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The integration of operational data using CORE: A global, bespoke SCADA system. *An investigation of the value added through the CORE system for integrating supervisory control and data acquisition (SCADA) across global assets.*

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Summary
Scottish Power Renewables (SPR) has deployed the CORE system which interfaces with all Original Equipment Manufacturers' (OEMs) supervisory control and data systems (SCADA). The objective is to enhance the management of a large portfolio of wind farms with multiple equipment suppliers. This case study explores the benefits of integrating operational data across an entire portfolio – comprising both on and offshore wind farms and a wide range of suppliers.

Key findings
- CORE has been implemented, and is deployed in the management of, 29 of SPR's 32 operational wind farms – comprising both on and offshore sites. All farms are managed centrally from a dedicated control centre near Glasgow.
- The CORE system interfaces effectively with OEMs' SCADA systems and presents data from the assets in a consistent, user-friendly and visual manner.
- CORE is a versatile system with the ability to implement permission rights to manage the flow of data and instructions. The wide range of screens displaying data in a standard layout makes it very easy to use.
- CORE facilitates both passive monitoring and active control of assets by interfacing with OEMs' SCADA systems.
- To improve safety, speed of response and consistency throughout an organisation, it is recommended that integration of operational data is considered by wind farm owner/operators.
- For wind farm operators, CORE is an exemplar of how best to present operational data.

Key benefits
- Standardisation of management of operational data from equipment provides consistency across a business and between departments.
- Increased speed of response to curtailment instructions from the grid.
- Facilitates collaboration with suppliers and OEMs in the warranty phase to deliver faster turbine resets.
- CORE is simple to use and empowers engineers and analysts to make better use of available data.
- Best-in-class alarm management.
- Facilitates enhanced communication and accessibility to data.
- The system is technology and manufacturer agnostic and its adaptability allows it to be deployed across a wide range of uses.
- Reduces the complexity of setting up new wind farms.
- The small number of secure interfaces and permission rights enhances security.

Introduction

CORE is the global bespoke supervisory control and data acquisition (SCADA) system used by Scottish Power Renewables (SPR). It connects and interfaces with any original equipment manufacturer (OEM) SCADA system. This system was developed by Iberdrola, the parent company of SPR, for their onshore wind portfolio in Spain. Today it is used to monitor and control 29 out of 32 UK-based on and offshore wind farms within the SPR portfolio.

Owner Operator:	Scottish Power Renewables (SPR)	
Interview Location:	Renewables Control Centre	
	(situated at the Whitelee wind farm site)	SPR Renewable Control Centre
Number of UK wind farms:	32	
Onshore Capacity:	1.8 GW	
Offshore Capacity:	389 MW	

Figure 1: Scottish Power Renewables wind farm portfolio key facts and figures

All SPR wind farms are controlled centrally from the SPR Renewables Control Centre (RCC) situated at the Whitelee onshore wind farm south of Glasgow.

This case study is based on observations from a visit to the RCC where a demonstration of the CORE system showed how it supports the vast range of operations and maintenance (O&M) activities being undertaken. The aim of this case study is to explore the benefits of integrating operational data from a diverse range of assets, across an entire wind farm portfolio, on a global basis.

The challenge

SPR have a UK wind power portfolio consisting of 32 wind farms with a cumulative installed capacity of over 1.8GW. This comprises over 1000 operational turbines from a range of different OEMs. Within this portfolio, SPR have 12 balancing units contributing to the national grid balancing mechanism. SPR is an active owner and plays a central role in the O&M of the wind turbine and balance of plant across their onshore wind farms. This is in addition to managing grid compliance and balancing services.

The wind power portfolio includes a 50% investment in the West of Duddon Sands offshore wind farm, with installed capacity of 389MW. Here SPR are responsible for wind farm balancing services and Offshore Transmission Owner (OFTO) control.

With over 500MW of onshore wind and over 1GW of offshore wind in development (Wikinger and East Anglia farms), SPR has a strong project pipeline.

