Future of the Electricity National Control Centre

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nationalgridESO

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Executive Summary

The Electricity National Control Centre (ENCC) is responsible for the real-time operation of the Great Britain (GB) power system. We provide signals to the market to ensure there is always enough energy to meet the country's demand and that the system is run safely, securely and as economically as possible for the end consumers who ultimately pay for it through their bills. Our actions we take in operating the network have allowed for the decarbonisation we have seen across GB to date, we have operated with over 75% of zero carbon generation and have ran the system without coal for 1000s of hours.

As we know, the world of energy is changing. Traditionally, the bulk of our electricity has been provided by a relatively small number of large, fossil fuel power stations, each able to produce enough energy for two or three million people. Today, that's no longer the case. The number of coal and old gas-fired power stations has reduced dramatically in favour of cleaner forms of energy like wind and solar, often produced by smaller generators. That impacts how we operate the network and brings new challenges, so the ENCC must evolve to meet those challenges. This document is the first step towards engaging the industry in conversations on the ENCC's future purpose, vision and strategy, to continue to fulfil its vital role over the next five years and beyond. To understand fully why the ENCC needs to transform, we will begin by providing an overview of how we currently operate, how we make our decisions, and the tools we use on a daily basis to perform three critical functions:

- **Balancing GB's demand for energy with supply from generators 24/7.** This includes managing the Balancing Mechanism in our role as the sole residual balancer on a second by second basis to fine tune the supply/demand equation and trade with market participants to obtain the energy we need to meet the nation's demand.
- **Maintaining security of supply in Control Room time scales.** This means making sure there is enough energy by providing data to the market so that the market can deliver to meet demand and the right location in the worst-case scenario, for example during bad weather conditions, other seasonal and unexpected changes. It involves providing signals to the market and obtaining data each day, which our analysts use to forecast next day demand and longer-term trends. We must also be able to 'restart' the system in the event of a local or national black-out.
- **Maintaining the integrity of the transmission network.** Running a high-voltage network of power lines is complex. Under our licence conditions, we have to run the network within physical tolerances of the equipment on the network. Failure to do so would potentially cause equipment failure and risk public and employee safety. We facilitate and manage the provision of transmission system access for asset maintenance, breakdown repairs and the connections of new assets. We have to deliver this whilst managing the economic operation of the transmission system in a way that unlocks value for the consumers.

We intend this to be the introduction of our suit of publications considering the future of the ENCC. In subsequent publications of the chapters of this document, we will look in more depth at the issues we outline in this overview. We will also discuss the work we are undertaking and the improvements required to meet current and future challenges.

We want our industry partners to share their ideas and inform the development of our future ENCC roadmap. To deliver the energy that society relies on takes a complex combination of infrastructure, cutting-edge technology, collaboration and industry expertise. Now is the right time to ensure we have a roadmap to shape how the ENCC operates so it remains fit for purpose.

This Future of the ENCC report, part of the Electricity System Operator's suite of System Operability Framework documents, has been written to help articulate the current real time operational decisions the ESO's Electricity National Control Centre (ENCC) faces and how these are likely to change in the future.

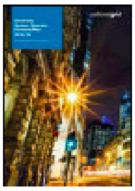
How this publications relate to the other National Grid publications below.

Creating the possible future scenerio that the system will need to accommodate

Future Energy Scenerios

A range of plausible and credible pathways for the future of energy from today out of 2050.

National Grids response to these future challenges:

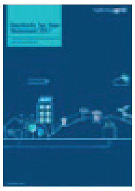


Electricity System Operator Forward Plan

This plan sets out what we will
deliver over the year.

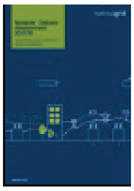
Operability Strategy Report

Outlines the operability challenges and sets out what is being done and what needs to be done to meet them.



Electricity Ten Year Statement

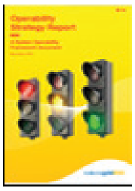
The likely future transmission requirements on the electricity system.



Network Options Assessment

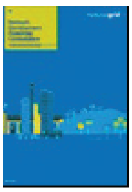
The options available yo meet reinforcement requirements on the electricity system.

