows users to input voltage, busbar arrangement, number of lines, number of transformers and the estimated cost of an outage. It then gives options for minimum space, extendability and maximum availability.

Visit [dcbsubstations.com](http://dcbsubstations.com)
Gotland smart grid

ABB and grid operator GEAB, a subsidiary of Vattenfall, are creating a fully developed large-scale smart grid on the island of Gotland. The largest island in the Baltic Sea is located 90 km from the Swedish mainland and around one third of the island’s electricity already comes from wind power and other renewable energy sources.

In bringing strategies for the planning, construction and operation of a large-scale smart grid on Gotland, ABB and GEAB, a subsidiary of Vattenfall, are developing one of the most advanced grids in the world. The island is ideal for the development of the smart grid because of the large amount of existing wind energy, the island’s physical size and existing modern distribution system.

The R&D project is likely to become an international model for a long-term sustainable smart grid and the island’s consumers are reaping the benefits of it being easier to save on energy bills and sell excess electricity.

The project was initiated in July 2010, when ABB and Vattenfall / GEAB signed an agreement to lead the development of future energy systems, building on several collaborations between ABB and Vattenfall in the power sector.

It combines advanced technologies that enable integration of renewables and maintains reliability of the grid as a whole. Technologies such as smart meters, smart control, energy storage, IT and communication technology, and smart SCADA (supervisory control and data acquisition) will all be integrated and evaluated.

Control and communication
A smart grid control centre sits at the centre of the grid and takes an overview of the operation and monitoring of the grid. Unusually for a SCADA system, the project’s smart SCADA controls the low voltage network and demand response as well as the medium voltage network. At the control centre, the grid’s activities are monitored and recorded to research the safe introduction of new grid applications.

An extensive information and communication network links every installation, enabling monitoring and control of the grid.

ABB’s software business Ventyx is deploying a comprehensive solution for Distribution System Optimization. This will encompass network control, demand response management, demand forecasting and business analytics to support the project. Distribution management system software supplied by Ventyx will be integrated with ABB hardware and will address bottlenecks in the distribution network that may restrict the flow from the wind turbines to consumers.

Upgrading the distribution grid
By using state-of-the-art substation equipment, the higher capacity substations maintain a compact footprint and have minimal environmental impact.

An upgraded distribution system enables advanced control and monitoring
of low and medium voltage systems. This includes last-mile-SCADA and will improve grid management and improve the ability to integrate renewable energy. Substations have been reinforced with the latest technology to handle the increase in power from wind generators.

Energy storage plays an important role in the system by actively balancing production and loads. A battery energy storage facility works in combination with a static VAr compensator (SVC).

Together, these support the introduction of additional wind power generation. The battery overcomes peaks and troughs in supply and demand, as well as grid regulation, and supplies up to 3.6 MW for five minutes. The SVC has the role of controlling active and reactive power that is injected into or retrieved from the system.

**Integrating consumers**
A major element of the project is in how it involves consumers and the community as a whole. The smart grid has been actively recruiting customers to participate in the project.

Around 3,000 consumers will be fitted with smart meters, giving real-time surveillance of the low voltage grid and measuring energy consumption, power quality and outages.

Demand response is also an essential element of Gotland’s smart grid. Around 2,000 households and 20 – 30 industrial customers will be recruited to a sub-project to test the market conditions of the smart grid. The consumers will be equipped with an Energy Service Interface (ESI), a product that reads electricity price signals and enables them to switch loads on and off.

This will link renewable energy generation with consumer demand, using structured tariffs to encourage highest use of energy when the supply is strongest.

Another important aspect is the Reference Group for the Smart Grid Gotland project. Bringing together representatives from government agencies and interest groups, the group acts in an advisory capacity and as a vital link between the smart grid and the business community.

**Environmental targets**
The project has brought together strategies to plan, build and operate a fully developed large-scale smart grid. It is helping Sweden fulfil its climate targets and is likely to become an international model for a long-term sustainable electricity power system.

**Next steps**
In early 2014, the Swedish Energy Agency approved the funding for the second phase of the Smart Grid Gotland project. This represents the development of a self-healing grid. The existing distribution network will be divided into smaller sections. In the event of faults, the self-healing network will re-route power to minimise the number of customers affected by an outage.
Active Filters
The ultimate solution

Mike Thornton, ABB’s Power Quality Products Manager for the UK, explains how active filter technology can combat network harmonic issues

Recently, some new banking offices required a major power network upgrade. Naturally, the building designers were well aware that they needed to protect PCs and other vital equipment against power outages and other network problems. So they specified multiple transformer infeeds and UPS systems. In addition, backup generators were installed in case the main utility power supply should be interrupted. Finally, power factor correction (PFC) capacitor banks were installed to maintain the power factor at an optimum level.

The designers believed they had done a good job. However, when the installation was energized the following problems occurred:

- PCs located some distance from the UPS-systems could not boot-up. Investigation showed that this was due to a high harmonic voltage distortion being present on the line. In addition, due to the unbalanced load current, a neutral current flowed, which together with the harmonic current in the neutral created too high a neutral to earth voltage, which also caused problems for some PCs.
- When running in generator backup mode, the harmonic voltage distortion added to the harmonics generated by the UPS systems caused the feeding voltage to become destabilized and the generators tripped out frequently.

To solve these problems, ABB active harmonic filters were installed both upstream and downstream of the UPS systems.

What are harmonics?
An harmonic frequency is simply a frequency that is a multiple of the fundamental frequency. For example, a 250 Hz waveform superimposed on a 50 Hz network is the 5th harmonic. The first effect of harmonic pollution is to increase the RMS (root mean square) and peak value of the distorted waveform.

This increase in RMS value leads to the increased heating of electrical equipment. Furthermore, circuit breakers may trip due to higher thermal or instantaneous levels. Additionally, fuses may blow and power factor correction capacitors may be damaged. The winding and iron losses of motors increases and they may experience perturbing shaft currents. Sensitive electronic equipment control and communications equipment may also be disrupted.
Power quality

In installations with a neutral, zero-phase sequence harmonics may give rise to excessive neutral currents. This is because they are in phase in the first three phases of the power system and sum together in the neutral. Excessive neutral currents are often found at locations where many single phase loads (PCs, light dimmers, printers etc) are in service.