Figure 2: SPR Renewables Control Centre (RCC) based at Whitelee Onshore Wind Farm

All O&M activity for the combined SPR fleet is managed from SPR's Renewables Control Centre (RCC). This dedicated central command centre was established in January 2008 to provide 24/7 monitoring and control of SPR's UK-based wind power portfolio.

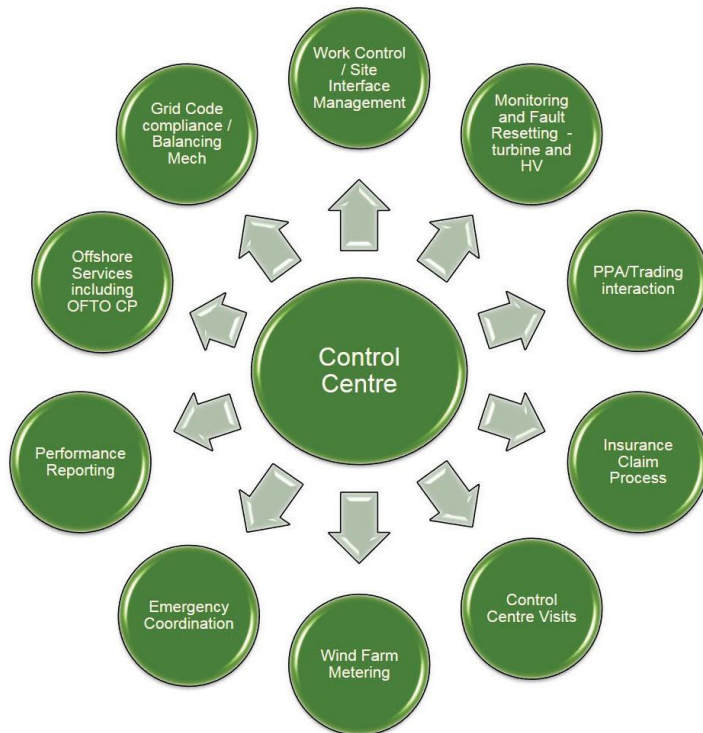The responsibilities of the RCC are illustrated in Figure 3.

Figure 3: Responsibilities of the SPR Renewables Control Centre

Factors that make the management of the SPR's O&M activity extremely challenging include:
- The extensive range of O&M activities.
- O&M activities relate to a significant portfolio comprising wind turbines from multiple OEMs.
- The coordination of complex operations involving significant volumes of data from multiple OEMs.

SPR have implemented a range of data systems to support the O&M activity coordinated by the RCC. Table 1 details the systems in use that are referenced throughout this case study.

Data system	Function
CORE	Global SCADA system capable of interfacing with proprietary OEM SCADA systems.
OsiSoft PI	SCADA data historian
Work Orders	Work order system
Verification Authorisation and Control System (VACS)	Work authorisation system for managing site, turbine and personnel restrictions
Domina	An application that generates KPIs. For instance, availability based on equipment measurements accessed via the CORE SCADA system
Meteoflow	In-house wind and site production forecasting tool
Visual Eyes	Weather forecasting tool provided by the Met Office. Gives a bespoke 5-day forecast of precipitation, temperature, wind, lightning and visibility

Table 1: Data systems implemented at the SPR Renewables Control Centre

The approach

Prior to explaining how the system works and providing a comprehensive description of the key features, this section outlines why the approach was adopted and sets out the drivers and history of CORE.

Drivers and motivations

The drivers and motivations for implementing CORE were:
• To improve safety management by providing real-time information and excellent lines of communication to colleagues on site.
• To facilitate fast responses to wind farm issues, resulting in increased availability, minimised downtime and maximised performance – the fundamental goals of wind farm operations.
• To provide uniformity across sites, suppliers and systems, so all SPR staff can access operational data in a consistent manner.

