ES Cornwall Memorial Scholarship

Third Quarter Report

7 May 2024 to 6 August 2024

National Grid Electricity Transmission, Warwick, United Kingdom

by

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THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

Acknowledgements

I would like to express my sincere gratitude to the following pillars that have played a pivotal role in shaping my personal and professional journey.

I would like to first express my sincere appreciation to Powerlink Queensland for their steadfast support, allowing me the opportunity to continue my development overseas. The encouragement I have received from my colleagues and their belief in my capabilities have been pivotal to my professional journey and my decision to pursue the ES Cornwall Memorial Scholarship.

I extend my sincere thanks to the ES Cornwall Memorial Scholarship Committee for their backing and support. Being chosen as an ES Cornwall Scholar provided the platform for me to pursue my professional aspirations in overseas electricity networks. I hope to learn as much as I can while I am abroad and make the most out of this amazing opportunity. I endeavour to capture as much of my learnings in my reports as I can.

I extend profound thanks to National Grid Electricity Transmission for providing this incredible opportunity to work on the latest and greatest challenges in the UK power system. The chance to contribute towards system-defining projects is both exciting and rewarding, and I am grateful for the trust and confidence you have placed in me.

I am deeply grateful for my family and friends, Ji Ni especially, whose unwavering support, encouragement, and understanding have been my constant motivation. Their belief in my abilities has been a source of strength throughout this journey.

I am deeply indebted to my mentors, Jonathan Dennis especially, for their invaluable guidance, wisdom, and unwavering support. Their mentorship has been instrumental in shaping my perspective, navigating challenges, and unlocking my potential. Jonathan who had encouraged me to apply for the ES Cornwall Memorial Scholarship over the years had truly set things in motion for me. I am truly fortunate to have had the pleasure of their company on this journey.

I extend my gratitude to The University of Queensland for providing a solid foundation of my skills and knowledge. The learning experiences gained there continue to contribute significantly to my professional endeavours. A special thanks to Professor Tapan Saha for his time as my thesis supervisor and his lessons as my Power Systems lecturer.

Each of these elements has contributed greatly to my journey. I extend my sincere appreciation for the collective support, trust, and opportunities that have shaped my path and fuelled my continued growth.

Executive Summary

Queensland's electricity system is undergoing a transformative shift towards cleaner, renewable energy sources. The ambitious Queensland Energy and Jobs Plan (QEJP) sets out a clear roadmap to drastically increase the share of renewable energy in the generation mix. This transition is underpinned by a new 500kV backbone and supported by significant investments towards new wind and solar projects, grid-scale batteries, and advanced pumped hydro storage facilities. The QEJP will reshape Queensland's energy landscape by phasing out coal-fired power generation, which has traditionally been a significant part of its electricity supply.

During this transition, I believe that Queensland can benefit from learning how other transmission system operators are developing their network, policies, performance requirements and control practices to facilitate the connection of inverter-based resources.

This report provides an overview of my experience during the third quarter of the ES Cornwall Memorial Scholarship. In November 2023, I began my placement at National Grid Electricity Transmission (NGET) in Warwick, United Kingdom in the Future Network Blueprints team. In my first and second quarter, I was tasked with developing the Regional Strategies for the business with an increasing focus placed on price control requirements as the project matured. While I still retained my key responsibilities in the Future Network Blueprints team, my role transitioned into a Power System Engineer in the Network Development division during the third quarter of my placement at NGET.

During my third quarter at National Grid Electricity Transmission, I shifted into the Strategic Network Planning (SNP) team in the Network Development division as Power System Engineer. The SNP team is responsible for determining the maximum power transfer across planning boundaries and developing network solutions for boundary constraints. The effectiveness of any network changes is determined by comparing the boundary uplift as a result of the upgrade against the baseline study. In the England and Wales network, thermal and voltage stability is accepted as the limiting factor for the network. Rotor angle stability is not a strong consideration as pole slipping is not considered to be a feasible network condition due to the heavily meshed system.

I however, was not yet finished with the price control related work. Distribution Network Operators (DNOs) manage and operate the regional infrastructure that distributes power supplied by NGET. During this quarter, I was part of a team that arranged and held meetings with each of the six DNOs to discuss, review and coordinate investments and strategic requirements between industry parties. These meetings revealed the need for additional communication channels between companies to facilitate the sharing of business plans that are early in development to better enable better the coordination between network operators.

The UK power system introduced Demand Flexibility Services (DFS) in 2022, which is a mechanism aimed to incentivise domestic consumers and industrial and commercial users to voluntarily reduce or flex their demand. Although successful initially, DFS faced a number of challenges that limited participation. Four key areas focus areas were identified during the DNO engagement meetings. The implementation of DFS in the UK was limited by fundamental market characteristics, revenue risks, administrative and procedural barriers to entry.

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Glossary

NAME	DESCRIPTION
AC	Alternating Current
AO	Asset Operations
CC	Customer Connections
CFD	Contract For Difference
DFS	Demand Flexibility Services
DFES	Distributed Future Energy Scenarios
DNO	Distribution Network Operator
DV	Delivery Vehicle
EISD	Earliest In-Service Date
ESO	Electricity System Operator
ETYS	Electricity Ten Year Statement
FES	Future Energy Scenarios
FNB	Future Network Blueprints
FSP	Flexibility Service Provider
HND	Holistic Network Design
HNDFUE	Holistic Network Design Follow Up Exercise
HVDC	High Voltage Direct Current
IDD	Infrastructure Development and Delivery
ND	Network Development
NESO	National Energy System Operator
NGESO	National Grid Electricity System Operator
NGET	National Grid Electricity Transmission
NOA	Network Options Assessment
OFGEM	Office of Gas and Electricity Markets
PPA	Power Purchasing Agreements
QEJP	Queensland Energy and Jobs Plan
RCM	Regional Connections Manager
RIIO	Revenue = Incentives + Innovation + Outputs
SI	National Grid Strategic Infrastructure
SNP	Strategic Network Planning
T3	Price Control Period 2026-2031
TCSNP	Transitional Centralised Strategic Network Plan
TO	Transmission Owner
TSO	Transmission System Operator
UK	United Kingdom

1 Background

My third quarter report builds on the information provided in my previous reports and details my learnings between May and August 2024. During this period, I remained at National Grid Electricity Transmission (NGET) as a Regional and Site Strategy Engineer. My role this quarter gradually transitioned from a strategic role, responsible for supporting the price control submission, into a power systems engineer role that is responsible for studying the technical capability of the England and Wales transmission network.