While these publications go into the detail by topic area



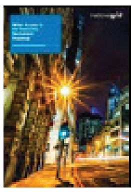
Future of the ENCC

Outlines the current and future operability challenges from a control room perspective.



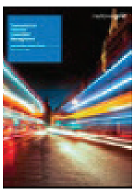
Network Development Roadmap

Proposeld on how to develop our network planning tools.



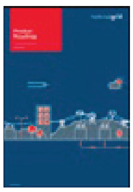
Wider Access to the Balancing Mechanism Roadmap

Our plan to widen access to the balancing mechanism.



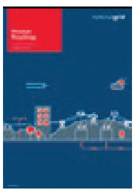
Transmission Thermal Constraints Management

Our plan for the managemnt of the thermal constraints.



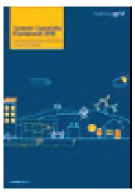
Product Roadmap for Restoration

Our plan to devop restoration products.



Product Roadmap for Reactive Power

Our plan to develop reactive power products.

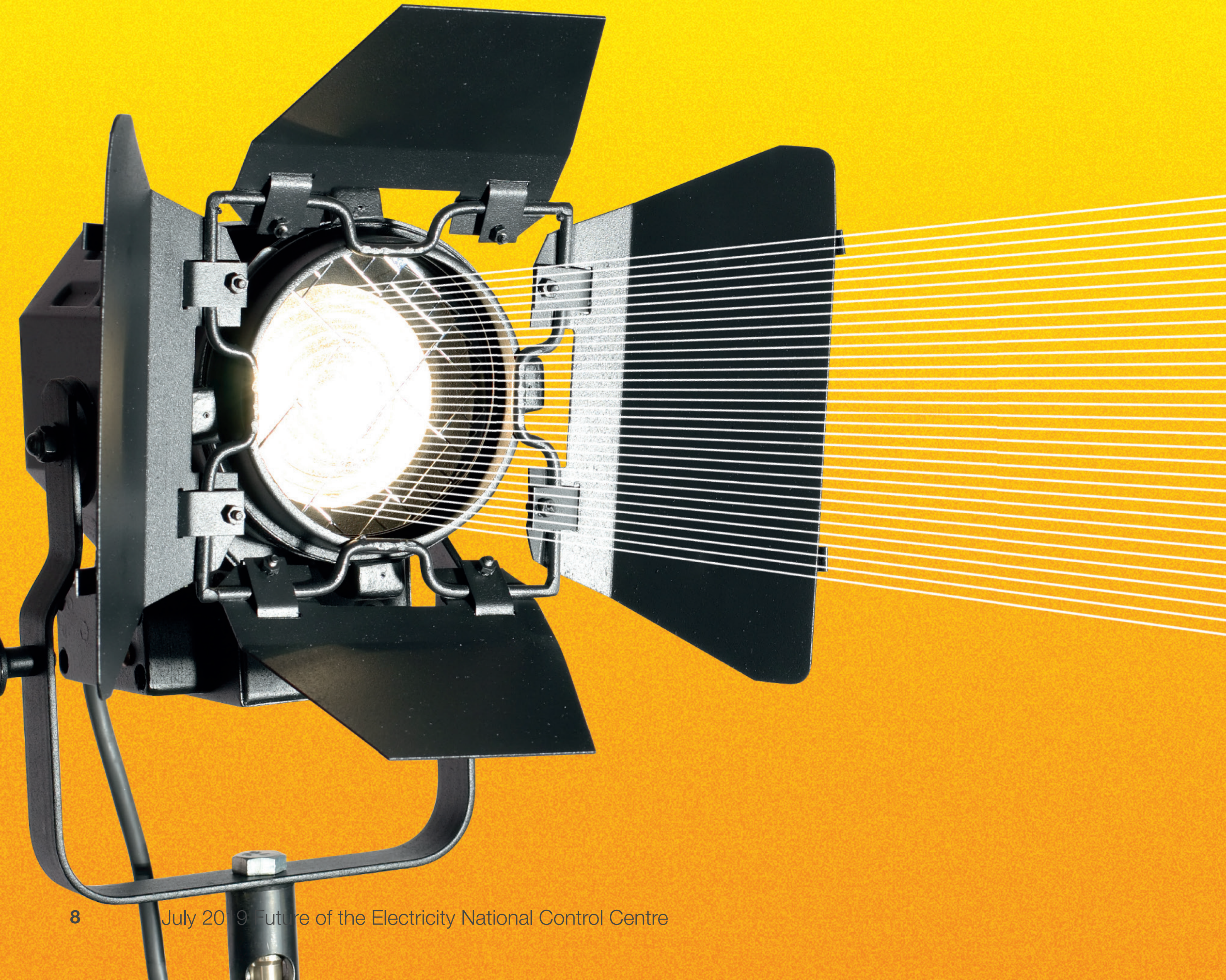


System Operability Framework

How the changing energy landscape will impact the operability of the electrcity system.

Managing System Balance and Operability

We operate the system safely and securely, whilst driving overall efficiency and transparency in balancing strategies across time horizons. Through our system operation and balancing role, we manage around £1 billion of cost per year and have held this broadly steady, despite the increasingly challenging environment.



ENCC Today

Our Role

Our aim is to be able to operate a carbon free network by 2025. In order for us to continue to operate GB's transmission network, collect and deliver energy from generators to meet the needs of homes and businesses across GB we will need to change the way we think about and operate the network in real time. We use a series of processes and tools to make sure the network is operated safely, securely and economically each and every day. We therefore support new providers and technologies to enter and compete in the existing and new markets basing our decisions on the technical capabilities of providers. To meet this ambition system operation will become ever more sophisticated and complex and we need to work with our industry colleagues to develop new tools and processes to continue to carry out our critical role.

Our Current Approach

Our power network is used by many different market participants who connect to it daily. These companies provide us with vital data which allows us to forecast how much energy GB will need each day to balance the system. We use many sources to obtain and develop a forecast of national demand on a daily basis. We ensure that the balance between supply and demand is maintained continuously by refining how much output we need from generators and how much extra generation we may need to schedule in reserve to provide short-term security margins in case of unforeseen events – such as last year's 'Beast from the East'. When we buy in these services, we use the most economical sources available. This is our duty of care and obligation to the consumer who pays for these services through their energy bills.