History and development of CORE

Prior to using CORE, SPR was collecting information from the OEMs' SCADA systems using a wide range of data formats. The SPR control centre team had already identified this as a significant source of inconsistency and complexity. A project to develop an in-house tool that could interface with all OEMs' SCADA systems in a simple, consistent and graphical way had been initiated. Meanwhile Iberdrola, who had recently acquired SPR, had already developed CORE, a tool designed to deliver the same efficiencies and it was being used to manage the Spanish onshore fleet. In 2010 Iberdrola Engineering and Construction began development of a bespoke version of CORE tailored to meet the UK's requirements. This case study explores CORE UK only.

Today, CORE has been rolled out to all SPR's wind farm sites with the exception of three of the mature sites that are currently under review for repowering. CORE also enables cross technology management. The data interfacing platform is designed to be adaptable and can handle any data format. This versatility allows the system to be applied in contexts beyond the original intention. The increased scope of CORE means that it is now used in Spain to interface with solar farm SCADA systems, in addition to the onshore wind fleet.

Deep dive – how does it work?

The primary function of CORE is to interface with OEMs' SCADA systems and to present data from the assets in a user-friendly and visual manner. CORE is also a real-time SCADA system itself, because in addition to monitoring data, it is used to control assets by communicating with SCADA specifically designed for individual OEMs.

CORE is adaptable because it is technology and manufacturer agnostic. To manage their wind farm portfolio, SPR have configured CORE to interact with wind turbine controllers, all wind turbine telemetry (SCADA), substation equipment such as Programmable Logic Controllers (PLCs) and site meteorological measurements from sources such as the met mast data loggers. CORE allows SPR to communicate with an asset and share information in one of two ways. Either CORE interfaces with an OEM SCADA system or CORE is connected directly to the asset.

The data collected from assets in the field is presented in the form of graphic visualisations which enhance understanding and the user experience. All visualisations use a standard template with a uniform presentation style, headers and navigation functionalities which allow users to rapidly familiarise themselves with the system. Three example data visualisations are shown in Figure 4. The top left screen shows how turbine OEM SCADA signals and alarms are visualised on a graphic model of the turbine. This helps engineers and analysts tasked with interpreting alarms and SCADA tags to quickly and efficiently locate the problem.

The top right screen demonstrates a dashboard view of the status of all turbines in a farm. It includes wind speeds local to each turbine and presents a valuable summary of the status of the farm. The screen at the bottom shows the geographical location and operating status of each turbine in the farm, which is particularly valuable when coordinating maintenance activity on-site. Critical commands such as 'Reset Turbine' can be sent from any of the screens, providing the user has the necessary authorisation and permission level.
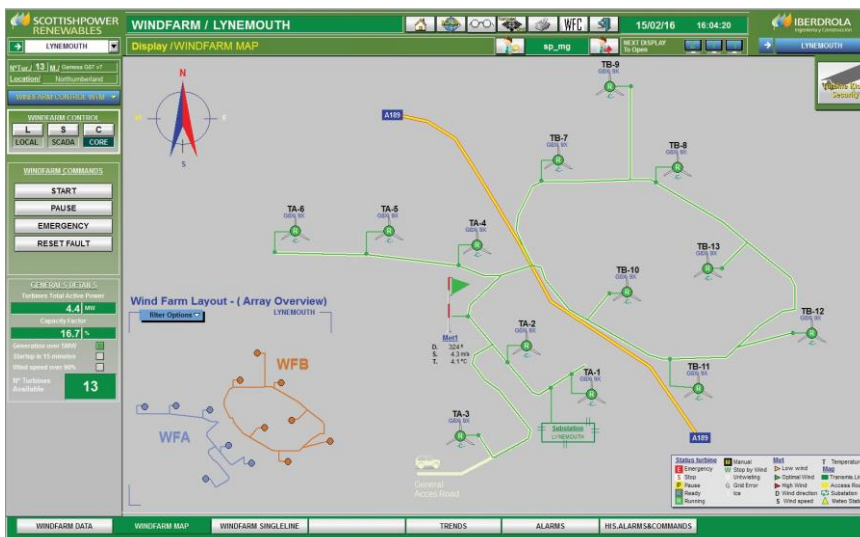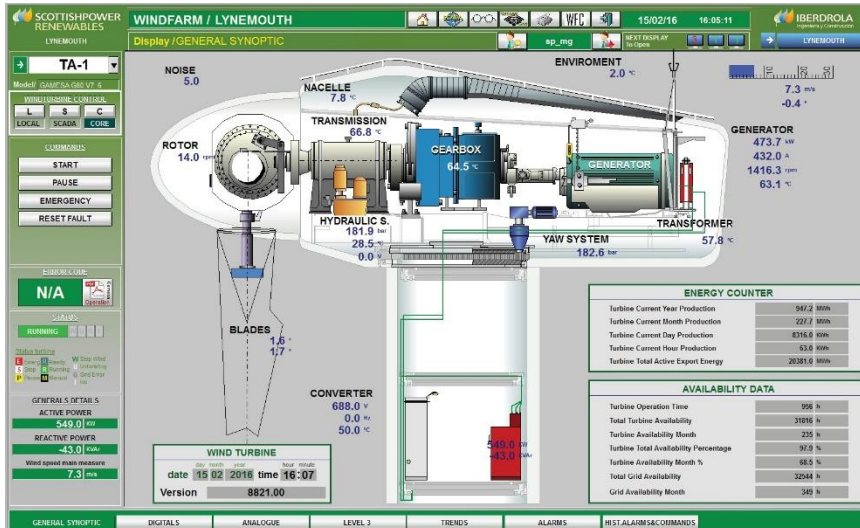
Figure 4: Sample core screens showing graphical visualisations of wind farm operational data