During this quarter, the price control team hosted engagement sessions with the six Distribution Network Operators (DNOs) across the English network to receive feedback on the NGET price control plan. Conducting these engagement sessions were part of a movement within NGET to better understand stakeholder ambitions to enable better coordination between businesses. The feedback and insights captured in these meetings were fed back into the price control submission. I was responsible for running the engagement sessions, and managing the resulting outcomes.

While abroad, I intend to develop an understanding of how the UK is evolving their network, performance requirements and policy to facilitate the connection of new renewable generation. My transition into the Strategic Network Planning team gave me the platform needed to better recognise the considerations and processes taken to develop a network plan at NGET and provided the opportunity for me to advance my technical capability.

2 Projects

2.1 Price Control

For the upcoming price control period, the energy regulator Ofgem is holding NGET to a higher standard. An increasing focus has been placed on planning the network based not only on factual evidence but also around uncertainty. The regulator wants to understand the meaning and need behind the investment proposals and would like NGET to demonstrate that all considerations have been accounted for; from the asset level up to the system level, and across the energy landscape.

2.1.1 Engagement with Distribution Network Operators

Distribution Network Operators (DNOs) play a crucial role in the electricity supply chain, managing the regional infrastructure that distributes electricity from the national transmission grid to end consumers, including homes, businesses, and public facilities. DNOs are essential in supporting the integration of renewable energy sources, such as wind and solar, into the grid by managing decentralized energy flows and balancing local supply and demand. Close collaboration between the DNOs and TSO is necessary to ensure the efficient delivery of long-term national energy strategies and infrastructure investments.

Meetings were arranged with each of the six Distribution Network Operators (DNOs) to discuss and review the strategic requirements of both parties for the upcoming price control period. As described in the second quarter report, the key aims were to:

- Identify areas of the network where more supply points to the distribution network are required;
- Develop an early understanding of DNOs requirements and ambitions around new NGET sites;
- Build a "whole system plan".

These meetings provided an early opportunity to present NGET's preliminary price control plans to the DNOs while the plans were still adaptable. In creating a platform that considers DNO inputs in transmission planning decisions, it is hoped that these meetings will result in a better designed network.

A number of common discussion points were raised by the DNOs during these sessions.

- DNOs have raised interest in diverting routes of strategic infrastructure projects to feed their network in order to maximise the value new schemes can bring;
- Extreme fault levels on the DNO network are of significant concern due to the rising volume of local generation and an increasingly meshed network;
- There is an understanding that the distribution network will require a revolutionary change to facilitate the transition to net zero.

2.1.1.1 Post Engagement Actions

Following the initial engagement sessions where high level concepts and problems were discussed, breakout sessions with the necessary personnel were set up to address specific topics raised during the sessions. The knowledge gained in the initial sessions were fed back into the business, bringing attention to further considerations that the NGET must account for in their price control submission.

In addition to discussion around network planning and strategy, these engagement sessions brought to light areas needing further consideration by NGET. The sessions offered insights into the system gaps that exist in the industry, described in Table 1.

Table 1 –DNO Session Key Takeaways

1	**Better channels of communications than what exists currently is required.** The current information transfer framework between network operators is defined by the UK Grid Code. The Grid Code dictates that information must be at a relatively mature state before it is permitted to be shared through official channels. Well-developed projects are generally less flexible to change and can lead to overdevelopment if projects between network players are not coordinated properly. A mechanism is required to allow for the sharing of more speculative information to enable to development and coordination of plans at an earlier stage.
2	**The model and schemes shared between TSO and DNO require improvement.** The system models provided by the Electricity System Operator are known to have an imprecise distribution network model. The engagement sessions have identified differences between the distribution network model used in studies by NGET and the model used by the DNO. Similarly, the DNOs do not have access to models of the transmission network changes that NGET has planned. The state of the industry has left different companies planning for different networks.

	The DNO engagement meetings have restarted the discussion on the need for a concerted effort to bridge differences in simulation models between the businesses.
3	**Increase focus must be placed on studying the impact of transmission level changes on DNO network.** The DNOs have identified that NGET's strategic plans will have a significant impact how the distribution network is operated. The studies NGET conducts to assess the impact of transmission level changes on the distribution network are no longer sufficient due to the extent of the impact incurred by transmission network changes. It is recommended that DNO specialists be brought into the transmission planning process to ensure a balanced perspective is heard.
4	**The sharing of outage plans to maximise outage value.** The transmission owners often have more limiting outage plans that are only shared with the DNO at a relatively short notice before the outage is taken. In order to maximise the outage value by coordinating maintenance work on the distribution network during the transmission outage, outages plans to be shared further in advance.
5	**NGET requires a better understanding of the distribution requirements in shared switchyards.** Developing a better understanding of stakeholder requirements can result in better coordination during the development and delivery of a project. Furthermore, understanding distribution requirements can strengthen business cases resulting in more funding that will mutually benefit both the DNO as well as NGET.

2.2 Strategic Network Planning

During the second quarter of the ES Cornwall Memorial Scholarship, I have been negotiating with my managers to gain more direct exposure to the work in the Network Development team. I believed that the work carried out by this team better aligns with my interest as well as my ES Cornwall. Now in the third quarter, the negotiations have finally come to fruition with responsibilities will shifting to the Strategic Network Planning team as the workload in that team reaches a peak.

2.2.1 Team Structure

The Strategic Network Planning team is located under the Network Development division. Network Development (ND) sits within the Infrastructure Development and Delivery (IDD) Delivery Vehicle (DV). ND is responsible for outage and strategic planning functions in addition to network model development and power systems performance analysis on behalf of the entire business.

The Network Planning team was recently restructured to give the leadership team better visibility of workload and thus improve allocation of resources. Reflected below in Figure 1, Network Development was subdivided into the System Transformation team, the Network Services Team and the Power Quality and Dynamic Performance Team.

