Scottish & Southern Electricity Networks

SSEN Transmission

RIIO-T2 Business Plan: RIIO-T2BP-EJP-0013 Rev1.1

Resilience - Operations Centre Engineering Justification Paper

1. Executive Summary

The growth in the SHE Transmission network and our adoption of new technologies is driving increased requirements for real-time control and system monitoring of the network which cannot be facilitated in the existing Transmission Control Centre (TCC). The existing location also provides significant challenges in ensuring the physical security, cyber security, and functionality of our control facilities as the role of the TCC expands. Our existing disaster recovery site is also unsuitable and would not allow full network operations to take place should the TCC become unavailable.

Following Ofgem's comments on the previous EJP, SHE Transmission has widened the options considered in this paper to include a “do nothing" option, as well as a refurbishment of the existing site, in addition to the two options to build new facilities. We also engaged Electric Power Research Institute (EPRI) to assess the need for new facilities against what is provided at Inveralmond House.

Following a process of optioneering and detailed analysis as set out in this paper, the proposed scope of works is unchanged from the December submission. The scope is for a new build control centre with modest changes to the existing TCC which will be retained as a contingency site. The cost remains as the original submission [redacted].

[redacted]

This scheme is not flagged as eligible for early or late competition due to it being under Ofgem's £50m and £l00m thresholds respectively.

Name of Scheme/Programme	Operations Centre
Primary Investment Driver	Resilience
Scheme reference/ mechanism or category	SHNLT2037
Output references/type	NLRT2SH2037
Cost	[redacted]
Delivery Year	2022/3
Reporting Table	D4.3a
Outputs included in RIIO-T1 Business Plan	No

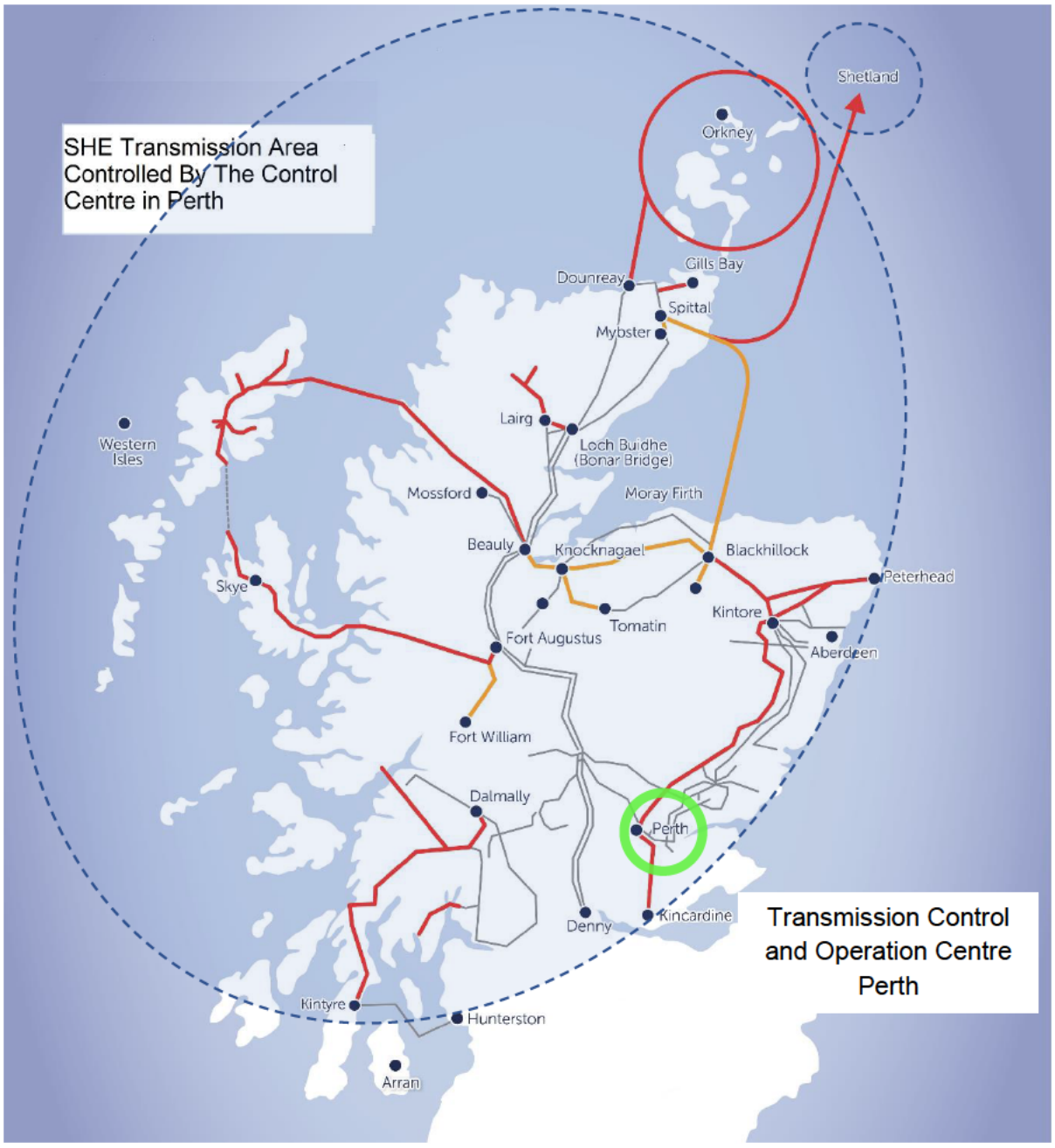


Figure 1 - SHE Transmission Operating Area

2. Introduction

This Engineering Justification Paper sets out our plans to undertake condition-related work during the RIIO-T2 period (April 2021 to March 2026). The Engineering Justification Paper is structured as follows:

Section 3: Background

This section provides an explanation of the growth in the SHE Transmission network and the importance of the TCC in operating the system. This includes the forecast growth in line with Future Energy Scenarios (FES) and climate change targets.

Section 4: Need

This section provides an explanation of the need for the planned works. It provides evidence of the primary and, where applicable, secondary drivers for undertaking the planned works. Where appropriate it provides background information and/or process outputs that generate or support the need.

Section 5: Optioneering

This section presents all the options considered to address the need that is described in Section 3. Each option considered here is either discounted at this Optioneering stage with supporting reasoning provided or is taken forward for detailed analysis in Section 5.

Section 6: Detailed Analysis

This section considers in more detail each of the options taken forward from the Optioneering section. Where appropriate the results of Cost Benefit Analysis are discussed and together with supporting objective and engineering judgement contribute toward the identification of a selected option. The section continues by setting out the costs for the selected option.

Section 7: Conclusion

This section provides summary detail of the selected option. It sets out the scope and outputs, costs and timing of investment and where applicable other key supporting information.

Section 8: Price Control Deliverables and Ring Fencing

This section provides a view of whether the proposed scheme should be ring-fenced or subject to other funding mechanisms.

Section 9: Outputs included in RIIO-T1 Business Plan

2.1. Post Draft Determination Update

This document has been updated in response to the Draft Determination on the RIIO-T2 Business Plan submission. In the Draft Determination, Ofgem states that SHE Transmission has not provided a clear and unambiguous justification for the preferred option of a new control room.

We have engaged an external consultant, EPRI, a leader in the field of control centre design to produce a high-level engineering report to review the current control centre and identify the short comings.

2.1.1 Consideration of Options

The Need and Optioneering sections have all been revised in response to the EPRI report; in particular a new refurbishment option for Inveralmond House has also been considered. A gap analysis has been provided to demonstrate the shortfalls in the existing facilities to further advise the “Do Nothing” Option.

3. Background

The SHE Transmission Operations Control Centre (TCC) monitors and manages the network from Inveralmond House in Perth (IHP). The TCC was relocated to IHP in 2000 to manage the North of Scotland's electricity network from the SSE Head Office. Critical tasks for the TCC include:

- Management of the transmission network to provide the secure supply of electricity to 0.8 million customers across a large portion of GB's land mass.
- Support the transition to net-zero by planning and operating a safe, reliable and cost-efficient network.
- Coordination of efficient network access for maintenance and construction.
- Fault finding and fault management across the network.
- Meeting 100% electricity demand in the Network area and the export of power across boundaries.
- Acting as a power island on behalf of National Grid Electricity System Operator (NGESO) during Blackstart conditions.

When it relocated in 2000, the original TCC was operating a network much smaller than today and had far fewer complexities in its operations, as shown in Figure 2. The size of and demands on the team were consequently much smaller.

Number of Sub Stations	Generation Capacity	Transmission Network Voltages.	Number of 3rd Parties.
100	2,500 MW	132kV, 275kV	3 – DNO, Scottish Power Transmission, SSE Generation

Figure 2 - System size when IHP was opened in 2000

There was a steady growth in the RIIO-T1 period (2014-2020) of approximately one new substation a year and little generation increase. The RIIO-T1 period history, and predictions for future growth to 2030, show the expected increase in SHE Transmission substation sites, with many of these in the period of RIIO-T2 and RIIO-T3.