A further motivation for taking action against harmonics is that as well as affecting local systems, they may also disturb equipment in other plants. In order to limit this disturbance, maximum permissible distortions are defined in standards and recommendations such as the ENA Engineering Recommendation G5/4-1 and BS EN 61000.

Where do harmonics come from?
- Variable speed drives (VSDs) that allow the accurate control of motor speed and power are increasingly popular as they allow flexible control of processes and improved energy efficiency. However standard drives produce harmonics.
- Most UPS systems used to provide clean power for sensitive loads themselves produce harmonics at their input side and will generate some background distortion at their output side if loaded with harmonic producing loads.
- PCs and laptops.
- Modern lighting systems.
In short, most ordinary loads connected to the supply generate some form of harmonics. If too many of these loads are present in an installation, then problems will start to occur.

How does an active filter work?
The basic concept of the active filter is very simple. If you add two currents, identical in magnitude and frequency, but exactly opposite in phase so that the peak in one coincides with a trough in the other then they cancel each other out. ABB’s PQF concept does this by continuously monitoring the line current in real time (at 40 ms intervals).

The PQF utilizes closed-loop measurement for greater accuracy and can be programmed to filter up to 20 individual harmonics for three-phase systems (15 harmonics in four-wire systems) from the 2nd to the 50th harmonic. It can filter the selected harmonics either until their magnitudes are close to zero (maximum filtering) or until their magnitudes reach a pre-set level (filtering to curve).

Latest PQFS Rating
The PQFS range has been extended to include a 120 A-rated version suited for commercial, residential and light industrial applications. The new version widens the offering for ABB’s customers and the hardware across the full range has been modified for improved protection and ease of maintenance.

Introducing QCap

ABB has over 70 years of expertise in capacitor technologies. This has been incorporated in the development of a range of low-voltage capacitors purpose built to deliver reactive power to address power quality issues in industrial and commercial installations.

Main benefits include:
- Reducing or eliminating expensive utility penalties for low power factor
- Reducing power losses in cables and transformers
- Increasing power transmission capacity in cables
- Increasing available transformer capacity
- Improving voltage stabilization in long cables

The latest addition to the range is the QCap standardized cylindrical design with key features including:
- Dry type design
- Safe sealing and overpressure disconnection system
- ABB in-house metalized film giving excellent dielectric properties
- Optimized thermal dissipation
- Long life
- Highly reliable
- Easy to mount in a capacitor bank
- Complies with international standards, CE marked
- Low loss design
One of Britain’s fastest growing independent connection providers (ICPs) is deploying ABB transformers as part of its complete ‘balance of plant’ infrastructure and grid connection package for renewable energy schemes across Britain.

The Lloyds registered, NERS (National Electricity Registration Scheme) accredited ICP is capable of providing contestable works at voltages up to and including 132 kV for embedded generation schemes, including solar and wind farms, and anaerobic digestor schemes.

Its success has seen it take a top 10 place in the 2013 Sunday Times Virgin Fast Track 100 list of Britain’s fastest growing privately owned companies. To date, g2 Energy has connected more than 371 MW of renewable energy to the grid, with a further 439 MW due to be connected in 2014.

Distribution transformers are a key element of g2 Energy’s package. They have the role of stepping up the output from generation plant, typically 690 or 433 V to feed into the local distribution grid at 11 or 33 kV.

After reviewing a number of competitive offers, g2 Energy selected ABB’s transformers for their combination of quality, performance and cost-effective price within a tight delivery schedule capable of meeting its fast-track growth programme.

ABB has already received orders for 18 transformers for projects, both already completed and under construction. Transformers are manufactured at ABB’s distribution transformer factory in Turkey and feature an oil immersed design with natural cooling. They are supplied direct to g2 Energy’s centralised warehouse facility in Milton Keynes, where the company builds containerised substations for renewable energy grid connection projects.
UK Power Networks has selected ABB’s innovative PASS M0 high-voltage switchgear to connect new solar farms to its 132 kV transmission network in the East of England.

UK Power Networks takes a shine to PASS M0

The switchgear will act as the main grid connection points for new solar photovoltaic (PV) farms, with one of the first installations being for the Leicester Square PV farm on the Hempton Grid in Norfolk. To help spread the demand on its 11 kV and 33 kV networks, UK Power Networks is now offering 132 kV connections for major new solar farms, typically producing in excess of 50 MW.

Compact and fast-track
Following a stringent review process, UK Power Networks adopted ABB's PASS M0 as the optimum switchgear for these projects due to its unique hybrid design that uses traditional air-insulated busbars to connect with other equipment in the substation, while the main bay functions are enclosed in a GIS housing to create an extremely compact installation footprint.

The PASS M0 modules will not only save space on site but will also enable a fast-track solution, as they are supply as completely pre-fabricated, pre-wired and pre-tested units. This reduces the need for civil works.

Metering and control in one
Because the PASS M0 integrates high quality tariff-code current transformers (CTs) and voltage transformers (VTs), UK Power Networks will be able to use it as a metering breaker to measure the quantity of power fed into its grid.

PASS M0 has full Energy Networks Association (ENA) approval and is rated up to 170 kV. It integrates all the necessary substation switchgear bay functions, including a circuit breaker, one or more combined disconnector / earthing switches, bushings for connection to single or double busbar systems and a current transformer (CT) in one compact module.

Another advantage is the PASS M0’s flexibility of configuration. It can be connected with various combinations of busbar and cable connections to suit different site needs.

PASS M0 modules will be installed at a number of sites in the eastern region of UK Power Networks’ operating area, which includes parts of Essex, Suffolk, Norfolk, Cambridgeshire, Bedfordshire and Hertfordshire. For some projects, they will be supplied directly by ABB to UK Power Networks, while for others, they will be purchased by the ICPs that are creating grid connections on behalf of solar farm developers.