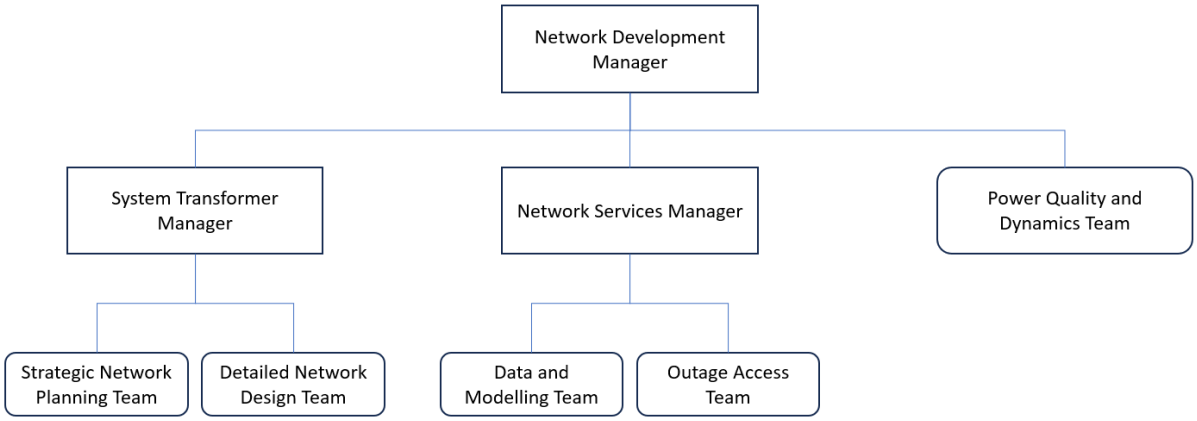

Figure 1 - Network Development Structure

The System Transformation team is responsible for the development the network to ensure the network remains capable of delivering net zero. The Strategic Network Planning team that I have moved into is one of the teams that sits under the System Transformation Manager.

The Network Services team is intended to be the customer facing side of Network Development, where requests from across the business are processed, allocated and managed. Network modelling and outage planning functions are performed under the Network Services manager with dedicated support from a scheduling assistant.

The Power Quality and Dynamic Performance (PQDP) team is a standalone team under Network Development. The team has remained separate to allow it the freedom to grow and function across different parts of the business. PQDP is primarily responsible for conducting harmonic studies, control interaction studies and any modelling in PSCAD.

2.2.2 Power Systems Studies

National Grid Electricity Transmission is faced with a myriad of challenges inherent to the dynamic energy landscape. These challenges span from the fundamental need to modernise aging infrastructure to the intricate demands of transitioning towards a sustainable, resilient, and digitally connected energy future.

From a power systems planning standpoint, changes to the network are underpinned by the understanding of boundary constraints and short circuit levels in the England and Wales network. Should any part of the network require uplift, the two aforementioned factors would be closely considered through every stage of study.

2.2.2.1 Boundary Studies

Managing power flows and the thermal capacity of the network is one of the key focus areas for National Grid Electricity Transmission . To reach Net Zero by 2050, National Grid Electricity Transmission is investing in their network and in new infrastructure to increase capability across key planning boundaries. The NGET planning boundaries are shown in Figure 2.

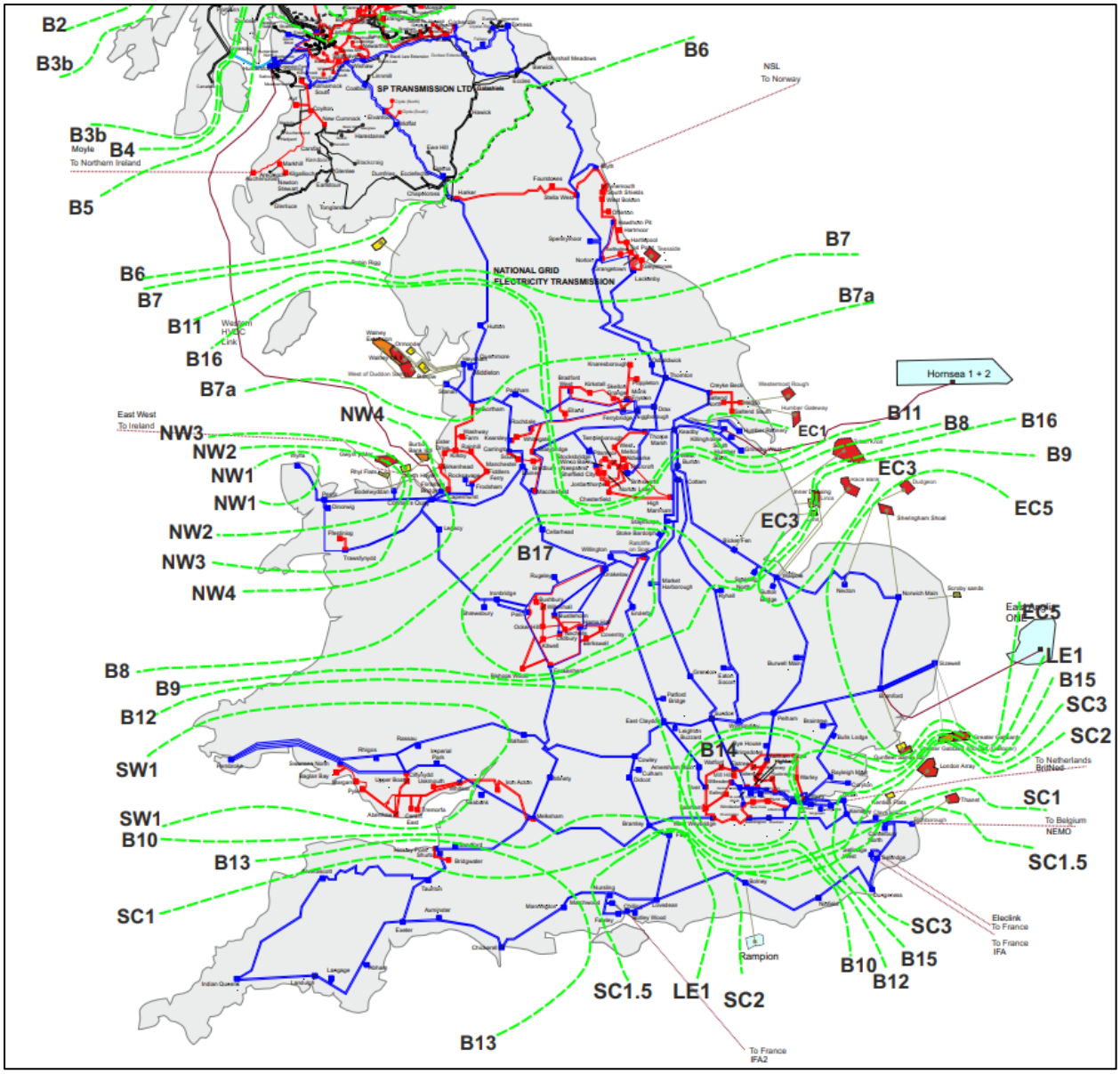

Figure 2 – England and Wales Planning Boundaries

Boundary studies are performed to evaluate the maximum power transfer from one side of the boundary to the other. In the Queensland transmission context, this can be likened to the maximum transfer for a set of circuits running between the bubble zones. The effectiveness of any network change is evaluated by comparing the boundary capability of the network with the proposed changes in against a baseline case.