Features

CORE capabilities include:

- *Monitoring and control of assets*
  CORE provides real-time access to some of the most important data for the effective management of wind farms, from anywhere that has an internet connection. CORE facilitates both passive monitoring and active control of assets by interfacing with OEM SCADA systems. As well as connecting through the OEM SCADA, CORE can also connect directly to the turbines at some sites where the protocol is available, this is currently the case at six wind farms.

- *Graphical visualisations of data*
  The graphical visualisations provide an intuitive user-experience for interfacing with and interpreting the significant volume of operational data generated at each site. Figure 5 shows a complete portfolio dashboard which provides SPR with a high-level view of the status of all operational wind farms.
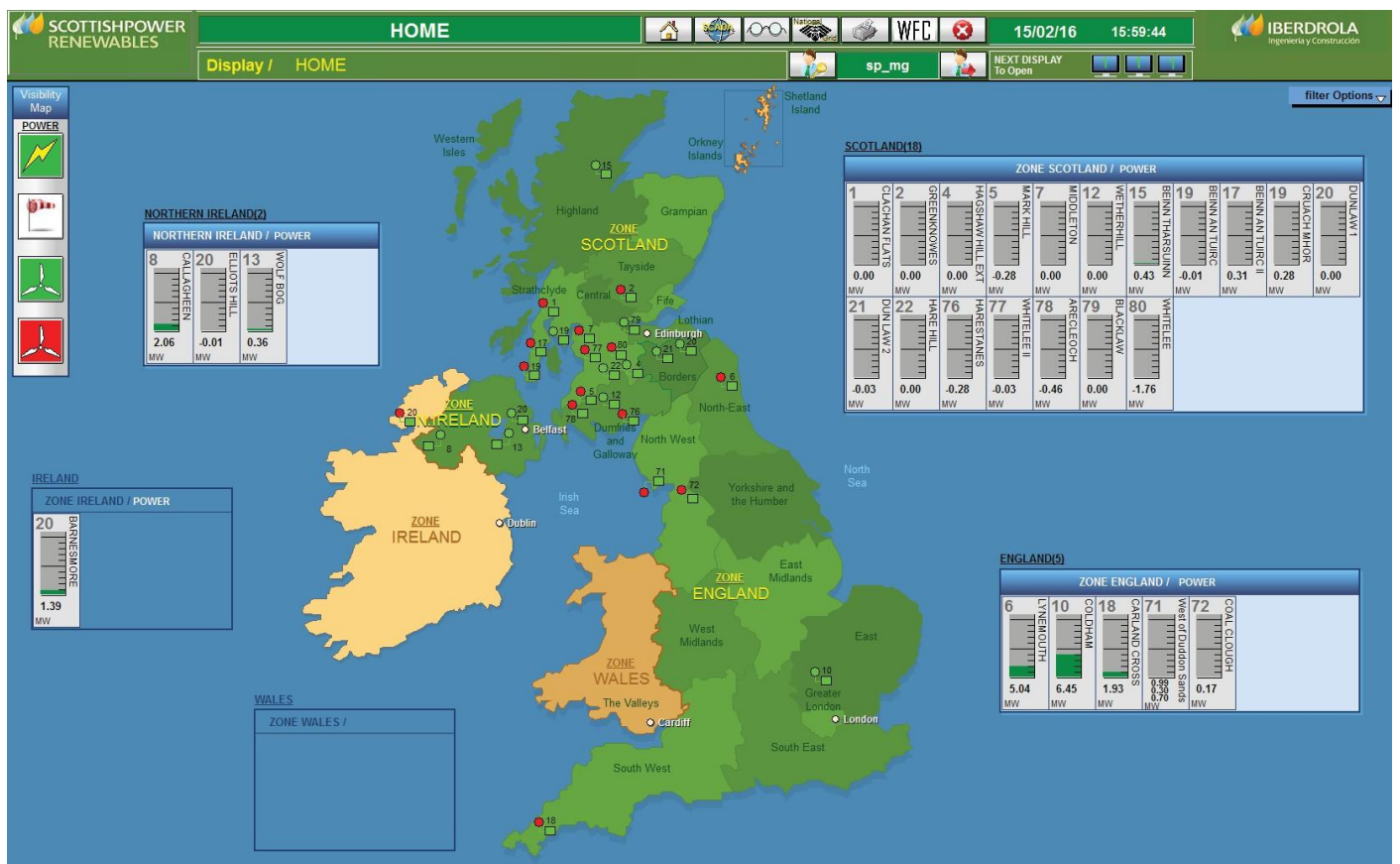

Figure 5: CORE used as a dashboard to view high priority wind farm data across the entire UK fleet

- *Adaptability*
  The system has been developed to be data and technology agnostic. This facilitates multiple manufacturer and multiple technology management. CORE can also adapt to emerging technologies such as an evolving international power system.

- *Alarm management*
  It is essential that CORE can interpret SCADA alarm codes, manipulate and categorise these codes in an effective manner and interface with any SCADA OEM.

  A significant challenge for wind farm operators is how best to handle the hundreds of alarm codes simultaneously logged during a fault, interpret which is the meaningful information, identify which components are affected and diagnose the nature of the problem. CORE has been developed by SCADA specialists to ensure alarm categorisation and alarm grouping is logical and effective. A key advantage of this is that once a particular OEM SCADA has been incorporated into CORE, the system can easily be applied at any farm using that OEM technology. The fact that SPR have successfully configured CORE with a wide range of manufacturers across 32 UK sites is testament to their effective alarm code management.

  When a new farm is developed or acquired a simple CORE plug-in ensures consistent and effective alarm code management processes are deployed.

- *Working with OEMs in the warranty phase to deliver faster turbine resets.*
  During the warranty phase, CORE allows SPR to monitor and work with the OEM. This relationship reduces the response time to faults that require intervention or escalation (for example, manual resets). SPR allocate a 15 minute window for the OEM to respond to incidents that require a manual reset and CORE permits SPR to actively monitor the response rate.

  SPR are planning to use CORE to take responsibility for fault resetting across all their sites. 10 sites are already functioning in this way, with the remaining 20 targeted for the end of the year.