PASS M0 will be installed on new solar farms in the east of England
Frequency conversion technology

A user’s guide

There are many potential applications for frequency converters – such as a cruise liner wanting to supply its hotel loads from the harbour network, or an industrial company that needs to power a process line purchased from a country with a different network frequency to the local supply. Jon Clews, ABB UK’s Power Conversion specialist, reviews the options.
Why does a ship need frequency conversion?

A rotary or static frequency converter allows equipment to be connected to a grid which has a different frequency from which it was designed, without the need to change the motors and other wound components. This is particularly needed in shore-to-ship power applications (otherwise known as ‘cold-ironing’), which helps ships in dock to connect to the local power grid so they can stop their onboard generators, reducing fuel use and cutting pollution.

Most power distribution networks generate at 50 Hz. But for historic reasons, most ships use a 60 Hz (Hertz) system. Using a rotary or static frequency converter ensures that the vessel is compatible with the grid requirements of the port where it is berthed.

What are rotary frequency converters?

The traditional frequency conversion technique uses a rotary frequency converter (RFC). This comprises a motor-generator set for speed control of the driven motor. It achieves the frequency change using a 10-pole motor with a 12-pole generator, or simply a fixed ratio gearbox.

While reliable, the RFC requires regular maintenance and has a conversion efficiency of less than 85 percent. RFCs suffer fixed losses, which are inherent in any electromechanical system. Spare parts can also be difficult to obtain for older equipment.

What are static frequency converters?

A static frequency converter (SFC) requires only a single annual service and has a much higher efficiency at 96 percent, the result of lower losses from this purely electrical system. The SFC’s power consumption is also more closely related to the connected load.

SFCs have lower standby losses and can be brought on-line and provide full output in a matter of seconds. They can automatically synchronise to an existing network, significantly reducing stresses on connected equipment.

SFCs offer a viable, modern and efficient alternative to RFCs, but can also be used in conjunction with traditional technology to provide a highly reliable hybrid solution.

Can frequency converters reduce noise levels?

Ships need to ensure they produce low noise levels when docked. In certain parts of the USA it is compulsory for vessels to switch off their auxiliary generators and connect to shore power systems. The rotating parts of RFCs produce noise from the motor, generator and, if used, gearbox. The system may require noise attenuation in order to comply with local regulations.

SFCs have none of these problems. They can work in temperatures up to 45°C, or higher if chillers are used. Most are air-cooled, although larger units utilise liquid cooling which further reduces ambient noise. An SFC can be installed in switchrooms or supplied in transportable, weatherproof, ISO style containers. This means that connecting to a shore power supply using a SFC reduces the noise levels in ports.

Can they provide redundant supplies?

Ports that offer a 60 Hz power supply may have a number of RFCs connected to a common bus. This allows a reasonable level of redundancy, but also means that the generators can be kept to a practical size. In practice it also means that at least two RFCs are always in service to ensure availability of power should an RFC fail. System losses are higher as a result.

It is feasible to use SFCs in conjunction with RFCs to provide a highly efficient ‘duty/assist’ system. In this way a RFC can be allowed to run at full load and maximum efficiency, with the SFC providing ‘top up’ power to the system.

Other features can include auto synchronisation and load sharing.

Can variable-speed drives be used?

The most common frequency converter in use in industry is a variable-speed drive (VSD) using IGBT semiconductor technology. These are designed to rotate induction motors with output frequencies in excess of 300 Hz.

Unfortunately the output waveform from a VSD is unsuitable for connection to the type of loads found on board a ship. In addition, VSDs are designed to be connected to single loads with a large induction, and cannot be connected to multiple loads which may regularly be switched on and off. In fact, a conventional VSD may incorrectly interpret a switched load as either an under- or over-current and shutdown as a result.

Therefore, this application requires specifically designed equipment, with a suitable output waveform and a very low total harmonic distortion (THD) of <2 percent. Otherwise, the connected loads may malfunction, suffer damage, or become stressed.

This is why it is important to use equipment which is specifically designed for the application – effectively a generator simulator with identical characteristics. This ensures that the high starting currents of large fixed speed motor loads are not interpreted as a short circuit.

What solutions does ABB offer?

ABB has developed a portfolio of state-of-the-art frequency converters including the PCS 100 SFC and PCS 6000 to cover applications ranging from 120 kVA (kilovoltamp) up to 120 MVA (megavoltamp).
ABB transformers are ready to meet or exceed new EU ecodesign requirements

David Hughes, Head of Power Products for ABB UK & Ireland, explains how new legislation now in force calls for new transformers to fulfill minimum energy efficiency requirements, while ABB is leading the way with innovative technology such as amorphous core dry-type transformers.
June 2014 saw the introduction of new ecodesign transformer regulations within the EU's internal market. This means that all new transformers put into service in the EU must fulfill minimum energy efficiency requirements from July 1, 2015, giving the industry and market a period of grace of only one year to adapt.

Large amounts of power pass through transformers, which account for 30-40 percent of the losses in transmission and distribution systems. Even a marginal increase in transformer efficiency can significantly reduce CO₂ emissions.

The new EU ecodesign regulation covers small, medium and large power transformers used in electrical transmission and distribution networks, and for industrial applications. However, it does not apply to all transformer products; for example, single phase transformers are unaffected.

The new legislation is intended to prevent high loss transformers from being installed in the EU, but the first phase (Tier 1) of efficiency requirements that come into play in July 2015 are only the start. By 2021, a Tier 2 standard will require transformer designs to be about 10 percent more energy efficient than Tier 1.

The European Commission (EC) estimates the combined effect of all ecodesign minimum efficiency regulations at full implementation will contribute to about one-third of its energy efficiency target. (The 20/20/20 targets include a 20 percent reduction in greenhouse gas emissions, a 20 percent rise in the share of renewable resources to Europe's energy needs, and 20 percent more efficiency in energy use across the EU).

By eliminating the worst performing transformer models, the EC expects energy savings in the range of 16 terawatt hours (TWh) per year from 2020 onwards (equal to about half the annual electricity consumption of Denmark), equivalent to 3.7 million tonnes (Mt) of CO₂ emissions avoided.

Transformers are generally very efficient devices, but even marginal improvements in their efficiency can yield substantial energy savings since their typical service life is 30 years or more. Multiply these new efficiencies by the estimated 3.6 million installed transformers in Europe in 2011, which is expected to rise to nearly 4.7 million units by 2025, and the energy savings are considerable.