In 2020 the TCC will manage circa 1000 outage requests delivering construction, operations and maintenance requirements across the network. In addition, an average of 100 system trips and failures will be resolved and managed to a successful conclusion. The TCC operates 24 hours a day, 365 days a year carrying out minute to minute voltage control and alarm monitoring responsibilities across boundaries on all individual components including the newly commissioned Caithness HVDC connection.

Whilst the network has grown steadily, the push for renewables has increased significantly since the advent of climate change targets. The SHE Transmission system has now become a major transporter of bulk energy, with its importance to the GB power system increasing each year.

Future growth projections are shown in Figure 3. Even with modest assumptions, this leads to circa 199 substation sites by the end of the decade and the capacity to meet over 20GW of generation.

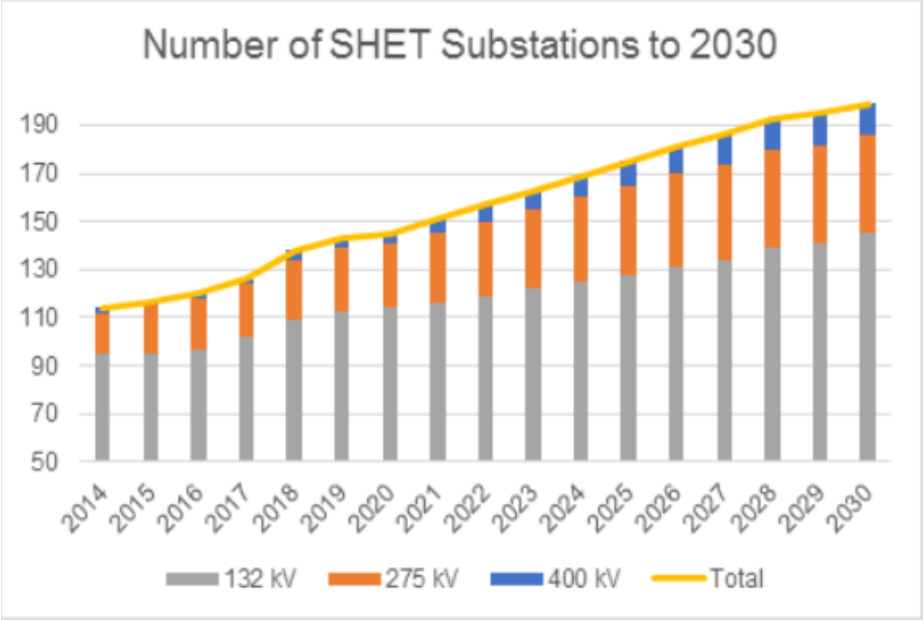


Figure 3 - Growth of SHE Transmission Operated Sites Since 2008 and forecast based on modest growth.

Future Readiness

Over the period of RIIO-T2 and RIIO-T3, the GB electricity system will become more complex to operate due to its changing characteristics (such as the implementation of DSOs), new technologies, interoperability's, interaction with 3rd parties (for interconnectors) and improved technology for monitoring and control.

4. Need

The need for new control centre infrastructure has been presented with an analysis of the centre needs over the following areas:

- Operational Awareness of System Conditions
- Site and Cyber Security
- Ability to Meet Statutory/Regulatory Obligations
- Control Centre Footprint
- Future Growth Provision

4.1 Operational Awareness of System Conditions

The current TCC is functioning adequately to maintain the existing transmission network but is ill equipped moving forward to deliver the step change expected in performance to meet the developing control room functions. Situational awareness is important for reliable and resilient system operation and it cannot be understated in its importance in sound and timely decision making.

The most widely accepted definition and model of situational awareness comes from Mica Endsley is shown in Figure 4.

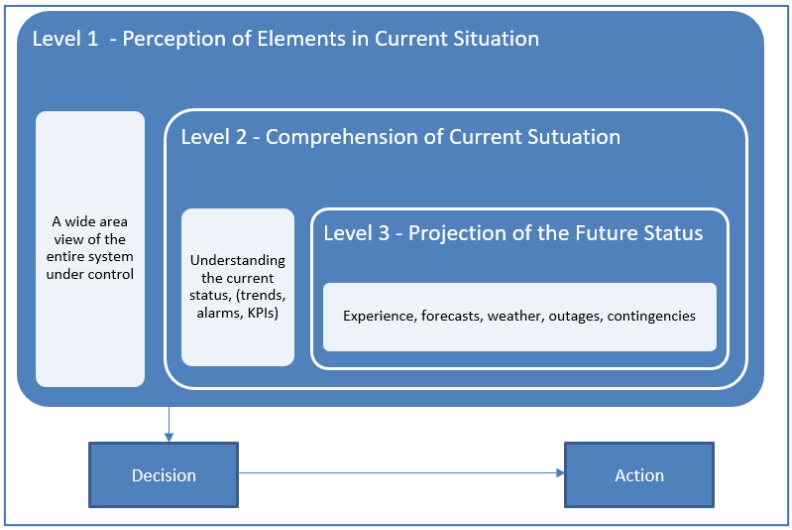


Figure 4 - Mica Endsley model for situational awareness

These levels equate the 4 tiers of how information is presented to the operators and eventual actions taken.

- Tier 1 displays the initial entry point of interacting with the system via the model. This should be as complete as possible display of the system under control or an all-encompassing dashboard, showing the key system parameters and whether they are within limits or not.

- Tier 2 displays more information about a specific task – voltage control, outages, alarms, substations
- Tier 3 displays more detailed information for switching, usually control displays in substations.
- Tier 4 are support displays, substation tabular or backend displays.

Tier 1

Many transmission operation companies around the world have a large video wall display in their control centres which give a wide overview of the entire system. The grid is represented in a dynamic manner and presents the control engineer with a high degree of situational awareness. Providing an overview gives improved decision making for the Operator by enabling them to view the entire system without searching for information on smaller monitors. These displays are essential for the management of High Incident Low Probability (HILP) events including blackstart operations. They also allow for operational team collaboration, emergency situations and silver command events.

In recent years the large video walls in control centres have been adapted to show not just the grid but also key indicators, trends, alarm status and other information related to the operator's role, thereby improving the speed, efficiency and safe operation of the network. Figure 5 shows an example of a European Control Room.

Tier 2

In addition to the system overviews there is a need for managing the network through workstations by monitoring alarms, system levels, coordinating safety and communications. Based on an analysis of the number of screens used in similar control centres in Europe. This requires on average between 9 and 10 individual programme screens for each operator[1] which are viewed on a smaller number of monitors.

[1] EPRI SSE - SHET New Transmission Resilience Operation Center Proposal Review Project Response to Ofgem RIIO ET2 Submission Final Report, August 12th, 2020

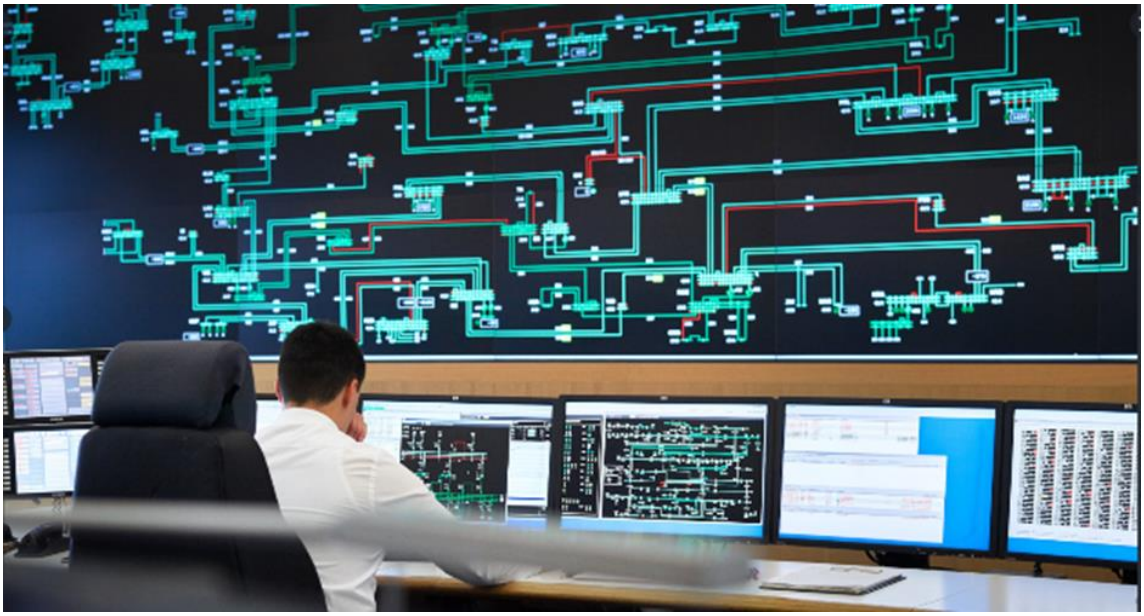


Figure 5 - German Transmission Control Room[2].

Tier 3

The third level in the hierarchy of situational awareness is the space where decisions can be arrived at and control executed safely and efficiently. To deliver Tier 3 performance, the teams require information from many systems such as weather, online study tools, performance monitoring, document libraries and business systems.