In the England and Wales network, thermal and voltage stability is accepted as the limiting factor for the network. As a consequence, the boundary studies focus on thermal and voltage limits in the system. Rotor angle stability is not yet considered as part of these studies as pole slipping is not considered to be a feasible network condition due to the heavy meshing of the network.

A boundary study is performed in three key phases. The setup phase, and the execution phase and the post-fault action.

Setup Phase

In the setup of the study case, a number of actions are performed.

- Define network boundary
  Boundaries are generally predefined by the ESO so it is a matter of selecting the boundary of study in the modelling software.

- Define credible single and double circuit contingencies
  Contingencies that could potentially result in the largest reduction in boundary transfer capacity were selected and added to the study case. Generally, these contingencies are limited to being two or three substations away from the boundary.

- Prepare generation and HVDC dispatch
  HVDC interconnectors in the UK have a significant impact on the network flows and thus network conditions. For boundaries close to HVDC interconnectors, the impact of both import and export conditions on the boundary limits are investigated.

- Set transformers, Quadrature Boosters (QBs) and Smart Wires to their nominal (or normal operating) taps
  Pre-fault tapping changes are generally limited to assets that are two to three substations away from the boundary. This limit is imposed as changes to the initial conditions of one boundary will also impact nearby boundaries. Consequently, changes to the network is limited to plant close to the boundary.

- Reactive plant that in service at the intended study date is switched in or kept on hot standby

If determining the boundary uplift is the objective of the study, any proposed changes to the network would also be added in the setup phase.

Execution Phase

Boundary studies at NGET are conducted in PowerFactory using a pre-written script. The script controls flow across the boundary by scaling the generation on each side of the boundary being studied.

The contingencies defined in the setup stage are applied independently and the consequent thermal loading and bus voltage is assessed against the Security and Quality of Supply Standard (SQSS). The contingency that results in a breach of the SQSS at the lowest boundary flow is considered to be the limiting contingency prior to any post-fault action.

Post-Fault Action

NGET allows a number of post-fault actions to be taken when determining the boundary transfer limits. Generally, these post-fault actions are limited to:

- The switching of any passive reactive plant (capacitor banks and reactors), and;

- The tapping of transformers and quadrature booster, up to a maximum of two transformers of quadrature boosters.

The post-fault actions are applied only to the limiting contingency. An effective post-fault action for one contingency may raise its boundary capability beyond that of the next most-limiting contingency. A new set of post-fault actions is then be applied to the new limiting contingency.

The boundary capability is determined by repeating this process until the transfer capability of the boundary cannot be improved even following the post-fault action.

2.2.2.2 Short Circuit Analysis

The England and Wales is well meshed with parts of the network having up to six 400kV double circuits existing in parallel. The result of this is a low overall system impedance and high fault levels.

High fault levels are a significant concern in the transmission network. NGET have traditionally employed five strategies to manage elevated fault level.

1. Increasing substation equipment ratings
   Substation bay equipment ratings have gradually moved from 50kA up to 63kA, with discussions for 80kA in the future for well interconnected sites.

2. Operate substations with split buses
   National Grid Electricity Transmission sites are typically laid out in a mesh (ring bus) or double bus, single breaker arrangement.

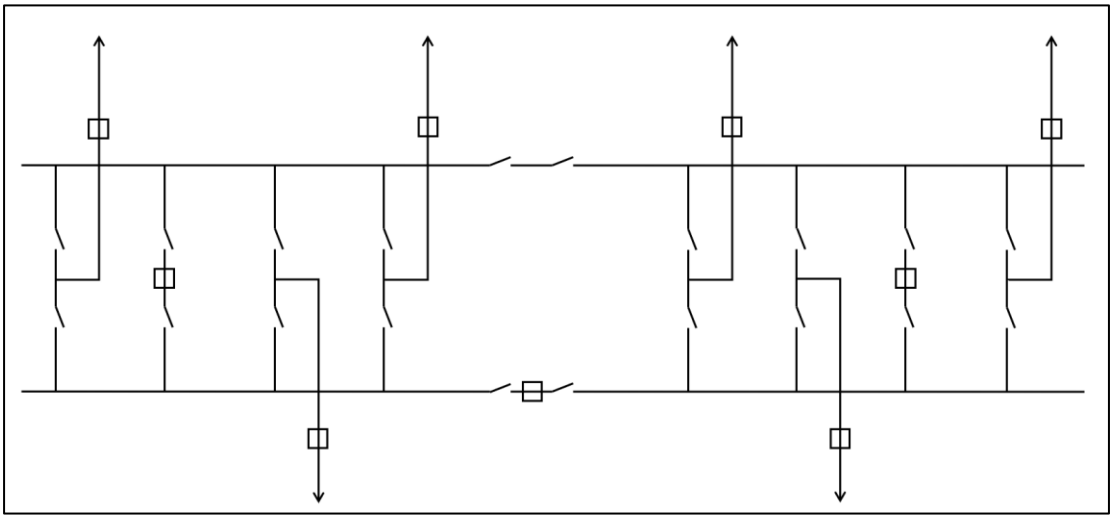

Figure 3 - Typical Double Bus, Single Breaker Single Line Diagram

   Double bus, single breaker sites in the England and Wales network are operated in two distinct ways. Sites are either run solid, with all circuits and buses connected electrically, or run split, with different circuits electrically separated. A split substation is the second method employed by NGET to decrease fault levels, as it reduces network interconnection and increases the overall system impedance.