ABB technology offers a head start

We can help our customers make a head start in meeting the new regulations, since ABB’s advanced technology already enables the production today of highly efficient transformers that exceed the rigorous demands of tomorrow, such as the anticipated Tier 2 standard planned for introduction in 2012. A typical example is the low-loss amorphous core technology, well proven in liquid-filled transformers, that has been adopted for ABB’s ultra-efficient EcoDry dry-type distribution transformers.

EcoDry transformers offer all the practical advantages associated with dry-type transformers such as: no fire risk; no risk of escape of pollutants or fire-hazardous substances; long lifetime; high mechanical strength; ability to cope with load changes, overloads, short-circuits and over-voltages; and reduced installation footprint. They are available in ratings from 100 to 3,150 kVA, with operating voltage up to 36 kV.

The EcoDry range includes three models, each designed to meet the different needs of applications where losses are either predominantly ‘no-load’ losses (caused by fluctuating magnetization of, and eddy currents in, the transformer core), or ‘load’ losses (which occur in the conductors due to ohmic loss and eddy currents, and increase quadratically with the load), or a combination of the two.

EcoDryBasic – low-load efficiency for power utilities

Distribution transformers at power utilities often see only a low mean load in actual operation. With low load profiles, it is the no-load losses that account for the major proportion of total losses and they are three to five times higher than the load losses. This means a significant reduction in no-load losses is one of the paramount considerations for the EcoDryBasic transformer, a product developed using the very latest simulation methods for a loss-optimized design, based on 30 years of experience. The EcoDryBasic transformer is specifically designed to meet the needs of power utilities by providing low-load efficiency that reduce losses and CO₂ emissions by more than 50 per cent.

EcoDry99plus – full-load efficiency for industrial applications

In an ideal world, industrial plant is operating at or near full capacity, and mean loading of the distribution transformer of 60 percent or more is not uncommon. The costs of load losses, and their reduction, can be significant.

In a typical industrial application, an EcoDry99plus transformer rated at 1,000 kVA, with 10,000 V primary voltage, would reduce annual power losses by more than 30,000 kWh, and cut CO₂ emissions by some 18 tonnes per year. At full load, the transformer operates at over 99 percent efficiency.

EcoDryUltra – efficiency across the load range

EcoDryUltra transformers combine the advantages of the EcoDryBasic and EcoDry99Plus to minimize no-load and load losses simultaneously. This transformer type is ideal for variable loads – such as renewable energy applications – and in applications where the supply is fed through two transformers at the same time (for redundancy), and so each is continuously operated at medium load – such as in pumping or ventilation systems.
FACTS smooth the way for modern railways

The fast growth in traffic on existing tracks combined with new high-speed rail projects has made traction a very significant load on electrical power networks. Hence, the increased focus on voltage stability and power quality. Trains drawing power from the catenary must be sure that the supply voltage is stable and does not sag.

For the most common 50 hertz (Hz) applications power is taken between two phases of the feeding grid, this can cause substantial imbalance between phases in networks not designed for this kind of operation.

Voltage and current imbalances between phases of alternating current (AC) supply systems must be confined in magnitude and prevented from spreading through the grid to other parts of the system. Voltage fluctuations and harmonics need to be controlled if they are to stay within the stipulated limits. This is where ABB’s portfolio of FACTS (flexible AC transmission systems) technologies comes in.

Deploying FACTS in existing systems saves both time and money, rather than investing in costly and time-consuming reinforcement of the railway feeding infrastructure, such as building new transmission or sub-transmission lines, and/or building new substations and feeding points.

Furthermore, FACTS can help achieve adequate power quality with lower infeed voltages than would otherwise be possible. For example, it could be sufficient to feed a railway system at 132 kV rather than at 220 kV or even 400 kV, which will of course enable a lower investment cost and also shorter implementation times.

FACTS for railways comprises SVC, SVC Light and Dynamic Energy Storage.

Load balancing
Connecting single-phase railway loads to a three-phase grid can result in severe imbalance conditions. Imbalance is measured in terms of negative-phase sequence voltage and current. These quantities are regulated in Grid Codes that stipulate how much negative-phase sequence can be tolerated at the point of common connection with the grid.

The relationship between the railway load and the fault level of the feeding grid is what determines the imbalance caused by the rail load. The larger the load and the lower the fault level, the worse the unbalance becomes, and thereby, the larger the negative-phase sequence components.

Besides violating grid codes, imbalance between phases induces extra losses, as well as causing wear to rotating machinery.

An ABB-supplied reactive power solution supports operations on HS1.
connected to the same grid. The remedy is FACTS, where SVC as well as SVC Light is capable of restoring three-phase balance.

**Voltage control**
Railway loads are highly fluctuating, since acceleration and braking lead to variation in voltage. FACTS controllers can keep the voltage levels stable, offering these benefits to grid owners and railway operators:
- Dynamic mitigation of voltage fluctuations in feeding grids, helping to fulfill Grid Code conditions
- Dynamic voltage support of catenaries feeding high power locomotives, maintaining traction capability despite weak feeding, and without harmful voltage drops along the catenary; furthermore enabling adequate power for locomotives during outages of feeding points, or, alternatively, with fewer feeding points required in the system. (saving investment in additional infrastructure)
- Dynamic voltage control of AC supply systems for DC converter fed traction (typically underground and suburban trains).

**Harmonic suppression**
Railway loads often generate harmonics that enter into the feeding power grid, creating Grid Code issues. FACTS controllers mitigate these harmonics.

Suppressing harmonics can also decrease or completely eliminate the extra losses they can induce, as well as preventing possible overloading of harmonic filters located elsewhere in the grid, and malfunction of protective devices.

**FACTS case study - SVC Light® for railway load balancing**
Evron is a substation in the French rail system between Paris and Rennes in Western France, fed from the RTE national power grid. An SVC Light® is operated by SNCF (the French railway company) for dynamic balancing of asymmetry between phases caused by the mode of traction feeding.