4.2 Site and Cyber Security

4.2.1 Physical Security

As part of the GB grid system, SHE Transmission requires to meet a high level of security. The current guidelines from Centre for Protection of National Infrastructure (CPNI) require control centres to meet guidelines in Table 1.

[2] 50 Hertz Source: https://www.50hertz.com/en/Grid/Systemcontrol

Threat Mitigation Topic	CPNI Suggested Measures
Doors	Measures to assist in the detection, tracking and monitoring of intruders and other threats, such as unmanned aerial vehicles
Search and screening	Measures to assist in the detection of threat weapons, including for example explosives, knives, firearms, chemical/biological/radiological material etc.
Access controls	Access control and locking systems Physical and active barriers to deny or delay the progress of adversaries
Perimeter physical defences	Physical and active barriers to deny or delay the progress of adversaries Measures to protect people or assets from the effect of blast or ballistic attack Measures to protect against or limit the spread of chemical, biological or radiological material
Intruder detection, monitoring	Measures to assist in the detection, tracking and monitoring of intruders and other threats, such as unmanned aerial vehicles Access control and locking systems
Windows	Measures to protect people or assets from the effect of blast or ballistic attack Measures to protect against or limit the spread of chemical, biological or radiological material
Building services	Measures to protect against or limit the spread of chemical, biological or radiological material
Structural framing, walls and floors	Measures to protect people or assets from the effect of blast or ballistic attack Measures to protect against or limit the spread of chemical, biological or radiological material
Protection of sensitive information and assets	Measures to protect sensitive (e.g. classified) material or assets
Security control room	Security personnel (covered within the Personnel and People Security). Command and control. The response to an incident

Table 1 - Requirements of a CPNI Site

[redacted]

Cyber Security

Supporting the need for physical security, Cyber Security is the second Principal Risk at SSE Group level – "The risk that key infrastructure, networks or core systems are compromised or are otherwise rendered unavailable".

As an Operator of Essential Services under the Network Information Services Directive (EU Network and Information Systems Directive[5]), we have specific obligations which are addressed in the draft SHE Transmission RIIO-T2 OT Cyber Resilience Plan, amongst others[6].

Although the most likely cyber threat is from actors based in a remote location or remote nation state, the threat of physical attack is equally important and site security measures must address this

[3] Initial Group Security opinion, Draft, July 2020
[4] Ofgem "Physical Security Upgrade Programme Submission May 2018" Ofgem, London 2018
[5] https://ec.europa.eu/digital-single-market/en/networkand-information-security-nis-directive
[6] Ofgem RIIO-T2 Cyber Resilience Guidelines issued February 2020, the NIST Guide to Industrial Control Systems (ICS)/ Security Supervisory Control and Data Acquisition (SCADA) Systems standards (NIST800-82), the IET Draft Code of Practice for Cyber Security and Safety as well as guidance and information obtained via engagement with the National Cyber Security Centre (NCSC).

possibility. The site security can be complex with access to the control room being limited to a central high security group of operators, whilst others require access to specified areas of the building for maintenance or cleaning. Access control and limitation is critical to maintaining a secure scenario, with identification and authentication needs regulated by role-based, group-based, or device-based access control, yet is not hampered by identification or authentication requirements.

[redacted]

[redacted]

[redacted]

Risk	Consequence
Misuse of information systems	The threat actor misuses legitimately-assigned access privileges to perform unauthorised actions on information systems.
Unauthorised physical access to information systems	The threat actor obtains physical access to an organisation's information systems (e.g. by misusing access or bypassing physical security checks) and uses this access to gain unauthorised access to organisational information systems and information assets.
Physical damage to or tampering with information systems	The threat actor deliberately tampers with or causes physical damage to an organisation's information systems in order to disrupt their normal function.
Theft of information system hardware	The threat actor steals physical information systems (e.g. servers, laptops or portable storage devices) or physical information assets (e.g. paper copies).
Conduct physical attacks on organisational facilities or their supporting infrastructure	The threat actor conducts a physical attack on an organisation's facilities or supporting infrastructure (e.g. telecommunications, power, water or gas).

Figure 6 - Consequences of Cyber Threat

[redacted]

[redacted]

NIST SP800-82 specifically recommends measures for Control Centre security. Providing physical security for the control centre/control room is essential to reduce the potential of many threats. Control centres/control rooms frequently have consoles continuously logged onto the primary control server, where speed of response and continual view of the plant is of utmost importance. These areas contain other critical computer nodes, and sometimes plant controllers. It is essential that access is limited to authorised users only, using authentication methods such as smart or magnetic identity cards or biometric devices. Provision of an offsite emergency control centre is required so that control can be maintained if the primary control centre becomes uninhabitable or is compromised. These measures can be more readily purposed within a new environment.

The IET Draft Code of Practice for Cyber Security and Safety recognises that addressing functional safety and cyber security risk is not just a technological issue, but involves people, process, physical and technological aspects, including physical security. It includes a recommendation for an organisation to define in its policy the requirements for protective measures for each impact level, to achieve a graded approach with the highest impact levels benefiting from the most stringent and, consequently, most expensive measures. Cyber security measures may specify different levels of system hardening, network hardening for example zoning to achieve the right balance of cost and risk mitigation.

A recent (April 2020) IET Technical Network Webinar "The Future of Industrial Cyber Security" recognised that physical site security is a key element of OT Cyber security in addition to technical solutions. As such the buildings housing the components of the OT systems must be as good or better than the equivalent technology solutions preventing compromise.

Physical security is a fundamental consideration that sits alongside technical solutions to mitigate cyber risk to operational technology, cyber-physical security measures outlined for control rooms are an imperative for an Operator of Essential Services and are more readily provided by incorporating into a new segregated standalone facility.

4.3. Ability to Meet Statutory/Regulatory Obligations

The Transmission licence, System Operator Transmission Owner Code (STC) and its associated procedures (STCPs) form the fundamental basis of how SHE Transmission must operate the System to align with the NGESO. There are almost 20 STCPs that TCC must comply with, which together with a summary of obligations and concerns are shown in Appendix 1 Operational and Functional Needs Summary. The most important STCPs for control centre operation are listed below:

Black Start STCP 06-1 : Initiate and operate the network during a power system blackout, undertaking System Operator role and the Transmission Operator roles in completing a joint restoration plan to restore the network.

Operational Switching STCP01-1: Operate a safe, secure and efficient power system. Maintain power quality standards, release and return of equipment for commissioning and maintenance, in liaison with other users and operators.

Alarm and Event Management STCP 02-1: monitor and manage system state by observing SCADA alarms and indications, then acting to resolve any issues affecting the System or equipment.

Real Time Data Change Management STCP 04-1: Network configuration, boundaries and SCADA information is managed through exchanges between all users, the System Operators and any other operators, to ensure safe and secure operation of the System.

Real Time Data Provision STCP 04-3: TCC programs and manages the SCADA information that is exchanged between users of the network in real time allowing safe and secure operation in the real time environment.

Outage Planning STCP 11-1: TCC coordinates construction and maintenance with the System Operator, ensuring that projects and operations work is scheduled in line with the GB system plan.

4.4. Control Centre Footprint

The Control Centre requires an area that can provide a good flow of communication for several functions, including day to day operations as well as for training, contingency planning and incident management and control. The size and shape of the space provided is important to ensure the flow in work, following the processes that deliver the outage plan and supporting information into real time operations. This section will analyse the requirement based on the advice of its consultants EPRI and the requirements of our STCP and Licence obligations.

The Control Centre requires the following functional spaces that include: -

- Segregated utilities dedicated to the Transmission team including HVAC, telecoms areas, toilets, welfare, rest areas and kitchen facilities. This covers blackstart events, which would require higher than normal staffing levels, as well as any future pandemic needs.
- An operational simulator and training facilities.
- Incident management rooms responding to incidents on the transmission network as well as for post incident analysis and review.
- Contingency operations room and disaster recovery facilities.
- Space to accommodate additional support teams as the complexity of the network grows, and the impact of technology innovations and system monitoring are considered. These changes will require action within RIIO-T2.

4.4.1 Sustainable Workforce Development and Renewal

There is a need for training and development facilities within the TCC to provide a trained and competent workforce. Training is currently based on providing on job experience in the live control room. This brings with it the associated risk of incidents and extended times for carrying out switching due to the extra care needed for trainees to carry out tasks under observation.

Offline training will improve safety, quality and duration through the following:

- Simulator training to provide a safe and consistent platform, ensuring teams are prepared for and capable of high performance in all situations, but particularly High Impact, Low Probability (HILP) events which cannot be replicated on the live network.
- Allows the standard of training to be controlled and certified in line with requirements for operation as a system operator within Europe.
- Provide flexible and accessible training to meet authorisation requirements.
- Ability to share experiences within the team in a safe environment by replay, test and review of events or new techniques.
- Training on site of the control centre would permit realistic scenarios and simulations for blackstart and restoration to be deployed.
- Reduction in the training time of new team members is needed. As the workforce career expectations and availability change, higher churn is a risk that requires constant training of new team members.
- With an increasing number of technologies on the system, comes the added risk of more HILP events. The ability of staff to prepare for these has never been more important.