The market is increasingly changing to utilise significate levels of embedded generation most of which has no operational metering. These changes are leading to significant demand forecasting challenges and pollution of historical demand curves, which are critical to the day demand predictions in our current process. Day Ahead forecasts used to be good enough but are no longer as much shorter term changes prevalent due to embedded generation which responds to market and weather. To manage these significant changes in market operation and behaviour in future we are exploring other enhanced ways of forecasting demand which account for the variabilities encountered in real time. We have made some changes using Artificial Intelligence (AI) and Machine Learning (ML) but more is needed. More details on future demand forecasting will be covered in our chapter on National Demand.

In control room time scales, we refine the system outage plans to provide access to take out some parts of the network and enable connection of new users to the transmission system, and to allow access for overhaul, breakdown repairs and maintenance of transmission assets. Any outage must be planned to maintain the integrity of the system and keep the energy flowing. To provide secure delivery of electricity the outage plan is refined right up until the time the outage happens and the system is continuously monitored throughout the outage to ensure it continues to run securely. The outage plan build is done in longer planning time scales until the plan is handed over to control room at Day Ahead by our Network Access Planning business unit.

Of course, there are sometimes unexpected issues and events that impact our network. These can range from sudden transmission system faults, or unexpected loss of a generator, to sudden spikes in demand. Our role is to make sure we have the right network available and configured effectively and we can immediately respond by calling on services from our energy partners connected to our network.

If a partial or total shutdown of the national electricity transmission system were to happen - although this is very unlikely - we must always have contingency arrangements in place to enable electricity supplies to be restored quickly and safely.