A London Underground SVC installation

The SVC Light also performs the task of active filtering of harmonics generated by thyristor and diode locomotives up to and including the 9th harmonic without the need for passive filters. Active filtering is made possible by the high dynamic response inherent in SVC Light.

By installing the SVC Light, the conditions set out in the National Grid Code concerning power quality at the point of connection to the grid of the traction feeder have been fulfilled, i.e. requirements on limits for voltage fluctuations, phase unbalance and harmonic distortion were met. An alternative to the SVC Light would have been to build a new overhead line, to increase the fault level of the feeding grid. In feasibility studies performed before the project, it was demonstrated that the SVC Light approach was considerably less costly as well as less time-consuming than building new lines.

**FACTS case study - London Underground**
In the early years of the 21st century, the London Underground closed its old 180 MW oil/gas fired power plant at Lots Road to take its supply from the National Grid. Since the underground load consists mainly of diode converters that feed DC current to the trains, FACTS has been deployed to limit or prevent disturbances, such as voltage fluctuations and harmonics, from reaching the public grid.

In 2009, an ABB SVC was commissioned for the 11 kV feeding grid to work together with several other ABB SVCs and standalone harmonic filters in operation since mid 2000 at critical points of the London Underground 22 kV and 11 kV grid.
ABB has further extended the SafeRing/SafePlus ring main unit (RMU) portfolio with SafeRing Air that uses dry air as an alternative, environmentally friendly insulation gas.

**SafeRing Air**

An innovative ring main unit

Traditional SafeRing/SafePlus ring main units are well suited to the needs of customers looking for closed SF6 handling and a very low leakage rate. Now, the innovative SafeRing Air offers the perfect solution for customers who seek to lower their carbon footprint even further.

Designed specifically for the 12 kV RMU market, SafeRing Air has the same physical dimensions, operation sequence, technical performance and quality as the traditional SafeRing with SF6. But it also comes with a new feature – the ability to upgrade a load-break switch panel to a circuit breaker panel on-site. This is an important difference, not currently available elsewhere, made possible by the use of vacuum technology for current interruption on both fault currents as well as load currents.

**A unique gas**

SF6 is used as an electrical insulator, as a thermal conductor and to interrupt current flow to enable the design of gas insulated switchgear (GIS) that provides the desired compactness and technical performance.

No alternative gas has been identified so far that exhibits the excellent properties of SF6 for the electrical distribution industry. However, it is also classified as a greenhouse gas.

**Challenges**

The main technical challenge in developing an RMU with an alternative environmentally friendly insulation gas has been to maintain the same physical size. This was vital since the dimensions place strict conditions on the dielectric and thermal performance.

Dielectric design targeted the distribution of electrical fields within the unit, aiming to reduce the field strength of weak points to compensate for the reduced dielectric strength of alternative insulating gases. Key parameters for optimization include choice of insulating materials, geometrical shape of conducting surfaces and definition of conductor/insulator interfaces. Advanced simulation tools were used for this purpose, and the results validated by dielectric tests in full-scale units.

Thermal design was also critical due to the lower thermal properties of alternative insulating gases, compared with SF6, and had two main objectives. The first was to reduce ohmic losses to a minimum (hence increasing energy efficiency) by utilizing a sophisticated design of select materials, surface treatment, contact forces, etc.

The second objective was to distribute the heat-generated losses through a combination of conduction, convection and radiation. Computational fluid dynamics (CFD) analysis was used to understand and optimize the temperature distributions inside the switchgear. The results of these simulations were validated by temperature rise tests in full-scale units.

Besides these key challenges, other factors were considered in developing the SafeRing Air RMU. ABB is committed to providing customers with the safest products and SafeRing Air is no different. Technical parameters and tests set by the IEC and other relevant standards were utilised to ensure safety when operating the RMU.

Another important aspect was to keep the simple, easy and logical operation of the RMU. To take this fully into account, SafeRing Air was designed using the same logic as traditional RMUs, leading to a familiar operating sequence. And of course environmental measures such as life-cycle assessment (LCA), environmental product declaration (EPD), and environmental product information (EPI) have been met.

Initial customer feedback during the launch of SafeRing Air has confirmed an increasing demand for this type of solution in low-end applications (12 kV).
Power House

ABB’s new UniPack-G secondary substation features a Glass fiber Reinforced Polyester (GRP) enclosure material that provides the strength and durability of concrete with better characteristics than steel.

The CSS (compact secondary substation) market was created when distribution utilities started to change from overhead power lines to underground cables.

With cables underground, the traditional, large step-down substation with its overhead lines became impractical. Customers now required a compact piece of equipment that could be installed quickly with a minimum of site work while providing the same functionality as an overhead line substation.

Concrete

Europe was one of the first markets to embrace the practice of undergrounding cables and installing CSSs built on site with either brick or concrete. Concrete is weather-resistant, but very heavy, difficult to work with and labour costs can be significant. However, if the unit is preassembled before shipment to site, the transportation and installation costs can be excessive as a concrete CSS weighs, on average, 24 tonnes.

Steel

In the search for lighter and more cost-effective solutions, a steel enclosure was found to fit the bill. With its comparatively light weight, transporting a steel CSS to rural locations is less expensive and heavy on-site installation work is not required.

However, while lighter than concrete, steel does not have the same strength and is more sensitive to ambient weather conditions. High levels of sunshine may increase the steel temperature to such an extent that a derated transformer has to be used, thus lowering the overall efficiency of the CSS.

UniPack-G

ABB recognized that a new CSS enclosure solution was needed – one that combined the benefits of steel and concrete. Ideally, it would be robust enough to protect the equipment inside from the extremes of heat and cold, while being lightweight enough to be easily transported, even to remote locations.

The answer was found in UniPack-G, where G represents the use of low maintenance GRP. It is unaffected by extreme temperatures and withstands attack by salt and humidity. Furthermore, since a UniPack-G enclosure is much lighter (one third the weight of an equivalent concrete CSS) transportation costs are reduced and it is much easier to install in remote locations.