4.4.2 Desk Number Analysis

Figure 7 below shows an analysis undertaken by EPRI to show in simple terms the short fall in desk requirements now against what is expected to be required by the end of RIIO-T2.

Team Area.	Current Numbers of Desks.	Increase Required by the end of RIIO-T2.
Switching Desks	4	5(6)
Technical Support Assistant (TSA)	4	6
Managers	4	4
System Specialists	3	6
Planning	5	12
Commissioning Desks	1	12
Other Future requirements, (Engineering, Tech Support)	0	30
Totals	21	75

Figure 7 - Basic Desk Analysis

In addition to the number of desks above, if there was another pandemic like COVID-19, over 50% of these desks would be unusable due to social distancing rules. This situation also highlights the pressing need for contingency facilities.

4.4.3 Functional Requirements

To meet the space requirements listed in the previous sections, Figure 8 shows the functional space requirement by size and area.

Function	Sizes (m)	Area (m2)
Control room area for up to 6 desks and storage. Required width of 12m for video and depth 12 for correct viewing angles. Double room height required	12x12 but on each floor for double height	288
Locker area for male and female	7x6	42
Control Staff toilet block (ground floor)	9x6	54
Desk area for planning, support teams and managers (24 workstations)	18x8	144
Desk area for commissioning team (12 oversize desks required)	14x7	98
Incident rooms	14x7	98
Server rooms	15x4	60
Telecom room	12x4	48
Storage	6x6	36
Security Buffer zone (reception and lobby)	42x6	252
Airlocks and security zones 4 off	2x3 each	24
Allowance for walkways and access	N/A	250
Training suite (video wall and up to 6 control desks, with operator room and classroom)	15x12	180
3 Meeting rooms (6x6 3 off)	6x6 each	108
Collaboration spaces and refreshment areas	12x6	72
Secondary/Visitor toilet block	8x6	48
Plant and HVAC	42x6	252
Flexible Office space for Engineering and Technical Support	18x6	108
TOTAL		2162

Figure 8 - Control Centre Functional Space Requirements

4.4.4 Incident Control Management

The incident control space is identified in Figure 8, and this requirement is explored in greater detail in this section. A suitably designed incident control room is required for efficient and effective decision making in the event of a major incident. The rooms are critical in providing co-ordination with external groups and buffering the real time team from outside interruptions. Operations, strategic planning and reporting are an obligation under the SHE Transmission operating licence.

Delays in resolving incidents will have safety, financial and reputational consequences. Furthermore, the role and responsibilities of SHE Transmission changes immediately in the blackstart environment as they become an islanded system operator, so requiring wide overviews of the system to manage restoration and reconnections.

During widespread nationwide power outages, each hour of delay is costly and severely affects customers: reduction of restoration time reduces impact on customers and costs. Restoration targets for demand restoration of 60% in 24hrs and 100% in 72hrs are expected by our licence commitments. Clearer awareness and better decision making could improve these by up to 4hrs[7], with the consequent benefit of cost and societal stress, but also giving advantage in early readiness to connect generating sites.

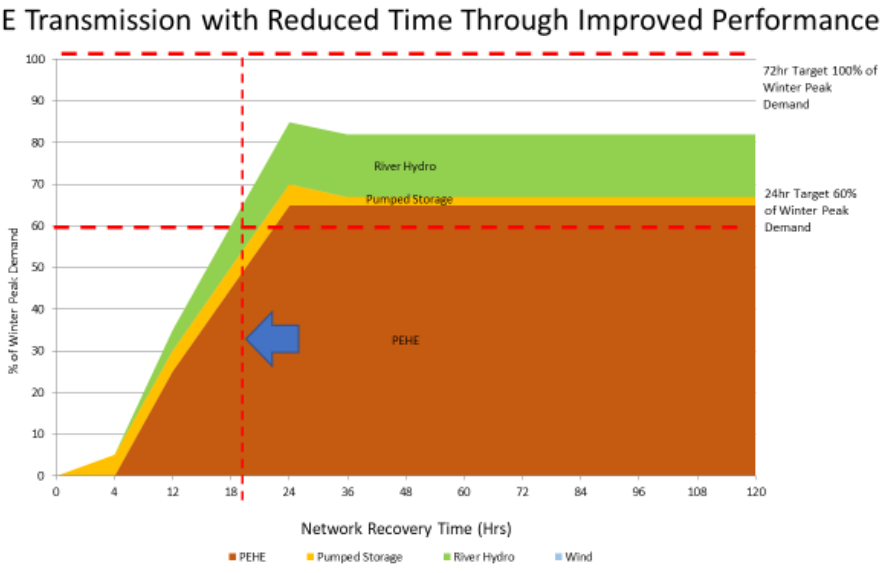


Figure 9 - Improved speed of black start restoration recovery by 4 hours

[7] Joint NGESO/SPT/SHET paper to SEAB 2018

4.5. Future Network Provision

Figure 10 shows the predicted network growth in substations, generating capacity, and connections by the end of RIIO-T2.

Year	Number of Sub Stations	Generation Capacity	Transmission Network Voltages	Number of 3rd Parties.	3rd Party Connection Points	Number of Connections by end of RIIO-T2
2000	100	2,500 MW	132kV, 275kV	3 – DNO, Scottish Power Transmission, SSE Generation	3	
2020-2030	145 and increasing to 199 by 2030	8,200MW increasing to 20,000MW by 2030	132kV, 220kV, 275kV, 400kV and HVDC	DNO, Scottish Power Transmission, Natural Power etc. future connections to England and Norway	76	80

Figure 10 - Network Size and Generation Capacity in 2020[8].

The growth of connections is shown by the graph in Figure 11. Proportionally a growth in this infrastructure needs the TCC to respond in its capacity to meet the increase in testing, commissioning, managing outages, safety switching and other related operations functions. It is interesting to note that there is planned growth across all system voltages demonstrating that this growth is system wide.

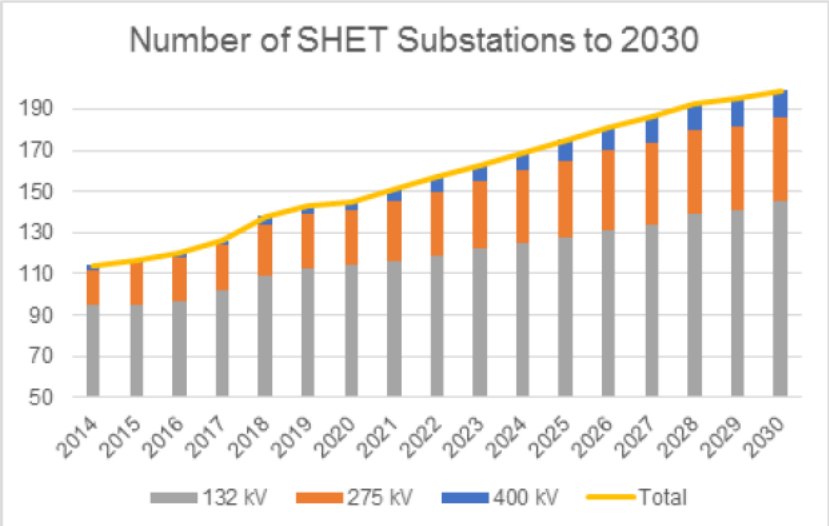


Figure 11 - SHE Transmission operated Substation by 2030[9]

[8] SHE Transmission Planning ETYS and forecast growth of connections
[9] ibid

Future Energy Scenarios as shown in Figure 12 are: FES 1 does not meet climate targets, FES 2 meets Government expectation and FES 3 is a more probable value based on contracted or planned schemes.

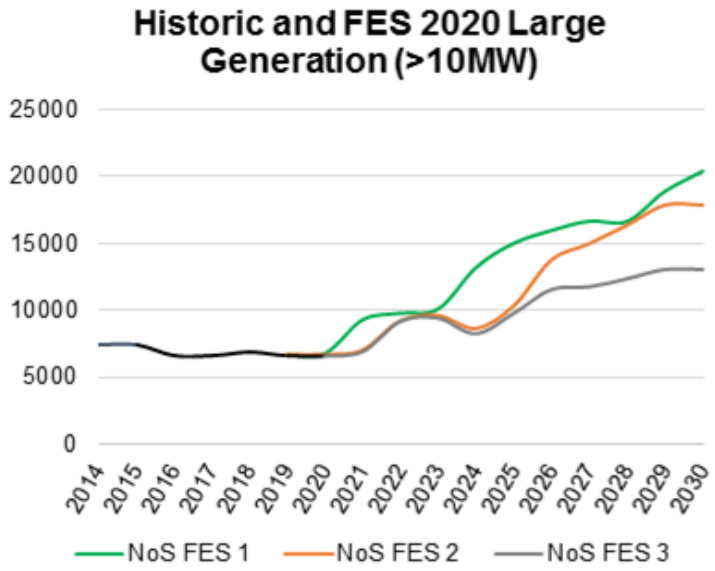


Figure 12 - Generation Growth Prediction During RIIO-T2 and Beyond[10]

In all Future Energy Scenarios (FES) in Figure 12, significant generation growth will occur in the next 2 price control periods into RIIO-T3: a minimum of 13GW is expected with the potential to be greater than 20GW. Much of this increase will be from off-shore wind, with a significant proportion based in Scotland.