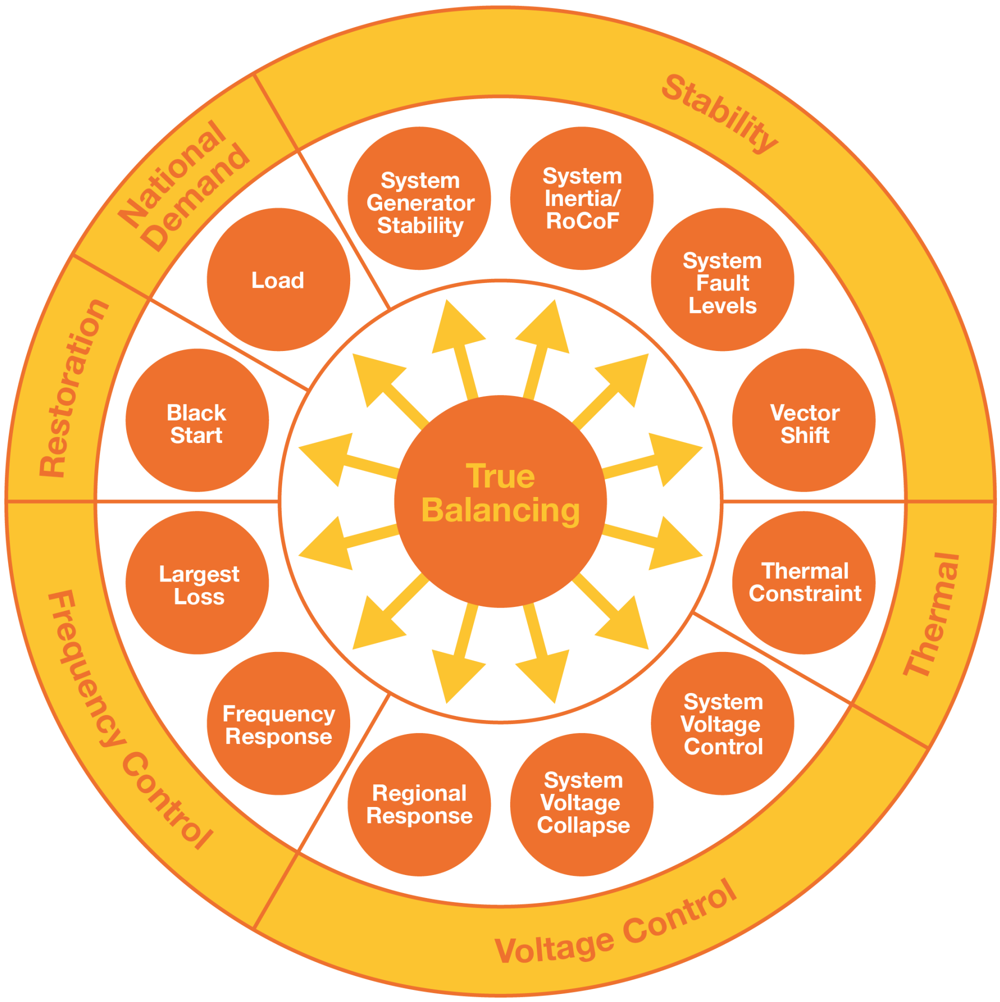
We work with other transmission system operators in Europe connected to the GB system via high voltage direct current interconnectors. This gives us access to more services, with the flexibility to increase or reduce power flows across an interconnector and resolve issues of balancing supply and demand

In a nutshell, our role involves balancing supply and demand efficiently to ensure efficient and reliable operation of the GB power system and to continually monitor and optimise the GB network configuration. There are many dimensions involved in balancing the system, as shown in the diagram on page 11.

By 2025, ESO will have transformed the operation of Great Britain's electricity system and put in place the innovative systems, products and services to ensure that the network is ready to handle 100% zero carbon. We will identify the systems, services and products we will need to run a zero-carbon network and design the new competitive marketplaces needed to source these as efficiently as possible, from both new and existing companies. We believe that by understanding the networks we operate and the services we need to solve operational challenges in real time will ultimately lead to greater value realisation by GB consumers.

Our Network: a balancing act

These form the operational challenges we solve every day and can be grouped under six key areas.



System security services

We use a number of techniques and services to help maintain the security and quality of electricity supply across Britain's transmission system.

We manage various operational challenges every day 24/7.