The UniPack-G design is tested to the highest standards in the GB and IEC ranges. In addition, the standard design has passed the internal arc classification (IAC) test, which ensures it offers the highest level of safety for operators and the general public.
Relay retrofit program

ABB has re-engineered its approach to replacing time-served IEDs in a move that has reduced the time required from one month to only one hour. Using the new Relay Retrofit Program, ABB’s customers will ensure the extended life of their switchgear and make substantial savings in time and effort.
In the conventional approach, engineers must identify as many as several hundred parameters for the old relay and transfer them across to a new unit. Installing the new unit into the space designed for the old has its own challenges. And then testing and commissioning identifies any errors in transferring the parameters before the replacement is complete.

An operator with 100 relays could be looking at more than eight years of effort. And with an installed base 700,000 relays worldwide, ABB recognised that a new method was needed.

By exploring the logic of their relays and creating a set of software and installation tools, ABB has created its Relay Retrofit Program.

In the new approach, ABB’s engineer will arrive on-site with the new IED, a pre-prepared set of wiring, a software tool and all the tools and equipment needed to install the new relay within an hour.

One-hour process
Once on-site, the relay’s low-voltage compartment is de-energised and secured. The engineer will then connect the old IED to a migration support tool loaded onto a laptop. This takes a perfect copy of the parameters of the existing IED and configures the new IED – a step that can be achieved in just a few minutes.

A set of ready-made wiring supplied with markings that correspond to both the existing and the new IED means that wiring can be transferred quickly and accurately from old to new, again within just a few minutes.

Fitting the new IED into the existing panel is straightforward using a customised set of tools to extend the cut-out in the panel if the new IED is larger than its predecessor. If it is smaller, a pre-prepared cover plate will cover the gap that is left by the old unit and fit around the new IED perfectly.

Moving on to testing and commissioning, an ABB Relion test box, testing template and test device bring together all the tools to test and commission the new IED in an easy and reliable manner.

In total, retrofitting a single relay will only take around one hour, with no risk of error or surprises as the parameters have been transferred digitally rather than manually.

Replacing old with new
To date, ABB has explored the logic of some of the most commonly installed IEDs that it supplied around 20 years ago. These include models from the SPAJ 140 series of overcurrent and earth fault relays, the SPAM 150 C motor protection relay and the SPAU 130 C overvoltage and undervoltage relay.

All of these can be replaced with relays from the Relion 615 range of IEDs. These are both future proof with IEC 61850 and interoperable with legacy systems. They have standard configurations and an extensive set of Ethernet and serial communication options.

An important aspect of the Relion 615 units for the Relay Retrofit Program is their plug-in design that speeds up installation, maintenance and testing, and allows the cases to be installed and wired before delivery.

The benefits of the approach are clear. By upgrading relays to IEC 61850 compliant Relion 615 models, operators will bring their protection and control systems into the modern age, therefore extending the life of the switchgear.

And by using a process that delivers the upgrade in a fraction of the time of the conventional approach, replacing relays has become something that an operator can now consider seriously. Using the conventional approach, a programme of replacing relays would represent a major investment.

By examining the logic of its legacy devices and re-engineering the process, ABB has opened up the potential to digitise substation control and automation on a large scale.
Digital substations

Until now, most substation automation projects have focused on the IEC 61850-8.1 station bus. However, there is growing interest in its companion standard IEC 61850-9-2, which governs process bus communication. The process bus standard enables current and voltage measurements to be transmitted to protection and control devices via a fibre-optic communication network. It represents the opportunity to make significant reductions in copper cabling and improve safety.
The process bus also supports the integration of non-conventional instrument transformers (NCITs). This leads to improvements in performance and also reduces cost and footprint. A further benefit is that NCITs improve safety by eliminating the risk of voltage hazards that can arise in conventional instrument transformer circuits.

In 2012, ABB completed the first fully compliant commercial installation of IEC 61850-9-2 process bus technology for Australian utility Powerlink. The installation has delivered advanced automation at the Loganlea substation, a key substation serving south east Queensland. The project has enhanced grid availability and reliability in the fast-growing region, which includes the city of Brisbane.

Digitisation of substation automation is important for grid operators. Broadly speaking, its benefits are improved security and greater levels of grid reliability. ABB has developed its hardware and software solutions for operators keen to achieve the benefits of substation automation and ensure interoperability with existing assets. Products include the SAM600, a stand-alone merging unit and SDM600, a software solution for system data management as well as the Relion 670 series 2.0 IEDs, which are the newest members of ABB’s family of protection and control devices, and the RTU520, the latest Remote Terminal Unit in the RTU500 family of network monitoring and control devices.

Interoperability and ease of configuration are central to all of the elements of ABB’s approach to digital substations. They also address the key security requirements of multi-access substation automation systems.

**SAM600 merging unit**

By installing a merging unit, operators can integrate their existing instrument transformers into digital IEC 61850-9-2 process bus substation automation, protection and control systems.

Being a stand-alone unit, installing a SAM600 causes minimal disruption to substation operation and allows step-by-step upgrades towards full digitisation.

The SAM600 is such a merging unit. It digitises electrical signals so that they can be passed over Ethernet and fibre optic channels. This removes the need for copper cabling and its service and maintenance risks, and improves safety. It also enables robust, fast and responsive messaging.

Because existing sensors can be integrated into modern digital systems, the SAM600 can bridge the gap between analogue and digital signalling, avoiding the need to replace existing sensors.

The unit can ensure a future-proof installation that takes advantage of enhanced tools for engineering and testing, such as ABB’s IET600 system configuration tool and ITT600 SA Explorer for simple and efficient testing.

**SDM600 data management software**

Acting as a cybernetic office manager, SDM600 manages and monitors the network and its users. The software has a unified user interface and restricts users’ access to systems and equipment by checking the credentials of all visitors and giving access only to approved users.

It also logs IED disturbances using IEC 61850-8-1 and creates comprehensive status reports to identify trends in use.

Lastly, it ensures that software and firmware on every IED in the system is tracked and that updates are properly distributed. By cascading updates to other SDM600s in a system, even the largest network can be comprehensively updated from a single interface.

**Relion 670 series 2.0**

The latest member of ABB’s family of Relion protection and control relays is the Relion 670 series 2.0. It offers faster and more accurate performance than previous generations of the product.