This doubling of the overall capacity coupled with an increase of up to 15 times the demand level of the SHE Transmission network, demonstrates the importance of the SHE Transmission system for bulk power transfer across boundaries and the support that SHE Transmission makes to the UK's overall system capacity.

EPRI in its control centre assessment identified 23[11] new technologies or innovations that will be incorporated partially or in full into the SHE Transmission network during the RIIO-T2 period. All of these innovations are loosely grouped into new network technology, interoperability and improved technology for monitoring and control. EPRI also identified 38[12] requirements in existing STCP codes that SHE Transmission will need to conduct in future to accommodate the changes to the control centre function. These increased requirements are mainly centred on personnel safety, system security and cost.

[10] Transmission Planning forecast model of FES

[11] EPRI SSE - SHET New Transmission Resilience Operation Center Proposal Review Project Response to Ofgem RIIO ET2 Submission Final Report, August 12th, 2020

5. Optioneering

When reviewing our options in this area, we produced a three-tier approach to our development in addition to a "Do Nothing" option: -

- Minimum Requirements

  Cannot meet minimum required to "keep the lights on" & maintain legal/regulatory compliance long term

- Responsible Operator

  A more resilient network for longer term customer benefit

- Progressive Network Enabler

  An adaptable, sustainable and flexible solution providing enhanced value to current and future customers

The scope, risks and benefits of each of these is laid out below.

Option Detail	Cost (£m)	Taken forward to Detailed Analysis?
Do Nothing	-	No
Adapt IHP to meet Minimum Requirements and defer rebuild to RIIO-T3	[redacted]	Yes
Responsible Operator – off site build of new Control Centre	[redacted]	Yes
Progressive Network Enabler – off site build of 2 new Control Centres	[redacted]	Yes

5.1. Do Nothing

This option would entail no changes to the current running of the TCC and would see the existing the Centre running through until the end of the RIIO-T2 price control period in 2026 in its current format and situation. [redacted] This option is now analysed against the need requirements set out in Section 4.

In summary, a total of 43 potential risks are identified by our control centre consultant EPRI with this option and have been grouped under safety, system security and cost issues[13]. The table of risks are shown in Appendix 1. Some of these issues will be identified in this Section as part of the analysis of the Situational Awareness, Security and Cyber Security, Ability to meet Statutory Obligations, Control Centre Footprint, Training, Incident Management and Future Network Growth.

5.1.1 Situational Awareness

The provision of a hierarchal tiered structure with resulting situational awareness is not provided in the existing layout. In particular, by not providing a Tier 1 visual system with a wide view of the entire system under control, the ability of the TCC to manage its day to day and HILP event functions is compromised.

A double height ceiling space is not provided so ergonomics are poor; no standing desks are allowed due to poor visibility and the existing environment is inefficient for day to day system operation. The existing layout will lead to poor incident management and risks the delivery of black start and silver command functions.

With the close proximity of other SSE business functions, the existing layout is busy, noisy and with perpetual distractions: this will lead to anxiety and stress for the work force. [redacted]

5.1.2 Security and Cyber Security

[redacted]. Extensive work is required to bring the control centre to an acceptable standard that meets both Ofgem and CPNI standards.

Physical security is a fundamental consideration that sits alongside technical solutions to mitigate cyber risk to operational technology. Cyber-physical security measures outlined for control rooms are an imperative for an Operator of Essential Services. [redacted]

[13] EPRI SSE - SHET New Transmission Resilience Operation Center Proposal Review Project Response to Ofgem RIIO ET2 Submission Final Report, August 12th 2020
[14] Ibid page 4-8

[redacted]

[redacted]

[redacted]

5.1.3 Ability to Meet Statutory/Regulatory Obligations

This section will demonstrate how the existing facilities are falling short of existing STCP requirements.

Black Start STCP 06-1

- The shared building has limited space for the number of people needed to manage a Black Start event.
- No clean communication flow due to ergonomics between the remote incident management centre, planning team and control room.
- The domestic facilities such as kitchen, toilets/showers and rest areas would not suit the requirements of the black start, which would require above normal staff attendance for a prolonged period of time.
- [redacted].
- Ability to train members from other teams that can assist with the TCC work is not provided. Staff that can be trained in Black Start from TCC and other teams are unable to assist as there is no a suitable training facility.

[15] SSE Group Security Review - Initial Opinion Survey results (draft)

Operational Switching STCP01-1

- Inadequate system overview is provided due to the lack of space and positions of the desks.
- Desk space is limited, giving a small footprint for the operators to use as workspace.
- No room to add additional system monitoring.
- [redacted].

Alarm and Event Management STCP 02-1

- Small and inadequate Tier 1 overview of the system reduces situational awareness. Engineers must search or interpret alarms before seeing the full picture.
- Events are not seen unless the engineer is at the desk and observing alarms.
- Small additional screens have been added to assist the engineers see more things on the desks. This blocks larger overview screen.

Real Time Data Change Management STCP 04-1

- In working on the live system and following instruction from the control engineers, there is the same, if not higher, risk of operation switching errors in this role. Distractions and stress often result in breaks of concentration as people traverse along the accessways next to them. Risk of mistakes and data security is a concern.
- [redacted]
- Risk of data breach is present due to the number of people from other departments passing behind or close to the team.
- Operational requirements are mostly met, with occasional delays caused by lack of capacity in the team. No capacity to increase the number of commissioning desks.

Real Time Data Provision STCP 04-3

- As above for bullets 1-3 of STCP 04-3.
- No capacity to increase the number of commissioning desks. Operational requirements are mostly met, with occasional delays caused by lack of capacity in the team.

[redacted]

5.1.4 Control Centre Footprint

The current size of the control centre footprint owned by SHE Transmission for the TCC is 125m^2. This is an over populated space, spilling over into 3 separate areas, over 2 floors and intrudes on other SSE business unit spaces due to lack of desks in the TCC. There is a shortfall of 54 desks from

an EPRI functional analysis and a shortfall of approximately 2100m^2 of floor space to cover all of the functions identified in Section 3, Figure 8.

There are no dedicated spaces for: incident management, separate plant and HVAC services, separate utilities and telecoms, welfare facilities, and technical support functions. [redacted]

[redacted]

5.1.5 Sustainable Workforce Development and Renewal

No facilities exist for offline training: all training and authorisations is conducted on the live network. This is barely adequate for routine tasks but fails to deliver training for HILP events, which is where the competence of the TCC is truly tested. No other organisation can provide this training as the rules for managing the Control Centre are unique SHE Transmission requirements. This is a significant capability gap in providing offline experience, particularly as there are few opportunities for trainers to deliver away from the live desk. Added to this staff churn will affect the overall capability of the TCC operation as workers become more mobile in careers.

5.1.6 Future Growth Provision

The existing infrastructure is not adequate to meet the predicted growth demands for the remainder of RIIO-T2 or the expected capacity for RIIO-T3. [redacted]

EPRI identified 23 changes in the way that control centres will function over the next 10 years and these changes are significant. The network is going to be weaker and more complex in future with greater pressure on staff to monitor and interpret new technologies that are with us now and will grow during RIIO-T2. EPRI also identified that the network changes will result in 38 further STCP activities and work load increases that will result. These have been grouped into areas such as personnel safety, system security and cost.

The existing facilities are inadequate to manage these new requirements effectively.

5.1.7 Incident Management

[redacted] to

[16] (Ernst/Young report, £1000m /3 as demand is roughly 1/3 of demand in Scotland)

[redacted]

[redacted]

On the basis of the above analysis, this option is unacceptable and will not be progressed further.

NOT PROGRESSED

5.2. Adapt IHP and attempt Minimum Requirements; Build Control Centre in RIIO-T3

The minimum requirement option attempts to address some of the shortfalls of the existing site in Inveralmond House. This section will conduct an analysis of this option against the need sections identified in Section 3, namely: Situational Awareness, Security and Cyber Security, Ability to meet Statutory Obligations, Space, Training, Incident Management and Future Network Growth.

In outline, the Refurbishment option would extend the existing TCC [redacted] A separate off campus contingency site would be required to implement this option and is included as part of the solution.

Given the future growth predictions, this solution is for the immediate short term and would only provide an interim solution for RIIO-T2; a rebuild would be required in RIIO-T3 as these refurbished facilities will be insufficient to take the TCC beyond 2026.

Figure 13 - IHP Adaptation shows a poor ergonomic solution

5.2.1 Situational Awareness

The Situational Awareness component would be partially resolved by the new layout by the addition of a bespoke video wall and by the reorientation of desks; the isolation of this function away from the SHEPD Control Centre and other SSE business users also assists. However, it provides only a minimal control centre area and without a double height space the ability of this layout to manage the Centre's functional expansion is limited.

Whilst the area [redacted], the restrictions on layout would mean that there would be no logical flow between the other functions that make up the whole of the control centre operation. This design would not provide an efficient operation. This solution is only suitable for the short term.

