January 2025 MSIP Reopener

MSIP Central Reactive Voltage Compliance: Ironbridge & Willington

National Grid Electricity Transmission
Medium Sized Investment Project

January 2025

Contents

Investment Summary

Project Name	Central Reactive: Ironbridge and Willington East	**Delivery year**	[redacted] (Ironbridge) and [redacted] (Willington East)

Drivers for the Investment	**NESO driven works to deliver SQSS compliance and voltage control for economic benefit: Installing two new 400kV 200MVAr shunt reactor units at Ironbridge and Willington East substations.** The National Energy System Operator (NESO) have requested that National Grid Electricity Transmission (NGET) install two new shunt reactor units to improve voltage management on the transmission system – one at Ironbridge substation to maintain compliance with the Security and Quality of Supply Standards (SQSS) and one at Willington East substation for economic benefit to minimise potential constraint costs.
Key considerations & challenges	**Time**: Investments should be delivered as efficiently as possible to meet the [redacted] ACL dates, as delays will impact obligations with NESO. Delays would cause consumer detriment from increased security risks or costs from the operation of the system. **Outages**: It is essential to coordinate system access and ensure outage bookings as unavailability to connect to the system would impact the ACL dates. **Futureproofing**: As these units are being installed in existing locations Optioneering has ensured the sites are not sterilised for potential future connections.
Optioneering	For both projects, NGET initially assessed 3 options categories (**doing nothing, market,** and **whole system solutions**). These options were not pursued as they would not provide an SQSS-compliant solution or could potentially increase end-user costs due to potential generation constraints. As a result, NGET then considered the following: For **Ironbridge**, 3 options – 1 to construct a new asset at the Hams Hall site, and 2 options to construct a new asset at the Ironbridge site. For **Willington East**, 2 options to construct a new asset at the substation – either reusing a vacated MSC1 bay or installing the shunt reactor as part of broader [redacted] works at Willington East.
Proposed Solution	**Ironbridge**: Build a new 400kV 200MVAr shunt reactor unit at the Ironbridge substation, utilising the site's former generation 1 bay. This is our preferred option given consideration of relevant factors, including site availability and potential future connections. **Willington East**: Install a new 400kV 200MVAr shunt reactor at the Willington East substation by repurposing a vacated mechanically-switched static capacitor (MSC) bay. This solution is preferred because it efficiently repurposes existing infrastructure while minimising disruption to ongoing site operations. NGET are confident that these two investments will benefit current and future consumers by delivering the required outputs in the most cost-effective and efficient way while aligning with NESO's directive to improve voltage management on the transmission system.
Outputs of the Investment	**Reactive power capability**: Both investments will deliver 200MVAr 400kV shunt reactors to maintain voltage on the transmission system within the required limits.
PCD Primary Output	**Ironbridge:** Delivery of a new 200MVAr 400kV shunt reactor to maintain SQSS compliance. **Willington:** Delivery of a new 200MVAr 400kV shunt reactor for economic benefit.
Estimated Cost (price base 2018/19)	**Ironbridge:** The current total cost of the project is [redacted]. The current direct cost of the project, and funding and funding allowance being sought, is [redacted]. **Willington East:** The current total cost of the project is [redacted] The current direct cost of the project is [redacted].

Spend profile	**T2 (FY2022 – FY2026):** Ironbridge: [redacted] Willington East: [redacted]	**T3 (FY 2027 – FY2031):** Ironbridge: [redacted] Willington East: [redacted]	**T4+ (FY 2032+):** Ironbridge: [redacted] Willington East: [redacted]
Reporting table	Forecast reported in RRP E1.11 Data table and BPDT 10.5 Pipeline log.	**PCD Modification Process**	Special Condition 3.14, Appendix 1
Historic funding interactions	No existing funding in RIIO-T1 or RIIO-T2 for either project. These projects represent two of a suite of seven shunt reactors being delivered by NGET under the direction of NESO. While the other five units have secured funding via the T2 baseline, no funding exists to deliver these additional two units – funding is subsequently being sought.		

1. Executive summary

1.1 Context

This paper summarises NGET's proposed investment to deliver **two new 400kV 200MVAr shunt reactor units** in the West Midlands – one at the Ironbridge substation, and the other at the Willington East substation – and seeks to demonstrate the consumer interest in the associated investments.

In line with former National Grid Electricity System Operator (ESO), now the National Energy System Operator (NESO) requirements, one shunt reactor will be for SQSS compliance (Ironbridge), and one will be for economic benefit (Willington East), to reduce potential constraint costs which would negatively impact consumers.