The techniques we use are:

buying or selling electricity in the balancing mechanism;

buying or selling electricity through trading; and entering into contracts for balancing services

optimising the configuration of the GB network

Operational Challenges

The list below briefly explains the challenges we face daily and the way we manage them.

Managing operational challenges

Demand Forecasting

- We continuously forecast how much electricity GB will need throughout each day and how much will flow through our transmission lines. We use this to maintain the balance between supply and demand minute by minute. However, this is changing as embedded generation responds to market and weather and as EV's become more prevalent.

Thermal

- Transmission lines have a rated thermal capacity we need to maintain. Too much energy in any part of the system would cause it to overheat and potentially lead to damage of equipment. So, we are constrained to run the network within certain thermal tolerances. This needs careful planning of how much energy will flow across our network, and we do this by taking account of outages on the network and other issues that might affect the network. We continuously refine our plans and monitor constraints in real time to ensure that system assets are running within their safe operating limits. As the generation becomes more variable due to changes in the weather the transmission flows on the system change as well causing significant variations to system constraints. See our transmission thermal constraints information note[1] for more information.

Voltage control

- Voltage is the 'pressure' that causes electric charges to move in electrical conductors. Maintaining the electricity system at the correct statutory voltage facilitates safe and efficient power transfer within the performance limits of the network, generation and consumer equipment. The amount of power flowing through the network affects voltage and requires the balance of power to be maintained in real-time. This is more challenging as the nature of the demand is changing and the changing flows on the transmission network can exacerbate the voltage issues. See our Product Roadmap for Reactive Power[2] document for more information.

Stability

- Stability is the system's capability to quickly return to acceptable operation following a disturbance. This characteristic of the power system is dependent on the system strength, which until today has been provided by conventional synchronous generating units. To meet this requirement in future we need to develop a system of technologies and products to replace the aging fleet of synchronous generation, and remove the reliance on them for this service.

Frequency control

- Electricity flows in waves and the number of waves that pass a given point at a given time is called frequency. Higher demand than supply will lead to low frequency and vice-versa, which could cause the system to become unstable. We need enough energy resources in reserve to cover imbalances between supply and demand caused, for example, by demand not turning out as forecast or due to generation failure. Frequency response is provided by generators that automatically react to frequency deviations caused by imbalances between generation and demand. We maintain sufficient levels of frequency response on the system to protect against the loss of the largest supply of generation or demand to avoid breaching security standards.

Restoration

- Restoration is the ability to re-energise the system after a complete loss of power. This is called a black start. Under the terms of our licence we must at all times have adequate generators in each of the black start zones on the GB system. We are exploring new ways of restarting the network using distributed energy resources through an innovative project. It is likely in the future that we will have many more smaller black providers to coordinate. Further information is available in the black start services[3] document.

These operational challenges underline both the importance and complexity of keeping our networks secure and it's one of our key focus in transforming the world of energy: how can we continue to access the critical services we need to balance the system. In real-time we optimise the procurement of these services so that we can be sure we are getting best value for the end consumer while running our network safely and efficiently. We will publish a series of documents over the next few months to consider in more depth each of the challenges identified above.

[1] https://www.nationalgrideso.com/Thermal Constraint/information note
[2] https://www.nationalgrideso.com/ProductRoadmapforReactivePower
[3] https://www.nationalgrideso.com/Product Roadmap for Restoration

Our Tools

We have developed a number of highly effective online and offline tools to help us manage the multitude of complex tasks that form the day-to-day operation of the transmission network today. Our current key tools include the Balancing Mechanism (BM) system that allows us to balance the system by accepting bids and offers in our role as residual balancer. We currently developing the Electricity Balancing System (EBS) tool for automated scheduling of generation to meet demand and reserve requirements. We use a system called the Frequency and Time Recorder (FATE) for monitoring the system frequency. We use the Supervisory Control and Data Acquisition-Integrated Energy Management System (SCADA-iEMS) system to manage and monitor the network remotely. Advanced software applications carry out real-time security analysis of the network. These include an online stability assessing tool and power network analysis tool. Other IS tools included in our suite support demand forecasting, wind output, solar forecasting and real time outturn monitor.