- *Consistency*
  CORE provides a single, consistent data platform for interfacing with all OEM SCADA across the entire SPR portfolio. This standardised approach makes it easy to compare the performance and reliability of different turbine designs. The user-friendly graphic interface is not only easy to learn and understand, it also allows users to interpret data in an intuitive manner and reduces the likelihood of human error.

- *Permission rights*
  By managing user permission rights, unauthorised personnel are restricted from viewing or amending certain data sets. For example, most sites are set up to have 'view only' access via on-site terminals, while the RCC has full admin rights. This allows the RCC to actively manage farms, while on-site staff have full visibility of any O&M plans.

  A further security enhancement means the RCC can only access the CORE application through secure connections that comply with ISO27000 cybersecurity requirements.

The results

This section details examples of how SPR manages an extensive portfolio of wind farms, all from one dedicated control centre; with CORE correlating data from multiple manufacturers.

Planning maintenance at Whitelee onshore wind farm

Whitelee onshore wind farm has an installed capacity of 539MW, using turbines from two different OEMs. There is a team of 25 on-site turbine OEM technicians that undertake service and maintenance, but SPR is ultimately responsible for the management of O&M activity and on-site personnel. CORE provides a valuable tool to support the planning of maintenance work.

Figure 6: Whitelee onshore wind farm

The OEM team carries out preventative maintenance and inspections; this activity is planned and recorded using a senior authorised person (SAP). However, it is vital that SPR is aware of any circumstances that may require deviation from the maintenance plan. Factors that impact on the plan include equipment health, weather and safety issues. CORE provides a single, consistent interface with all equipment data for the Whitelee wind turbines, so SPR staff and OEM technicians can effectively plan and execute maintenance activity.

A comprehensive display of the CORE's range of applications was demonstrated during the RCC visit for this case study. CORE was simultaneously being used for diagnosing a wind turbine technical problem on one screen, while another analyst was busy submitting bids for the balancing mechanism. Meanwhile, the largest screen in the control room was set up to permanently show the wind farm portfolio dashboard (Figure 5).

CORE implemented offshore at West of Duddon Sands wind farm

West of Duddon Sands (WODS) offshore wind farm is a joint venture co-owned by SPR (50%) and DONG Energy (50%). WODS was fully commissioned in October 2014 and is currently under a five-year warranty with DONG Energy leading wind farm operations. SPR are responsible for wind farm balancing services and OFTO control point responsibilities.

CORE provides access to substation sensors, met mast and all wind turbine SCADA data. Essentially, this provides SPR with full connectivity to the wind farm operational data. All CORE functionality is available at WODS, however as this wind farm is a joint venture, the other partner is responsible for day-to-day operations. Because the co-owner does not utilise CORE, CORE's full functionality is not deployed at WODS.

It was acknowledged that if the contractual arrangement was to be amended, CORE's capabilities means that it is technically possible for the offshore wind farm to be managed from the RCC in Glasgow, in exactly the same manner as any onshore SPR site.

Impact: KPI measuring speed of response

One of the objectives for installing CORE was to improve the speed of response to wind farm issues. Since installing CORE, SPR has implemented a key performance indicator that every fault must be reset or escalated within 15 minutes. The RCC manager explained that CORE not only provides the necessary information to act quickly to any fault, but records responses measured against the KPI to drive ongoing improvement.

Example: Balancing mechanism and curtailment

The SPR wind farm portfolio includes 12 balancing mechanism units (BMUs), explained in Figure 7, which together offer the National Grid 1.3 GW of variable generation. A power plant operator can only offer this value-adding service through the balancing mechanism (BM), if they are able to respond quickly and alter exported production levels. When National Grid instructs a wind farm to reduce production, the instruction must be manifested as a curtailment of the farm and operators at the control point must be able to respond within two minutes.

What is the Balancing Mechanism?