This Medium Sized Investment Project (MSIP) paper seeks approval of the need for the investment, as well as approval of the proposed solution and requests funding allowances for efficient spend on the project.

1.2 What is the background to this Investment?

NESO voltage control driver

In 2022, the former ESO (referred to throughout this document as NESO) commissioned National Grid Electricity Transmission (NGET) to investigate and advise whether the NGET network is expected to be compliant with Security and Quality of Supply Standard (SQSS) voltage limits in summer scenarios for 2025. As part of this, NESO and NGET determined the need to install seven new shunt reactors at various existing 400kV substations to provide additional voltage control on the network for SQSS compliance and economic benefit.

Shunt reactors are a form of inductor that absorb reactive power, thereby helping to increase the energy efficiency and stability of the system. By maintaining voltage within acceptable limits, the reactor prevents high-voltage issues that can disrupt network operations and require costly interventions. This increased stability reduces the need for expensive constraint management measures, such as re-dispatching power or curtailing generation, thereby minimising operational inefficiencies and ultimately lowering costs for consumers.

There is a growing need for greater voltage control as the share of variable renewable energy in the grid increases. Increasing capability to manage reactive power via shunt reactors subsequently aligns to NGET's strategic priorities and will help to enable the UK's Clean Power 2030 target.

The Willington East and Ironbridge shunt reactors form two of a portfolio of seven shunt reactor units. Five of the seven units are being funded in the RIIO-T2 baseline. This is because when NESO's request came in 2022, we established that there was remaining RIIO-T2 baseline funding which could be used to deliver 5 of the requested 7 shunt reactors. This MSIP is subsequently seeking approval for the need and associated funding allowances for the additional 2 shunt reactors.

The current out-turn estimates for delivering the other five shunt reactor units are higher than the original T2 allowance for several reasons, including that the material cost of shunt reactor units has increased significantly. Primary plant and equipment materials costs have increased [redacted] since T2 allowances were agreed. As a result, NGET have identified a [redacted] shortfall in delivering the five units – with the excess being shared between NGET and consumers through the TIM – while no funding exists to deliver these additional two units.

This paper seeks approval of the delivery of two additional shunt reactors (Ironbridge and Willington East), which were not identified as required at the time of RIIO-T2 final determinations and as such are additional outputs which require additional funding[1].

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1 [redacted]

Siting: Selecting Ironbridge and Willington East

To achieve the voltage management objectives outlined above, NESO recommended that NGET install shunt reactors across several regions – including the West Midlands. Outside of London, this region is experiencing the fastest increase in reactive injection from the distribution networks.

As part of this overarching programme of work, NESO recommended that NGET build one of the West Midlands shunt reactor units at Ironbridge for SQSS compliance, noting NGET may also explore similar prospective sites in the region.

In addition to the shunt reactor unit at Ironbridge, as part of this voltage control assessment, NESO delivered an economic assessment for reactive investment and identified that an additional reactor was required for economic benefit in the West Midlands region. NESO originally proposed Ironbridge for this economic shunt reactor, however as Ironbridge had already been identified as a location for an SQSS compliance unit, the West Midlands requirement was re-evaluated and Willington East was subsequently identified as the most effective location to achieve required output.

Once a demand-heavy region, Willington is now a critical hub for new generation capacity, playing a key role in delivering renewable energy to the grid and supporting the UK's transition to net zero. [redacted]

1.3 What have we considered in developing options for this investment?

NGET assessed a range of solutions to meet the investment drivers in a way that best serves the interest of consumers. In line with our optioneering process, we considered options to do nothing, or to utilise market or whole system solutions. These options were discounted as they would risk licence non-compliance and increasing consumer costs. In line with NESO direction, NGET determined that new shunt reactor assets were required to enable greater voltage management and keep voltage within defined tolerances.

For the **Ironbridge** shunt reactor unit, NGET considered three options to install shunt reactors across the two electrically suitable sites:

- Construct a new asset at Ironbridge:
    - Option E-1: New asset at Ironbridge Generator 1 Bay.
    - Option E-2: New asset at Ironbridge Generator 2 Bay.
- Option E-3: Construct a new asset at Hams Hall.

Following this initial optioneering process, NGET determined that whilst both sites would be electrically suitable, Ironbridge had an existing spare bay that could be utilised whereas Hams Hall would require substantially more construction works.