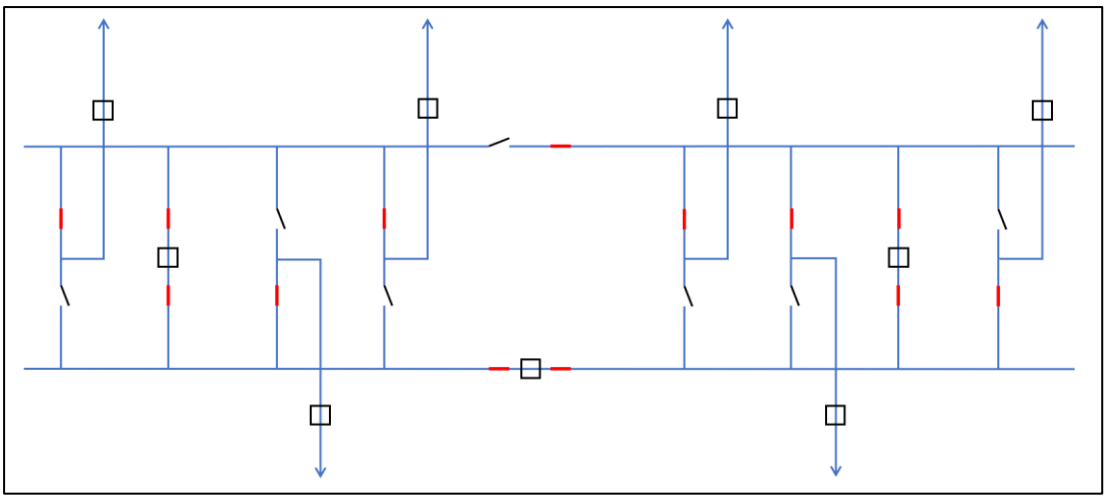

Figure 4 - Double Bus Site Run Solid

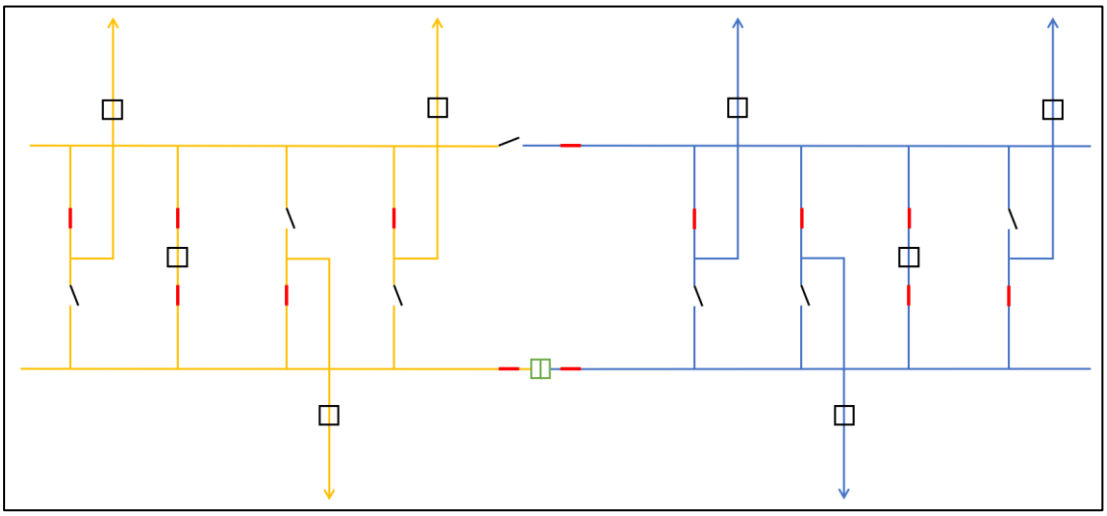

Figure 5 - Double Bus Site Run Horizontal Split

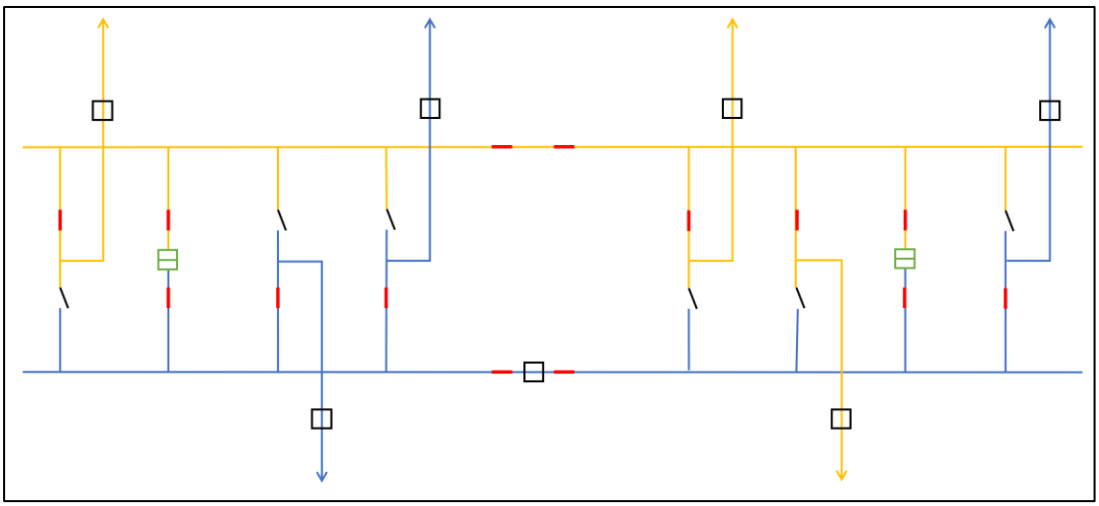

Figure 6 - Double Bus Site Run Vertical Split

NGET utilises the disconnectors to great effect, allowing changes to the substation operating arrangement to be made while energised. Although this would shorten the

life cycle of the plant, this type of switching does not occur often and consequently has not been deemed to have a significant impact on the life cycle of the disconnector.

The additional operability provided the operating arrangements gives operations staff more control of the network power flow, adding to the range of mitigating actions.

3. Operating transformers on hot standby
   If putting all transformers in service elevates LV fault levels to beyond the equipment ratings, a transformer may be run into hot standby. This allows the transformer to immediately come into service following a network disturbance.

4. Neutral Earth Resistors
   A proven technology known to reduce fault impedance.

5. Switching out circuits
   Not commonly used to manage fault levels, but is considered as part of the business' voltage management strategy.

The execution of the short circuit analysis itself is unremarkable. The maximum fault level case is set up with all generators online and outputting at no to low MW values.

The one tool note is built into the NGET edition of the PowerFactory software. The *Fault Level Infeed Programme* (FLIP) report tool creates a report that details the sub-transient and transient fault level contribution from the network. The FLIP report identifies the key short circuit current contribution from all nearby cricuits. This report is a useful tool when devising a fault level management strategy as it accelerates the identification of key fault level contributors at a given bus.

3 Other Learnings

3.1 Demand Flexibility Services

In 2022, the ESO launched a new Demand Flexibility Service (DFS) for the winter period which rewarded households and businesses that shifted their electricity use during DFS events. Over 1.6 million households and businesses participated in supporting the ESO balance the grid at peak times. Approximately 97% of participants over this period were household customers responding to aggregator signals.

The DFS aimed to incentivise domestic consumers and industrial and commercial users through suppliers/aggregators to voluntarily reduce or flex their demand. The DFS has been viewed as a pioneering initiative, lowering the entry barrier for households and businesses to participate in a flexibility market. Currently, DFS is only available for planned outages.