The Balancing Mechanism (BM) is a tool that National Grid uses to balance electricity supply and demand in each half hour trading period of every day. It is needed because electricity is not stored effectively and must be manufactured at the time of demand. Where National Grid predicts that there will be a discrepancy between the amount of electricity produced and that which will be in demand during a certain time period, they may accept a 'bid' or 'offer' to either increase or decrease generation or consumption.

If a bid to reduce generation from a wind farm is accepted by National Grid, the wind farm has 30 seconds from the start of the relevant 30 min period to activate and a two-minute response time to show a reduction in exported production. If the wind farm does not react fast enough, the wind farm could face regulatory action.

What is a balancing unit?

A Balancing Mechanism Unit (BMU) is considered as a unit of trade within the BM. Each BMU accounts for a collection of plant that can be independently controlled. As a result, most BMUs contain either a thermal generating unit, a group of wind turbines or a collection of consumption devices.

Figure 8: What is the Balancing Mechanism?

Before CORE was installed, SPR acted on instructions to curtail production by instructing on-site staff to manipulate the turbine behaviour through the on-site OEM SCADA, which altered the wind turbine power set-points.

The integration of operational data from multiple OEM SCADA systems into one platform has significantly improved this process. Curtailment of all SPR farms is now managed from one single location. Effectively, engineers based in the Glasgow RCC can send an instruction to the park controller at Beinn Tharsuinn onshore wind farm situated in Alness in the Scottish Highlands. This will automatically adjust the individual turbine set-points and limit the export production, in response to the National Grid's BM instruction.

The key benefits of CORE in this example are:
- The reduced cost of remotely supporting power plants from a single control room.
- The increase in speed of response.
- The increased speed of response to curtailment instructions which allows SPR the confidence to increase their contributions to the BM in the knowledge they will not violate any National Grid time of response constraints.

The centralised approach to managing curtailment facilitates a clustered approach allowing SPR to optimise how it responds to a National Grid instruction. Currently this concept is in development.

As a result of integrating operational data through CORE, it has been possible to significantly improve revenue generating grid services such as:

- The provision of reactive power and frequency control.
- The offering of grid inter-tripping, where portions of the grid are automatically tripped to protect the integrity of the wider network.

Example: Minimising downtime due to network issues

The deployment of CORE has resulted in a significant reduction in downtime associated with grid network trips. This is because CORE provides SPR with the necessary alarms and mimics required to diagnose this type of fault quickly and efficiently. The network is managed under SPR's HV safety rules and the RCC have the authority to open breakers in an emergency and remotely perform a one shot reclose, in agreement with a Senior Authorised Person (SAP). This provides an efficient but safe restoration of the wind farm 24/7.

Before CORE was introduced, in the event of a grid trip under routine conditions where no fault was detected, a SAP would be required to attend site to diagnose the issue. Effectively this meant that turbines would be switched off while a SAP was mobilised, travelled to site and carried out the diagnosis.

The situation is now very different, with the data and visual representation provided by CORE, the RCC can remote diagnose these type of problems and work remotely with the SAP to restore the site quickly and safely. The impact of this increased control for SPR is a reduction in downtime and therefore an increase in availability.

Key benefits

Integration of data from all equipment supplier SCADA systems via the CORE system delivers key benefits:

- *Standardisation and consistency across a business and between departments*
  The SPR wind portfolio consists of radically different wind farms. These range from small onshore farms in remote locations in the Scottish Highlands, to utility scale offshore wind farms in the Irish Sea – each with bespoke operational challenges. Additionally, SPR work with a wide range of suppliers, each with proprietary data systems. The CORE system provides a global, standard solution for the management of a global portfolio that minimises variation across the business.

- *Increased speed of response and improved fault response*
  One of the most significant benefits of integrating operational data is the substantial improvements in response time to a multitude of issues. Two excellent examples are curtailment in response to balancing mechanism instructions and diagnosing network problems. SPR has used CORE to implement a key performance indicator that every fault must be reset or escalated within 15 minutes.