A unique set of monitoring functions ensure protection and control in transmission systems and have been certified by independent laboratories as being fully compliant with both editions of the IEC 61850 standard.

**RTU520**

The new RTU520 offers simple and cost-efficient solutions for distribution monitoring and control. DIN rail input / output modules can be connected to meet a wide range of applications.

ABB’s RTU500 series also provides a comprehensive switch portfolio in the field of Ethernet communication. This enables customers to mix different types of media like fibre-optic and two-wire copper cables (SHDSL – symmetrical high-speed digital subscriber line) in one network.
Craig Carrington, ABB’s Transformer Service Sales Manager, outlines a new service targeted at the two most common points of failure for power distribution transformers.

Our new refurbishment and upgrading service targets the two most common points of failure for power transformers at 132 kilovolt (kV) and above – the tap-changer and bushings. Replacing one or both of these components offers a cost-effective way to provide a life-extension of at least 10 years for the UK’s vast fleet of transformers that are now mid-life or beyond, many having been installed 30 years ago.

The service is available for transformers from any manufacturer and is particularly suitable for older legacy designs that are no longer supported by the original manufacturer. As part of the service we provide either a direct replacement for the tap-changer or, depending on suitability, an upgrade to a state-of-the-art vacuum tap-changer. The brittle and easily damaged porcelain oil-impregnated bushings can be replaced with modern resin impregnated (RIP) bushings or the next generation of dry-type resin-impregnated synthetic (RIS) bushing.

The challenge of an ageing transformer fleet
The enormous cost of power transformer failure provides ample incentive for operators to ensure reliability and availability throughout the life cycle of these key assets. Transformers typically cost from £1 million upward and on the rare occasions they do fail, the financial impact can be even more significant – in extreme cases, they can leave a company facing financial ruin. In addition, as most countries have strict laws in place that control and regulate power supply, non-delivery penalties can be as high as 100 times the price of the energy itself.

Although transformers are normally highly dependable, the UK’s current transformer fleet is quite old. The average age for those in industrial plants is 30 years, and 40 years for those used by utilities. While aging transformers are generally not “ticking time bombs,” their failure rates, as well as their replacement and repair costs are steadily – albeit slowly – increasing with age. Carrying out diagnostic testing on a continuous basis can support fleet and asset management by providing assurance of asset condition.

The tap-changer – upgrading the transformer’s gearbox
The tap-changer is effectively the transformer’s gearbox. It connects or disconnects turns in the tap winding to change the ratio between windings to maintain a constant voltage out of the transformer. This is vital for the stabilization of network voltage under variable load conditions. Regulation is performed in around 9 to 35 steps and in normal grid applications the tap-changer can operate between 10 to 20 times a day.
Over the life of the transformer the tap-changer will suffer from wear and may sometimes fail catastrophically. ABB’s service starts with a thorough review of the condition of the transformer to determine the most appropriate response. One option is to fit a direct replacement based on conventional technology in which the switching takes place in oil. However, in the quest for greater efficiency and to meet key performance and financial targets like improved availability and cost reduction, many transformer users worldwide are now embracing ABB’s vacuum interrupter technology such as our VUBB and VUCG models.

In these new-generation tap-changers, electrical arc quenching takes place in a vacuum and not in oil. This substantially reduces contact wear and residues from arcing do not pollute the insulating oil. The benefits of using a vacuum tap-changer include:

- Lower lifecycle costs, less maintenance and increased time in operation because of a radical reduction in contact wear
- A cleaner environment for routine inspection, which reduces downtime
- Reduced sensitivity to moisture in the insulating oil due to the absence of polluting by-products such as carbon
- Independence of switching characteristics from the condition of the insulating oil
- Reliability due to the redundant contact system
- Full interchangeability with existing installations
- Possibility of using alternative insulating fluids.

If the design allows, then we recommend the use of a vacuum tap-changer specifically because of its extended maintenance periods. This is because vacuum tap-changers can deliver 300,000 operations between maintenance, versus 100,000 for conventional technology. Our service team can carry out the replacement on site. This will require the transformer to be taken off-line for two to three days. However, the work can also be carried out as part of a more extensive upgrading and refurbishment exercise with the transformer transported to ABB’s specialised facility in Drammen, Norway.

**Bushing replacement**

Transformer bushings provide the insulated connection between the internal windings of the transformer and the substation’s overhead power lines or busbars. Historically, these bushings are a solid porcelain or oil impregnated design. They generally perform well but by the time they have been in service for 20 years it is possible that their performance will be affected by partial discharge and they sometimes fail catastrophically by shattering. Bushing replacement is therefore an essential element of a transformer’s mid-life service.

If the transformer bushings need replacement then ABB recommends the installation of a new generation composite resin impregnated (RIP) or resin impregnated synthetic (RIS) design. RIP bushings offer the following advantages:

- High mechanical strength and flexibility combined with reduced weight, increasing the ability to withstand shocks such as earthquakes
- Increased safety to personnel – unlike porcelain, the material does not shatter and disperse on failure
- Because no oil is in the bushing, there is no need to have an expansion volume at its highest point. This means that even if RIP bushings are stored horizontally, they can be energized immediately after installation
- Eliminates the risk of bushing oil being sprayed over the equipment and causing a fire in the event of an explosive failure.
- The transformer is sealed, which means that the risk for moisture ingress to the transformer is reduced in the event of flashovers
- Downtime in the event of major transformer failures is also reduced because no porcelain fragments are left inside the transformer.
Leading marine certification body DNV GL has given its approval to ABB’s REA 10 arc flash monitoring systems for ship and offshore electrical systems. The REA relays are designed for ultra-fast detection of arc flash incidents, reduce arcing times and minimise risk to operators and equipment.

REA modules use fibre optic detectors to monitor and protect against electrical arcs and can be installed to protect new and existing medium and low voltage switchgear.

There has been growing awareness of the risks posed by arc flash, particularly in the oil and gas sector, in response to new guidelines and standards developed by various international trade and safety bodies including the IEEE (Institute of Electrical and Electronic Engineers), the US Occupational Safety and Health Administration (OSHA) and Lloyds Register.