5.2.2 Security and Cyber Security

[redacted]

[redacted]

5.2.3 Ability to meet Statutory Obligations

The need to comply with all statutory obligations creates a heavy workload on the TCC teams which will increase considerably within T2. To mitigate this additional space is partly the answer, but to create an arrangement that makes the business processes flow smoothly is needed. This option will address a few of the immediate risks but is likely to require further change during the T2 period to meet the growing workload of a larger, more complex network. The complexity in the planning, data preparation, information exchange processes can be eased by the addition of more desks within the TCC area, to give better communication across the team. However, other important areas such as, security, operational displays and adequate resilience cannot be provided, which leads to risk of failure in operating the network as prescribed by the Transmission Licence and SO/TO codes.

5.2.4 Control Centre Footprint

The space shortfall would be resolved for most primary control centre functions however, the ergonomics and organization of the spaces would be compromised by the orientation of the available

floor space. Planning functions would be improved but the layout is restricted by the physical dimensions of the available space. We would still however, be sharing some of the spaces for UPS, telecoms, servers, utilities, welfare and security with other business functions.

A separate new contingency and DR site would still be required.

5.2.5 Sustainable Workforce Development and Renewal

Training requirements can now be met with the additional space and layout.

5.2.6 Incident Management

Incident Management response would improve significantly with dedicated rooms and monitors but without an overarching Tier 1 visual display the situational awareness element for managing events is reduced. Restrictions on what the revised layout can achieved means that the changes will not make significant improvements to the delivery and management of the process.

5.2.7 Future Network Growth

The main limitation to accommodating future network growth is the lack of height to develop a fully inclusive Tier 1-3 facility and the open area space to accommodate sufficient desks with good visibility of the video wall. As such, the layout would not be suitable for the technology, monitoring and control functions that is anticipated for control centre operations. To provide the situational awareness and future needs functionality to the control room space, would require an arrangement that cannot be accommodated in the existing office floor environment. As a result, this layout would only suffice for a short duration and no more than the end of RIIO-T2.

This option is progressed to detailed analysis.

PROGRESSED TO DETAILED ANALYSIS

5.3. Responsible Operator

The "Responsible Operator" option would be to build a purpose-built control centre and use the old TCC as Contingency, with DR out of area. The sketches showing the layout of a 2-storey control centre are shown in Figure 14 below.

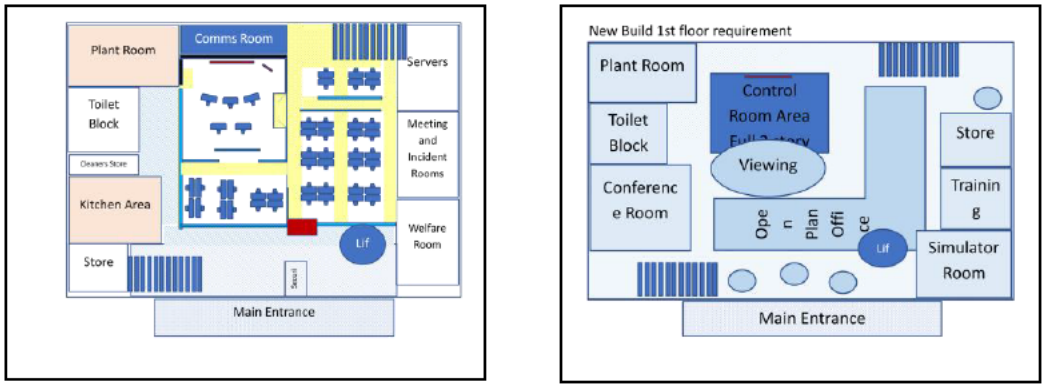


Figure 14 - New Build Option - Layout Sketches

This option will meet all of the need elements described in section 3 for Situational Awareness, Security and Cyber Security, Ability to meet Statutory Obligations, Space, Training, Incident Management and Future Network Growth. In particular, this option will:

- Allow full implementation of CPNI control rooms guidance.
- Enable the full implementation of physical and cyber security requirements.
- Allow for any repeat pandemic such as that in 2020. The new facility would have complete control of the environment with the ability to separate the building into 2 environment-controlled work areas to avoid cross contamination within the teams.
- Provide a purpose-built control centre with flexible work spaces that can be changed into accommodation in a black start situation or other future uses.
- The footprint of the ground floor creates an area on the first floor at small cost that gives up to 30 extra workstations, for engineering or project support use.
- Allow the existing TCC to develop into the contingency site.

On this basis, this option has been progressed to detailed analysis.

PROGRESS TO DETAILED ANALYSIS

5.4. Progressive Network Enabler

The "Progressive Network Enabler" option would include the scope of work for the "Responsible Operator" option for an off-site rebuild. In addition, this would build a near identical fully operational contingency site in reasonable proximity to the main control centre, with an out of area DR. The existing facility at Inveralmond would be released back to the SSE Group.

Figure 15 shows the required floor layouts of a new contingency building.

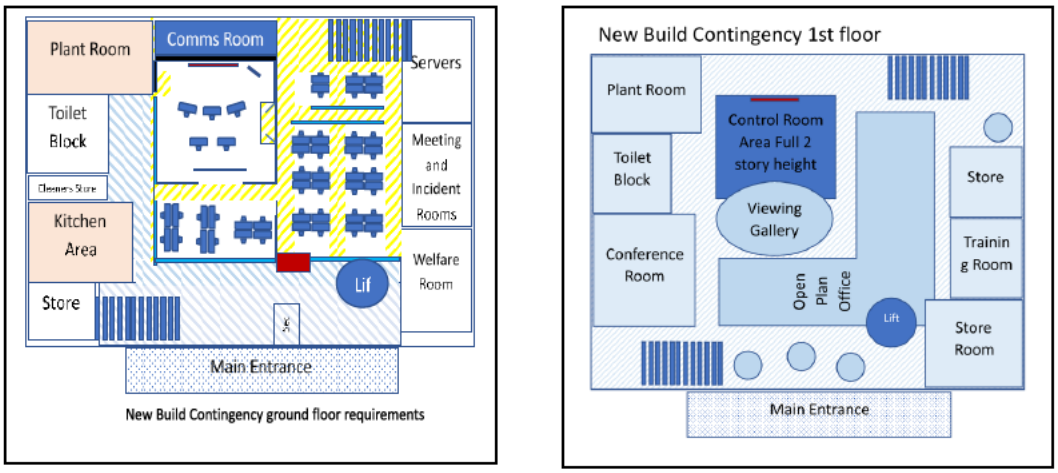
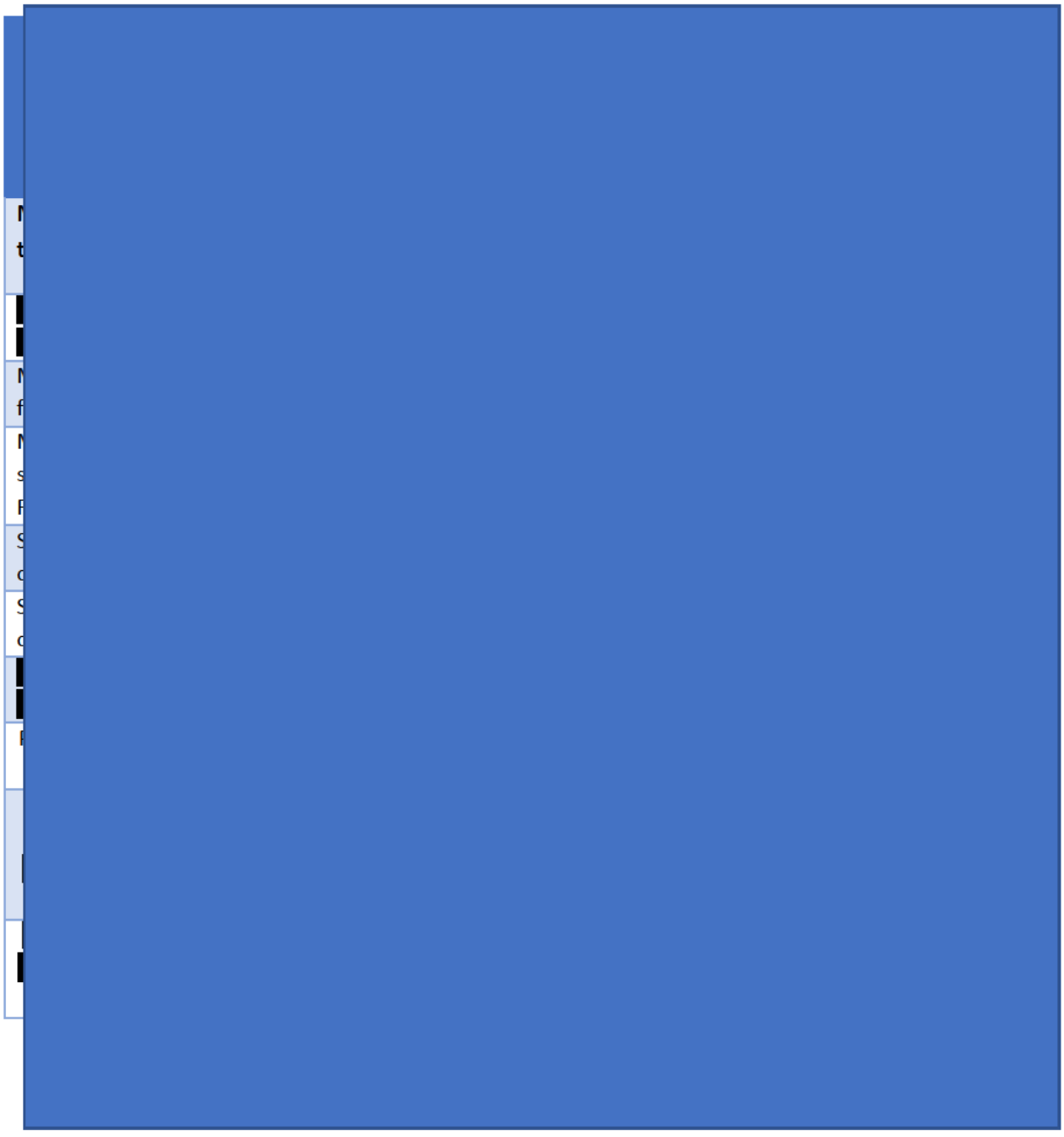