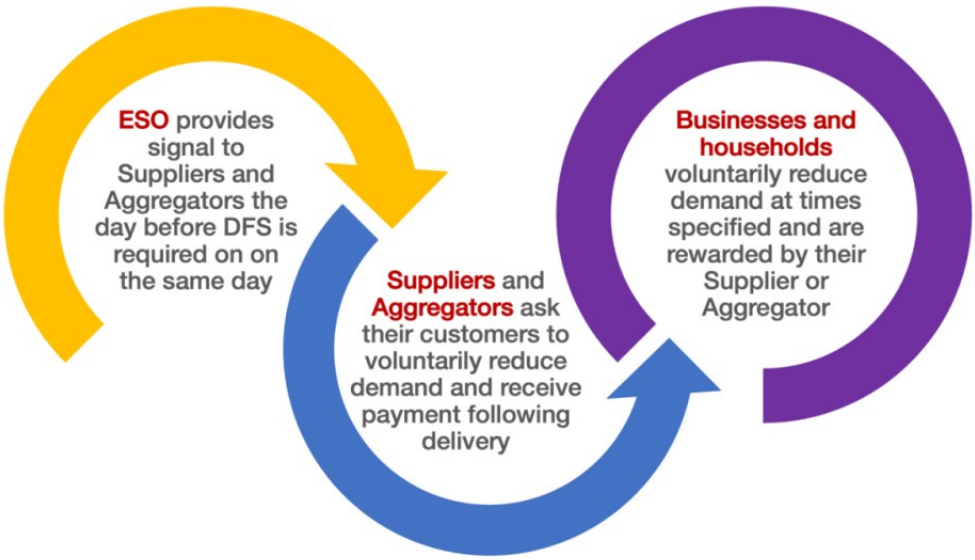

Figure 7 - Demand Flexibility Flowchart

The DFS extends beyond demand reduction incentives. In 2023, energy retailer and technology company Octopus Energy in a partnership with UK Power Networks, the country's largest electricity distribution network operator, to offer households free energy to help the grid consume excess renewable power. Octopus sent customers a notification of the times they can power their homes for free a day in advance, based on UK Power Networks' forecasts.

Octopus Energy is a market leader in consumer participation in the UK. Octopus Energy has made participating in DFS easy for consumers by providing a straightforward process for customers to sign on and take part.

- Customers with smart meters are eligible to sign on to Demand Flexibility Services.
- Notifications for a demand response are sent out to customers in advance who can choose to accept or decline the notification
    - Customers are not penalised if they do not provide a demand response, even if they have accepted the notification.

- Customers are able to reduce their electricity demand over the prescribed period are paid out by Octopus.
- Advanced users with electric vehicles can install a retail API in their electric vehicles to enable intelligent charging.
    - Octopus Energy designates charging timeslots for each participating vehicle to ensure demand remains steady during the off-peak period.

With the help of an aggressive marketing strategy, Octopus Energy has already made itself known to most if not all of my peers outside the energy industry.

3.1.1 Challenges to the Uptake of Demand Flexibility Services [1]

In 2023, following the initial success of the Demand Flexibility Services, a report was commissioned by Scottish Power Energy Networks (SPEN), the Distribution Network Operator supplying Liverpool and Northern Wales, to understand the challenges faced by Flexibility Service Providers (FSP) participating in DFS.

The report identified 13 barriers which have been categorised into four main areas that the distribution owners, regulator and policy makers can focus their efforts to increase participation. As shown below, the four key areas are fundamental market characteristics, revenue risks, administrative and procedural barriers to entry, and difficult of making longer-term commitments.

Figure 8 - Barriers Faced by Flexibility Service Providers

Fundamental Market Characteristics

Fundamental Market Characteristics are barriers that likely need to be changed at the regulatory and policymaking level. These market characteristics interact heavily with all other main areas.

The first barrier is that the DNO flexibility market is **locational,** where only FSPs with assets located in specific constraint locations can access the revenues from services tendered in that

location. Some constraint locations are situated in areas that are very sparsely populated with limited-to-no generation sources, making it particularly difficult for FSPs to secure sufficient flexibility resources in those areas.

The second barrier identified is that the DNO flexibility market is **inter-temporally transient**. The DNO flexibility market is unlikely to be able to support flexibility assets for their entire lifetime. As a result, while a constraint in a particular location may require a flexibility solution for a given amount of time, there may come a point when the network needs to be reinforced anyway. As a consequence, FSPs may find it difficult to secure long-term revenue streams.

Thirdly, the DNO flexibility market is **perceived to offer low revenues**, both in absolute terms and relative to other markets such as the Balancing Mechanism, various ancillary services tendered by the ESO, or the wholesale market that FSPs can also participate in. Thus, FSPs are less likely to make great efforts to participate in DFS compared to higher revenue alternatives.

Revenue Risks

Although four barriers have been depicted in Figure 8, SPEN only considered two to be of high importance.

Utilisation risk refers to the risk that an FSP is not dispatched after it has declared itself available to provide a DFS. Under the current market framework, most if not all of the revenue is generated through utilisation payments. If an FSP sets aside capacity but is then not activated, no revenue is generated. The ESO has partially mitigated this risk by publishing the expected levels of utilisation for a particular product.

The second high-importance barrier is that it is not always possible to **stack revenues across different flexibility markets.** There is an opportunity cost to participation. FSPs risk losing out on alternative revenue streams when they bid into DNO flexibility markets. In combination with the utilisation risk, participation in DFS is comparatively less attractive.

Administrative and Procedural Barriers to Entry

Of the four barriers, three have been declared to be of high importance by SPEN.

Up-front frictions that prevent new entrants from tendering disincentivises new players from bidding into the DNO flexibility markets. The primary frictions are

- The pre-qualification process, that FSPs have to undertake for each DNO and the ESO before they can participate;
- A lack of a consistent framework approach to the signing of flexibility contracts. The contracting process is lengthy and complex, and contracts can take a very long time (e.g. several months) to sign. As new contract needs to be signed for each product after each tender, administrative costs can be very high.

- A lack of historical or forecast market data makes it difficult for FSPs to value the opportunity presented in bidding into the DFS market

Fewer FSPs bid into flexibility tenders because they **lack of knowledge about the flexibility markets** function. It is expected that this barrier will self-remedy as the industry becomes familiar with the markets.

The third high-importance barrier is **the wide range of APIs that FSPs need to use**. FSPs need to connect their assets to a non-standard range of APIs provided by the DNOs. Currently a tendering program call Picolo is being developed to standardised one component of the supply chain.

Difficulty of Making Longer Term Commitment

Long lead times from tender to delivery mean that FSPs need to make long-term pricing commitments. These long-term pricing commitments are at odds with the trends in ESO flexibility markets, which have been moving towards real-time procurement of flexibility. As shown below in Figure 9, that the market median time from tender to delivery is 5 years.