As the world of energy continue to transform, so too must the ENCC. We are looking to use the latest technology to future proof our operation and deliver new processes, enhanced tools and system capabilities. In the following chapters of the Future of the ENCC document, we will explore the other evolving more complex operational challenges and share our plan for the upgrade of our IT systems, processes and enhanced tools for forecasting demand, wind and solar PV. Increasing numbers of energy suppliers are looking to connect to the network to provide us with services, so we aim to enhance our capability and to be transparent in the way we operate the system and to promote a level playing field for all our customers and stakeholders.

Managing volatility in a low-inertia system

Electricity system inertia is decreasing as we transition from conventional (e.g. synchronous spinning plant) to inverter connected (e.g. wind and solar) generation, leading to faster changes in system frequency. New methods of controlling frequency need to be developed to manage this volatility.

Supporting voltage and reactive power

On the electricity network, requirements have moved from generating to absorption of reactive power, driven by lower transmission demands and increased reactive power contribution from distribution networks. We deploy system actions and buy reactive services from various providers in real-time to assist in the management of voltage during minimum demand periods.

As the ESO we will continue to explore how new technologies and commercial approaches can help support voltage across networks in the future.

Reliable and Secure system operation to deliver energy when consumers need it……...

Our selection and utilisation of resources will be transparent and based on driving consumer value – optimising across generation, storage and demand side on an equal basis.

We are transparent around data used in the ENCC and in our short-term decision making.

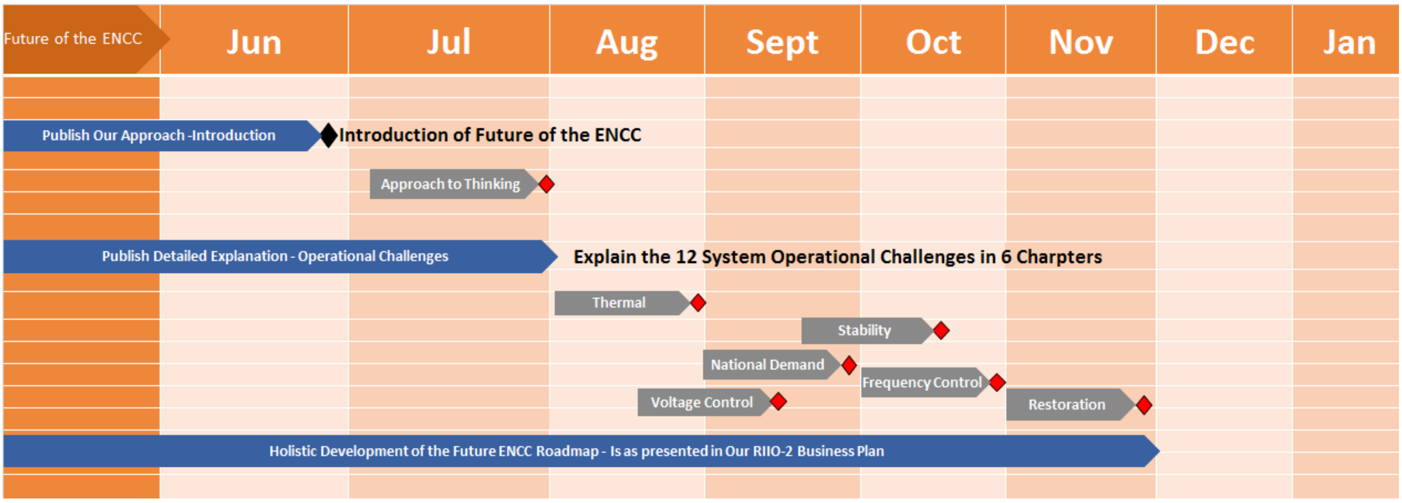
Next Steps

We have been engaging with our industry partners over the last few months and reviewing our findings based on your feedback. This has informed the development of our business plans for RIIO-2.

The timeline below shows our target dates for follow-up chapters of this publication which will provide more detailed information on the operational challenges covered in this document.

We will examine how these challenges are evolving, how they impact ENCC operations and resources today and will continue to ask for your feedback and recommendations to future proof our operations in the next five years and beyond.

Timeline



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