- *Ease of use empowers engineers and analysts to make better use of available data*
  The uniform layout of the CORE screens and user-friendly visualisations of operational data makes CORE very simple to use and the online system provides a valuable platform for interactive training. This allows staff to quickly make better operational decisions because they have access to, and clear presentations of, data generated by the wind farm.

- *Best in class alarm management*
  CORE effectively interprets SCADA alarm codes and data signals from the range of OEM SCADA systems used within the SPR portfolio. This automatically manages the hundreds of alarm codes simultaneously logged during a fault. It also interprets the codes as meaningful information to help identify which components are affected and diagnose the nature of the problem. Rolling CORE out across all sites provides a well-developed and company-wide standard for alarm categorisation and alarm grouping.

- *Enhanced communication and accessibility to data*
  CORE provides real-time access to some of the most important data for the effective management of wind farms, from anywhere that has an internet connection. This critical information is shared across teams to enhance communication and coordination of O&M activity.

- *Adaptability and flexibility of use case*
  CORE has been developed to be data, technology and manufacturer agnostic. This adaptability suits an evolving power system. The scope of data that can be accessed via CORE means the system can be deployed across an extensive range of use cases, including asset problem diagnosis, performance reporting and feeding the balancing mechanism.

- *Reduction in the complexity of setting up a new farm*
  It is very simple to plug in farms to the CORE system. Once a manufacturer has been set up in CORE, it is straightforward to migrate the data and include other farms that involve that manufacturer.

  Additionally, when developing new wind farms, SPR can specify IT requirements at an early stage, which has significant contractual benefits and negates the need for negotiations regarding data.

- *Increased security with a small number of secure interfaces and permission rights*
  A very secure front end has been deployed systematically across all SPR sites. By reducing the number of interfaces that can access sensitive asset data, this decreases the risk of exposure to unauthorised traffic. Unauthorised personnel are restricted from viewing or amending certain data sets through the management of user permission rights.

- *CORE serves as an excellent example of how to correlate, manage and present operational data*
  Wind farm owner/operators can improve safety, speed of response and consistency throughout their organisation by integrating their operational data. The SPR system showcased in this case study highlights some of the most important benefits and what to take into account when designing or implementing a data system to support wind farm operations

Recommended reading

National Grid general information website regarding the balancing mechanism:
http://www2.nationalgrid.com/UK/Our-company/Electricity/Balancing-the-network/

This is one in a series of offshore wind operations and maintenance (O&M)-focused case studies, supported by ORE Catapult's O&M Forum and funded by The Crown Estate and the Offshore Wind Programme Board. These studies aim to highlight game-changing O&M projects and share knowledge among the offshore wind O&M community.

Offshore Wind Programme Board   **THE CROWN ESTATE**

Author profiles

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Conaill Soraghan is a Renewable Technology Engineer at the Offshore Renewable Energy Catapult. He has a background in applied mathematics and completed a PhD in wind turbine design. Conaill's main area of interest is the management and optimisation of operational assets and he has extensive experience in the design and development of benchmarking systems and data/knowledge sharing for the offshore wind industry.

Andy Lewin, Head of Innovation Projects, ORE Catapult

As Head of Innovation Projects at the Offshore Renewable Energy Catapult, Andy Lewin heads up a team of project managers delivering collaborative industry projects including key testing, demonstration, technology development and R&D activities. A project manager with over 10 years of experience in renewable energy sector, Andy has considerable project and commercial management experience having spent 8 years at Scottish Power Renewables delivering wind farm projects and strategic business programmes. Most recently Andy has worked within major joint venture teams delivering project development and overseeing construction activities for UK offshore windfarms.

Contributor profiles

Mark Gailey, Scottish Power Renewables RCC Manager

Mark Gailey had an electronics engineering background for 17 years before moving into renewables and working with Nordex (turbine manufacturer) as Field Operations Manager. Mark moved to Scottish Power Renewables in 2008 to establish their Renewables Control Centre and take on the role of Control Centre Manager, a role that has diversified greatly over the 8 years of operation.

Disclaimer

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