On the other hand, the impact of an arc flash incident in the sector can be significant, potentially causing injury and major damage to switchgear, with a knock-on effect on valuable process continuity.

The most practical method of reducing the impact is by reducing arcing time. Energy released during arcing is directly proportional to time. Even a few milliseconds less may shift hazard levels and PPE requirements to lower categories. Arcing that lasts 40 ms or less typically causes no personal injury or switchgear damage, whereas if left for 500 ms or more, an arc has the potential to result in serious personal injury and major damage to switchgear.

Offshore operators are now required to carry out studies to identify risk from arc flash and put protective measures in place. One approach is to supply and renew specialist PPE on an annual basis but operators could instead install ABB’s REA 10 system, which eliminates risk by reducing tripping times.

The REA system’s long unclad fibre optic sensor delivers ultra-fast detection by absorbing the light from a flash anywhere along its entire length and signalling for the circuit to break within only 2.5 ms. In normal operation, both intense light and over-current must both be present for tripping to occur.

Ian Hodkinson, Head of ABB’s Distribution Automation business in the UK said: “Winning type approval from DNV is a major endorsement for ABB’s REA Arc Flash Detection System. A typical substation might only experience a single incidence of arc flash in its lifetime but the impact is significant in terms of risk to life and limb, serious damage to electrical hardware and lost production time.”

REA protects the main distribution substation at Total’s Lindsey Oil Refinery

Centrica Energy has improved its HSE (Health, Safety and Environment) performance at its South Humber Bank power station by retrofitting REA 10 arc flash protection systems to the site’s medium-voltage power distribution network.

The combined cycle gas turbine plant in north-east Lincolnshire has an output of almost 1.3 MW. By retrofitting the site’s existing ABB medium-voltage switchgear with REA 10 arc flash protection relays, Centrica has minimised the risk of arc flash incident from the 11 kV distribution network.
Countdown to IET Innovation Awards

The clock is ticking towards this year's IET Innovations Awards on 19th November at the Brewery in London, which will be hosted by TV technology presenter Kate Russell, who appears on the BBC’s technology programme Click.

Last year, ABB was able to celebrate an award win itself as its ENVILINE Energy Recuperation System (ERS) was awarded the prize in the transport category, with the judging panel commenting: “The new solution, launched this year, offers a huge opportunity to improve the energy-efficiency and sustainability of rail transportation systems.”

ABB is once again sponsoring the Sustainability category, which recognises innovations that meet the needs of the present generation without compromising the ability of future generations to meet their needs. Past winners of the award include systems that recover energy and a biodegradable packaging material.

This year, the awards are growing in scope as the IET has marked the 10th year of the awards scheme with a brand new category on Manufacturing Technology, which is supported by the Institution of Mechanical Engineers.

David Hughes, head of ABB’s Power Products business in the UK said: “The awards are a great showcase of the very best in new technology and I’m looking forward to the night.”

Innovation in service

Effective Power Asset Management Conference

ABB is inviting its customers to sign up for a Power Asset Management Conference on 24 – 25th September in Chester. The informative two-day event will include network, round-table discussions, expert panel questions and demonstrations.

Operating and maintaining power assets is of primary importance to an organisation. Today’s focus is not just on operation, but also the safety improvement, functionality, enhancement and potential life extension of existing power assets. Through a mixture of presentations, practical demonstrations and interactive discussion sessions, we will give an insight into the options and approaches available to manage power assets to maximise their effectiveness and availability.

Highlights of the conference will include keynote speeches by ABB’s Bruno Melles, global head of ABB’s Medium Voltage products business, followed by industry expert John Eddington from K2 Ace.

A dinner event on the evening of 25th will feature after-dinner guest speaker Gyles Brandreth, the former Conservative MP, writer, broadcaster and actor.

Attendance, hospitality and hotel accommodation is complimentary and so we ask guests to secure line management approval to register.

Find out more
Contact Jayne Brownsword on jayne.brownsword@gb.abb.com or on 01785 285 981 for more information and to register or visit new.abb.com/uk/service-innovation.

Datacentre Dynamics

ABB is planning to attend the Datacentre Dynamics conference and expo on 19 – 20 November in London’s ExCeL.
Looking out for ourselves and our colleagues

As part of its commitment to business ethics, ABB has launched a new campaign that will raise the bar on workplace health and safety. Safety of employees, contractors, customers and others affected by our operations is of vital importance, which is why we launched the ‘Don’t look the other way’ initiative.

Put simply, the core message of the campaign is that ABB employees and their colleagues should not look away when they see potentially unsafe acts or unsafe conditions and that they should instead report them immediately. Based on the fundamentals of: prevent, detect and resolve, ABB’s employees at every level of the organisation have the responsibility to ensure safe working.

Multiple reporting lines
The goal is to avoid the risk of injury by putting in place a system where employees will consult with others if they have any doubt about ways of working or compliance.

Multiple reporting channels are available to all employees, who can approach any one of a number of individuals, including their own manager, a specialist integrity officer in their own country or at ABB’s headquarters, a neutral ABB Ombudsperson, the human resources team or our business ethics hotline.

And while the campaign extends through every level within ABB, it also reaches out to business partners, who can report any perceived risk through a hotline for business partners or via our human resources team, corporate communications, sustainability, quality, audit or finance teams.

All reports are followed up, investigated and brought to full closure. By giving our employees and stakeholders multiple reporting channels and enforcing a rigorous non-retaliation policy, we ensure that risks are detected and prevented.

Building on ethics
In 2013 and 2014, the Ethisphere Institute named ABB as one of the world’s most ethical companies in recognition of its leadership in ethical business practices. The designation is awarded to companies that promote ethical business standards and practices internally, and also exceed legal compliance minimums and shape industry standards by introducing best practices.

CEO Ulrich Spiesshofer said: “A culture of integrity is a prerequisite for a world-class business. Many valuable customers choose to do business with us in part because they know ABB behaves in a responsible and ethical way, and that we respect the needs of individuals, society, and the environment.

“At ABB, performance is measured not only by the results achieved, but also how these results were achieved. This is why our stakeholders can rely on the fact that our services, operations, and daily business are based on ethical behaviour.”