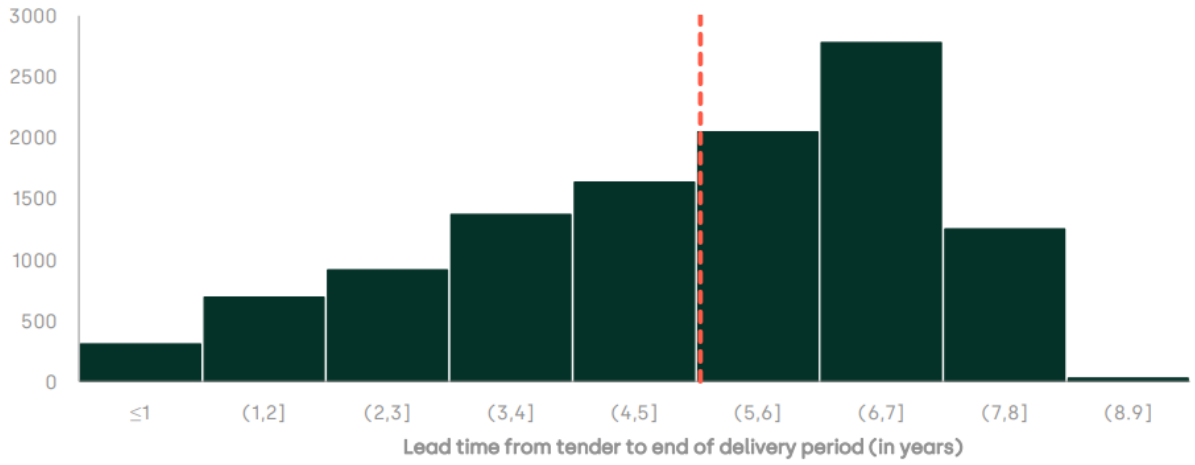

Figure 9 - DFS Lead Time

Most assets are domestic and EV Aggregators and it is difficult to determine capacity in long timeframes. This may lead to FSPs under-bidding the volumes of assets that they can provide, meaning that their revenues are lower than they would. In some instances, FSP have withdrawn from the process because they were not about to recruit sufficient resources. Tenders conducted closer to the date would give FSPs more certainty over their available resources.

Deciding the availability of assets in advance is challenging for domestic and EV Aggregators, particularly when it comes to smaller constraint locations. When a constraint location is relatively small, domestic and EV Aggregators are unlikely to have many assets located in it. This makes it harder to forecast whether the domestic customers that the Aggregator has contracted with will turn down their consumption, or whether an EV owner will be charging their car at that particular point in time, forcing the FSP into making conservative decisions.

The 13 barriers for FSPs were evaluated based on their importances and tractability to establish priority, difficult and low importance areas of work in Figure 10.

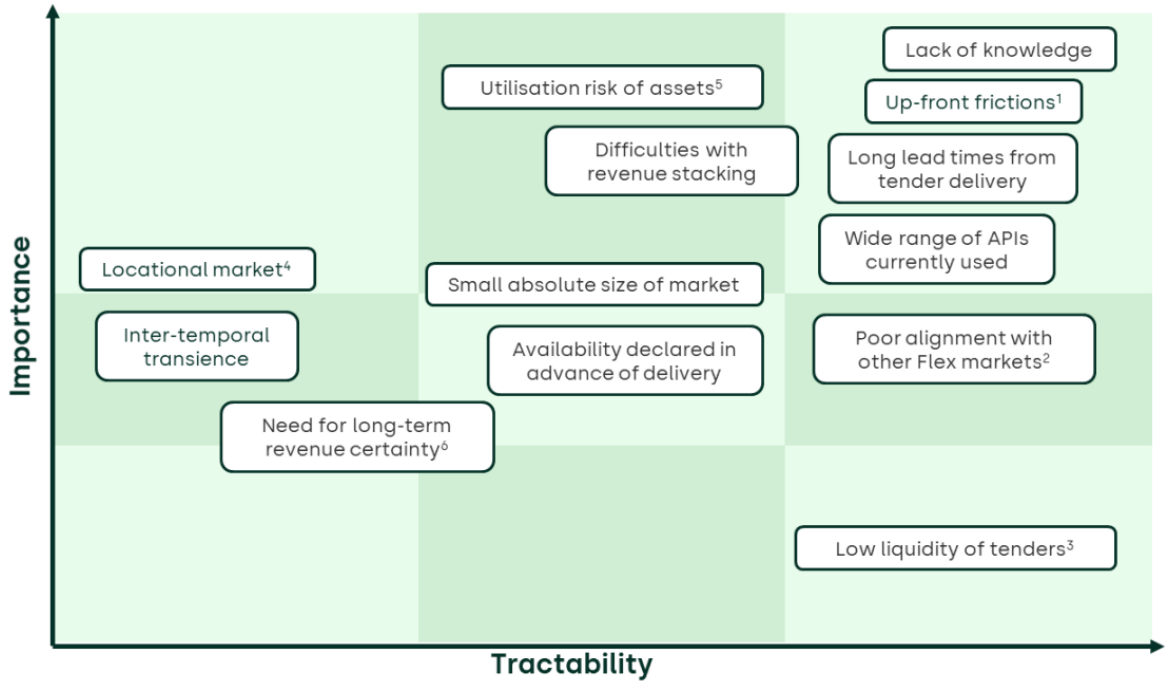

Figure 10 - FSP Barrier Categorisation

3.2 Distribution Innovation Projects

3.2.1 Realtime Fault Level Management

The increasing number of generation connected to the network have resulted in high fault levels in both the transmission and distribution networks. As a consequence, the system operator and distribution owners must better manager their network to keep fault levels within the capability of their network.

SPEN have been utilising real time fault level to provide network visibility. A fault level monitor is installed in a standalone cubicle and fault level information is generated through the measurement of a number of very small artificial perturbations over a short period. Real time fault level monitors are said to be effective in combating problems and constraints in both high and low fault level networks.

3.3 Adaptive Planning Mechanism from OFWAT [2]

Part of National Grid Electricity Transmission's process of renewing their strategic plans is to understand how comparable companies and industries are approaching their strategic challenges. OFWAT, the Water Services Regulation Authority, is responsible for the regulation of the privatised water and sewerage industry in England and Wales. OFWAT has published a document that provides a guideline for how businesses in the sector should develop their long-term delivery strategies.

OFWAT introduces a strategic approach called *Adaptive Planning*. This approach makes use of *adaptive pathways* which are intended to optimise the timing of key decision and interventions, while minimising the risk of stranded assets. Adaptive pathways should establish what activities are needed now, and where decision points can be scheduled in the strategy, when there is likely to be greater certainty about what is needed. It can also help consider when to bring forward investment and when to invest to create flexibility.