Figure 15 - New Build Contingency Site Sketches

On this basis, this solution is taken forward to detailed analysis.

PROGRESS TO DETAILED ANALYSIS

A summary of the above optioneering is shown in Table 2 below.



6. Detailed Analysis

This section considers in more detail each of the options taken forward from the Optioneering section. It examines three comparative factors in order to determine the preferred option:

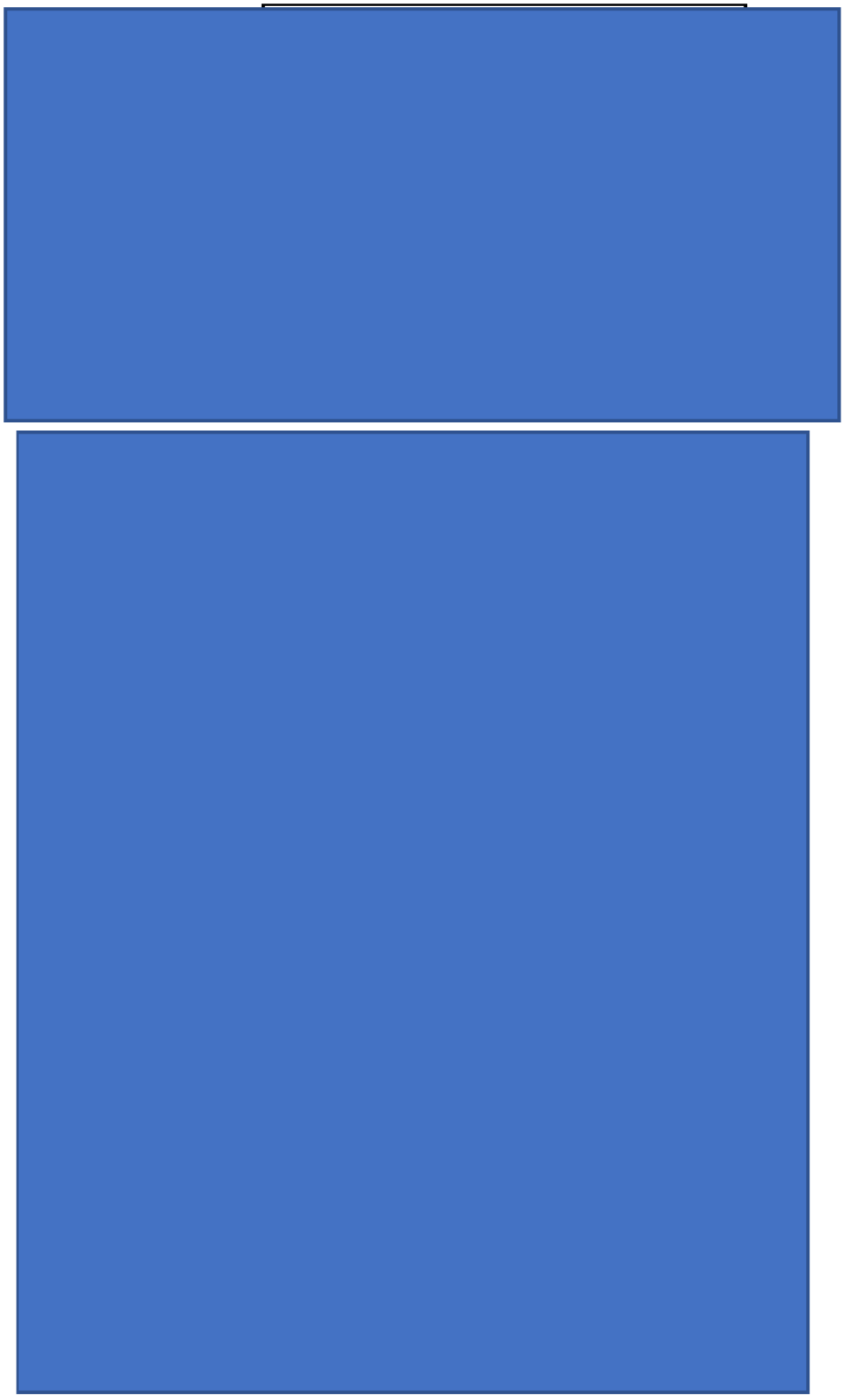
- Risk
- Cost
- Stakeholder Requirements

6.1 Risk & Benefit Analysis

This section will analyse the risk profile of the options against the areas identified by EPRI. This exercise was conducted in conjunction with EPRI. Table 3 below shows the legend and Figure 16 to Figure 19 show the resulting risk map for the unmitigated site and the Responsible Operation solution; the remaining Risk Maps and all risk tables are in Appendix 3.

Risk ID Key	Risk Title
1	Failure to Observe System conditions (Situational Awareness)
2	Operational Safety
3	Space
4	Physical Security
5	Control Centre Resilience/Integrity (Business Continuity) [Partial Recovery of Business Facilities]
6	Control Centre Resilience/Integrity (Business Continuity) [Full duplicated Business Facilities]
7	Control Centre Resilience/Integrity (Welfare)
8	Future Needs
9	Failure of Telephony
10	Deficiencies in Training
11	Cyber Security

Table 3 - Risk Legend



[redacted]

6.1.1 EPRI GAP Analysis

In addition to the Risk and Benefit Analysis described above, EPRI produced a GAP Analysis to assist in deriving the risks and their criticality for the TCC. It is specific to the existing infrastructure and the ongoing needs of SHE transmission. The Analysis is shown in Table 4.

Need from GAP analysis	Observation	Risk	Consequence	Ranking
Improve situational awareness of system conditions	Failure to observe system events or manage information presented in real time due to lack of suitable space for displays or appropriate presentation	Operational judgement and decision making would be impeded	This could lead to severe disruption to the whole GB power system.	[redacted]
	Operational switching errors	Failure to deliver a safe, secure and reliable Power System	Loss of life, damage to equipment and impact the System such as endangering personnel or reducing security of supply	[redacted]
Improve Physical security	[redacted]	[redacted]	[redacted]	[redacted]
	[redacted]	[redacted]	[redacted]	[redacted]
	[redacted]	[redacted]	[redacted]	[redacted]

	[redacted]	[redacted]	[redacted]	[redacted]
Address lack of space for current operations and accommodate growth of the team	Distraction and operational errors in the Control Room	Switching errors and failure to observe system conditions	Loss of life, damage to equipment and impact the System, such as endangering personnel or reducing security of supply	[redacted]
	Distraction and error in data preparation and commissioning	Switching errors and failure to observe system conditions	Safety and operationally critical information may be missed	
	Insufficient workstations or desk space on them to provide enough displays	Judgement and decision making will be impeded	Reduced capacity within the teams, leading to delay in delivery of customer connections, knock on effects in the GB plan for carbon targets	[redacted]
	The teams are unable collaborate or work efficiently by being segregated	Waste and errors occur through ineffective communication	Delays in TCC outputs such as plan coordination, data preparation, addition of new HV equipment and operational information. This can affect project delivery and operating costs for the ESO.	[redacted]
Create Incident Response capability	[redacted]	[redacted]	[redacted]	[redacted]
	[redacted]	[redacted]	[redacted]	[redacted]

	[redacted]	[redacted]		
Planning for the Future	Additions and changes are not possible due to the space constraints so bringing in new technologies cannot be made within the TCC.	Unable to adapt to future needs	Failure to adapt to future energy scenarios. Loss of capability to operate the network and loss of Transmission Licence	[redacted]
	Suitable and accessible power system training facilities are unavailable	Poorly prepared teams	Ineffective in carrying out obligations such as planning, preparing and operating the network. Loss of capability to operate the network and loss of Transmission Licence	[redacted]

Table 4 - EPRI Gap Analysis

6.2 Costs – Minimum Requirements

As described above, this option will allow for the refurbishment of the existing control centre and the design, construction and deployment of a new contingency site. This is forecast to cost £13.42m, as noted in Table 5.