OFWAT stresses the importance of delivering a strategy flexible and robust enough to cope with changes in circumstances over time. Large capital investments made on the basis of uncertain assumptions about the future may lead to the underutilisation of new investments. Despite the likelihood of large solutions being the most efficient solution, the focus of adaptive planning is to correctly time incremental investments. The adaptive planning approach can facilitate the delivery of solutions that more closely reflects the required capability, reducing the risk of gross overinvestment as shown Figure 11.

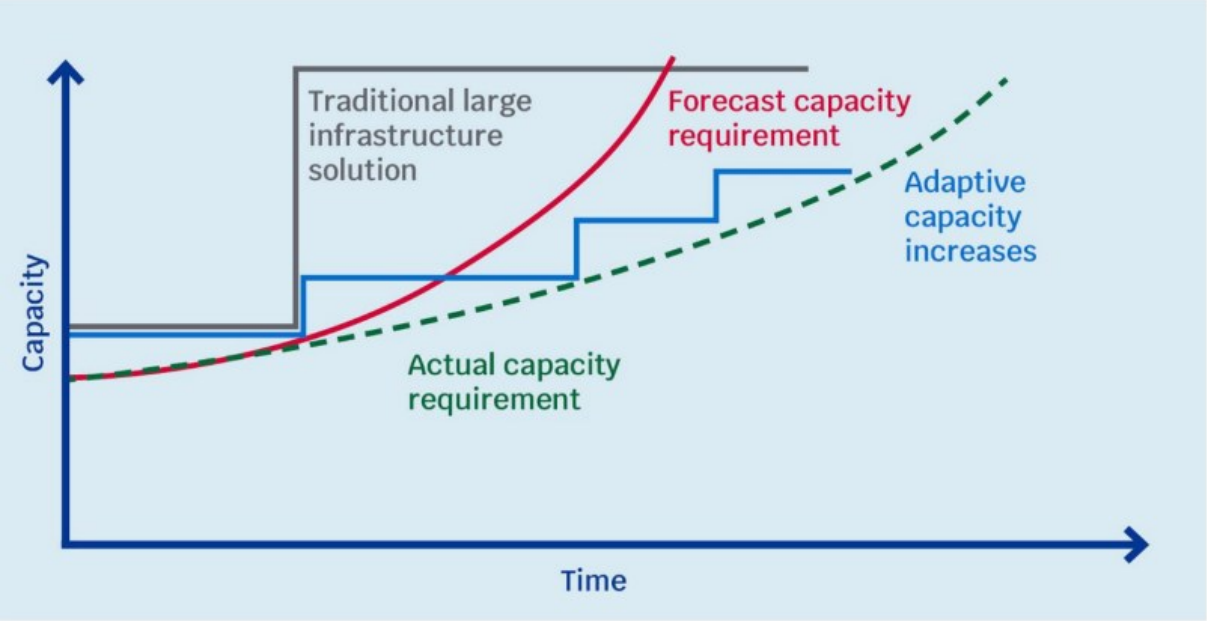

Figure 11 - Adaptive Solutions

Figure 12 presents an example of how an adaptive planning strategy may impact system capacity. An adaptive planning strategy sets up a core pathway of enhancement strategies and a number of alternative pathways that can be taken. The core pathway should be consistent with best practice adaptation techniques and should include all activities that need to be undertaken to be ready for all plausible future scenarios. Where investments do not meet the core scenario criteria, but are important for meeting more adverse scenarios, they should be set out within alternative pathways, with decision and trigger points identified. Decision points should set out the conditions that would cause one pathway to be adopted over another, using clear and observable metrics supported by a monitoring plan.

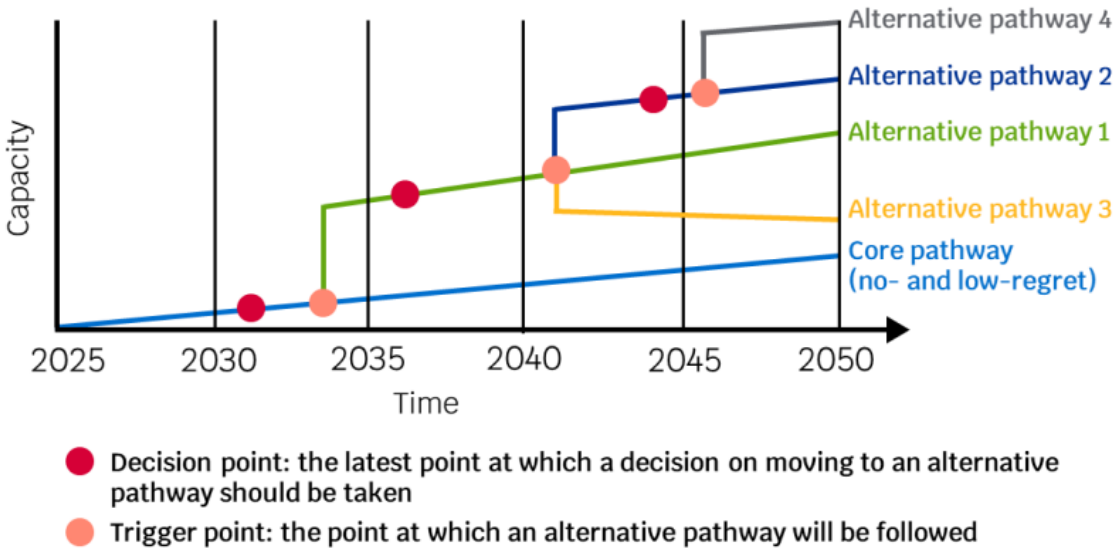

Figure 12 - Example of Core and Alternate Pathways

A well-designed adaptive planning approach should, in most circumstances:

- Not unnecessarily constrain future choices;
- Be efficient and effective under the wides set of all plausible futures, and;
- Enable appropriate modification of plans as the reality of the future becomes known.

A flexible and robust strategy will enable a business to maximise the long-term value it provides for customers, communities and the environment in a safe, resilient and cost-effective manner.

4 Reference List

[1] Scottish Power Energy Networks, Review of Scottish Power Energy Networks uptake of flexibility services, Scottish Power Energy Networks, [Online]. Available: https://www.spenergynetworks.co.uk/userfiles/file/Review_of_Scottish_Power_Energy_Networks_uptake_of_flexibility_services%20-%20Copy.pdf.

[2] Ofwat, PR24 and beyond: Final guidance on long-term delivery strategies, Ofwat, [Online]. Available: https://www.ofwat.gov.uk/wp-content/uploads/2022/04/PR24-and-beyond-Final-guidance-on-long-term-delivery-strategies_Pr24.pdf.