6.3 Costs – Responsible Operator

As described above, this option will allow for the design, construction and deployment of a new Operations Centre to replace the existing Control Room. This would include the relocation of existing standby facilities to the existing Control Room. This is forecast to [redacted], as noted in Table 6.

6.4 Costs – Progressive Network Enabler

The scope of this option covers the Installation of the "Responsible Operator" approach as well as developing a second Operations Centre in a geographically separate area of our network. This is forecast to [redacted], as outlined in Table 6.

Costs have been determined through experience of similar projects, and through discussions with surveyors and architects. The project will be fully tendered prior to the commencement of the RIIO-T2 period.

	Responsible Operator	Progressive Network Enabler
Land Purchase	[redacted]	[redacted]
Build Costs	[redacted]	[redacted]
Professional Fees	[redacted]	[redacted]
Black Start/Resilience	[redacted]	[redacted]
IT/Furniture	[redacted]	[redacted]
Site Investigation	[redacted]	[redacted]
Groundworks	[redacted]	[redacted]
Utility Connections	[redacted]	[redacted]
Security Enhancements	[redacted]	[redacted]
Control Room Fit Out	[redacted]	[redacted]
Risk & Contingency	[redacted]	[redacted]
Staff Costs	[redacted]	[redacted]
Total	[redacted]	[redacted]

Table 6 - Option Costs

6.5 Cost Benefit Analysis

We have carried out a Cost Benefit Analysis (CBA) using counterfactual Net Present Value (NPV) analysis to demonstrate the potential benefits of each of the shortlisted options, with Option 1 presented as the baseline option for comparison purposes. Our CBA Methodology[17] sets the process and mechanics of our approach to CBA. The results for this CBA, including relevant calculated Net Present Values (NPVs), are summarised below:

CBA reference	Description of Option	Total Forecast Expenditure (£m)	Total NPV (£m)	Delta (Option to Baseline)	Total NPV (inc. Monetised Risk)
Baseline (Option 1)	Refurbishment of existing site, with rebuild in RIIO-T3	[redacted]	[redacted]		[redacted]
Option 2	New build control centre with retention of Inveralmond House facilities as contingency	[redacted]	[redacted]	[redacted]	[redacted]
Option 3	New build control centre and new build of contingency facility	[redacted]	[redacted]	[redacted]	[redacted]

Table 7 - CBA Results

These results demonstrate that Option 2 performs the best in an NPV assessment as it delivers additional value compared to Options 1 or 3.

[17] Cost Benefit Analysis Methodology

6.6 Stakeholder Engagement

These Options were presented in March 2019 to SHE Transmission stakeholders at a stakeholder engagement day. This was done through two exercises asking them to the choose their preferred option.

In both exercises, stakeholders wanted to see SHE Transmission choose the "Responsible Operator" option for control centres.

In round table discussions, whilst a number of stakeholders did feel that "minimum standard" was sufficient as this was what the regulator stipulated, most wanted to see SHE Transmission go further, with one commenting that if a new standby facility were to become the "minimum standard" option in twenty years' time, the company should build it in RIIO-T2.

However, stakeholders recognised that ultimately it was down to cost and so, whilst in an ideal world they would choose "Progressive Network Enabler" to increase the resilience of the network, the significant increase in cost ruled out the "Progressive Network Enabler" option.

Given the feedback above relating to cost, it is clear the right choice of (Responsible Operator) is influenced by the numbers. The question here is if we were to remove the cost from the proposal, we would be picking the option of have two purpose-built control centres that would allow for the complete loss of one TCC and allow the network to be unhindered in its daily operations.

6.7 Proposed Solution

We have examined each of the options in terms of three comparative factors:

- Risk Reduction
- Cost
- Stakeholder Requirements

The Refurbishment option is a significant piece of work in a heavily occupied area. [redacted] Furthermore, the refurbished facilities would only extend the life of the facility until the end of RIIO-T2 so would only be in operation for 2 or so years before it would be obsolete.

[redacted]. (The

[redacted].)

[redacted] There are major shortfalls in what can be realistically achieved with an in-situ refurbishment: there is a risk that money is committed to a solution that is not workable or practical.

By contrast, the offsite build of a new Control Centre poses no risk to the ongoing delivery of Control Centre services. It is also the most efficient in real-estate as the new Control Centre would be built first and only when it was fully commissioned would a gradual transition take place, leaving behind a working contingency site in Inveralmond House. The efficiency of the off-site newbuild option is demonstrated in the CBA analysis as a separate, temporary contingency facility need not be built.

The offsite build option is preferred as it delivers a new build Control Centre that addresses all the needs identified in Section 3, meets stakeholder expectations and the SHE Transmission ambitions for RIIO-T2. This option is also cost efficient against the progressive network enabler option as a contingency site need not be built.

From the Detail Analysis, the Responsible Operator solution to build an off-site control centre is selected.

7. Conclusion

The growth in the SHE Transmission network and our adoption of new technologies is driving increased requirements for real-time control and system monitoring of the network which cannot be facilitated in its current premises. [redacted]

An optioneering assessment took place which investigated 4 options, three of which were taken forward for detailed analysis. From the detailed analysis a significant number of needs were identified which will be addressed by building a new control centre.

The Responsible Operator option will deliver a control centre that:

1. Will improve the efficiency of the whole control centre operation through the implementation of a tiered hierarchal display system for critical information management to maximize system awareness and response. This will be effective for normal system operations and for HILP events such as blackouts and supply restoration.

[redacted]

5. Can provide the appropriate level of training, simulation and authorisation for staff.
6. Will be future proofed to cope with the increase in future expected growth in network size, demand, new connections, and changes for future control and monitoring requirements.
7. Can cope with any repeat of the Covid 19 or another pandemic disease. The new TCC building will have the utilities and space provision to socially distance the all team members and still be fully functional.
8. Will meet the UK and Scottish Government's target of net zero by 2050.

This option will deliver a new Operations Centre with a contingency control centre at the current location. This will be carried out over the course of RIIO-T2 at a [redacted]. This scheme is not flagged as eligible for early or late competition due to it being under Ofgem's £50m and £100m thresholds respectively.

Appendix

Across Europe there are examples of how different countries have prepared for this such as: dedicated switching desks for renewables management, offshore grid management. One common factor in all examples is the importance of situational awareness. Below shows a comparison of overview displays at IHP and Control Centres in Europe. Full comparisons can be found in EPRI report Appendix 2.

Figure 20 - Existing SHE Transmission Control Centre

Figure 21 - Hungary Transmission Control Room[18]

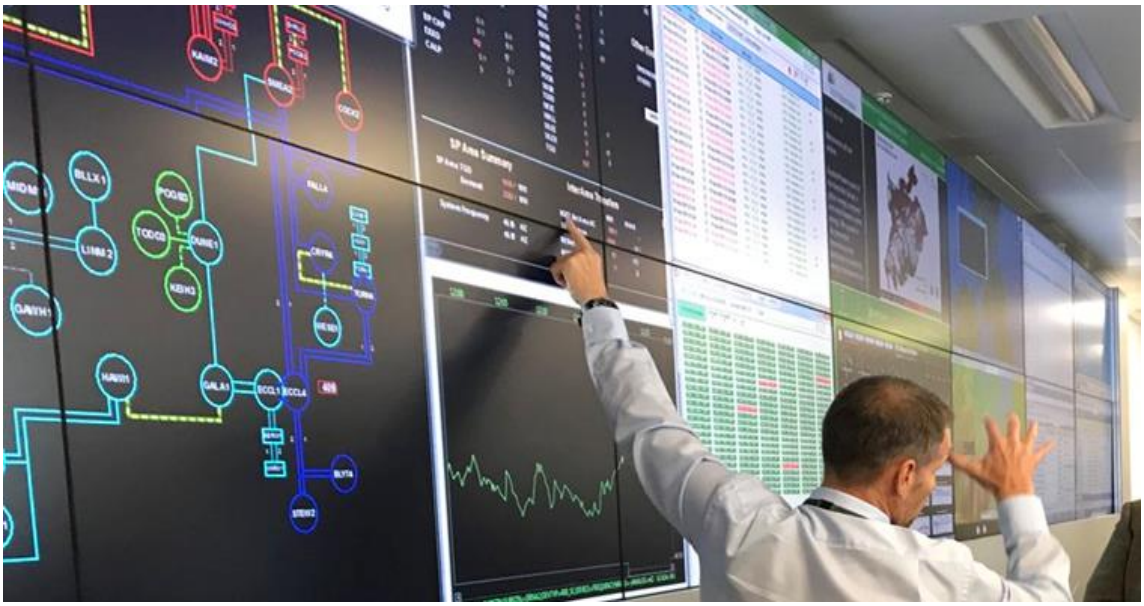


Figure 22 - Scottish Power Transmission Control Room[19]

[18] https://www.linkedin.com/posts/mavirtransmissionity-6692366634625064960-pzZU /

[19] Twitter, @SPENergyNetwork