Having identified Ironbridge as the preferred site, NGET evaluated 2 shortlisted options to install a new 400kV 200MVAr shunt reactor unit at Ironbridge: Option E-1 and Option E-2. While NGET determined that both options would have analogous cost profiles for delivery, the key difference between the two related to the ease of buildability and safety, noting that Option E-2 would see the shunt reactor located adjacent to live equipment.

For the **Willington East** shunt reactor, NGET considered two options:

- Option E-1: Reuse the vacated MSC1 bay at Willington East for shunt reactor.
- Option E-2: Installing the shunt reactor in a location further east in an extension of the substation.

[redacted]

[redacted]

[redacted]

To address this challenge, NGET initiated an optioneering process to explore alternative solutions. The key considerations that guided this process considered minimising disruption to ongoing operations, future network requirements, land and consent considerations, delivery timelines, and the efficient use of existing infrastructure.

[redacted] The solution needed to support future expansion and avoid the site's capacity being constrained by the reactor's placement or related infrastructure. As a result, Option E-1 was ultimately selected as the preferred final option.

1.4 What is the preferred option and what outputs does it deliver?

<u>Ironbridge</u>: **The preferred option is to build a new 400kV 200MVAr shunt reactor unit at the Ironbridge substation utilising the site's former generation 1 bay (Option E-1).** This option aligns with the key investment driver to enable project delivery by 22 July 2025 to ensure SQSS compliance. This solution utilises existing space within the Ironbridge substation, avoiding the need for expensive substation extensions. This project benefits from bulk procurement activities associated with the delivery of the other five shunt reactors as part of the Central Reactive Shunt Reactor Programme. In addition, this option incorporates an offline build, meaning the reactor bay will be constructed offline, thereby minimising the length of the outage needed at the site to install the shunt reactor. [redacted]

<u>Willington East</u>: **The preferred option is to build a new 400kV 200MVAr shunt reactor at the Willington substation by repurposing the vacated MSC1 bay (Option E-1).** The solution involves the reuse of existing assets and site infrastructure. Removal and demolition of the existing redundant MSC1 bay was completed in [redacted] enabling the construction of a new shunt reactor bay. This option provides the best balance between addressing immediate needs and supporting the long-term growth of the Willington East substation. [redacted]

These preferred options will ensure the timely delivery of shunt reactors, ensuring NGET meets NESO's objective to improve voltage capacity on the transmission system, thereby protecting the interests of consumers by helping to avoid network inefficiency and potential constraint cost.

The solution carries lower delay risks [redacted]

1.5 How has future proofing been considered in the proposed investment?

These shunt reactor units will play a key role in future-proofing the network, enabling the connection of renewables, reducing the risk of higher constraint costs, and will help secure the network for the coming years. These investments align with NGET and NESO's shared goal of improving voltage capacity on the transmission system while protecting the interests of consumers by helping to avoid network inefficiency and potential constraint costs. This will deliver strong consumer benefits by enabling the delivery of a stable and efficient electricity network.

Additionally, by selecting the appropriate locations for these shunt reactors, we have been able to form deliverable packages of works that align with NGET's strategic priority of delivery efficiency for consumers. At Ironbridge, we are using on-site suppliers with NGET executing the delivery to ensure cost efficiency. The existing disconnectors were identified as suitable for refurbishment, ensuring a commissioned in-service circuit life of 40 years.

The decision to install the second West Midlands shunt reactor unit at Willington East acknowledges that there will be more generation at this site in the future, marking it as a strategic site selection. The existing redundant MSC1 bay is being repurposed for the new 400kV 200MVAr shunt reactor unit, enabling an efficient use of space while reusing the old MSC for training purposes.

Both projects benefit from bulk procurement activities, as the shunt reactor units have been purchased in combination with the other five units, including other primary equipment. There is also a single designer across all seven shunt reactor schemes, allowing detailed design to commence earlier for greater programme efficiency.

At both sites, the solutions utilise existing space within the substations, thereby negating the need for expensive substation extensions. Re-using existing assets and site infrastructure where possible, the designs consider all known future connections and potential substation alterations and reconfigurations, ensuring the correct and appropriate choice of associated HV equipment, such as circuit breakers.

1.6 What are the uncertainties and how have they been accounted for?

Several risks and uncertainties have been considered in relation to the preferred options selected for the Ironbridge and Willington East sites:

Delivery delays: There is a risk that the shunt reactor, primary plant or protection and control solution delivery is delayed to site due to supply chain issues. Mitigation strategies are in place to avoid the impact on ACL dates. These include activities such as early procurement of key plant items and advance site works.

Outage availability: There are challenges in retaining outage dates due to potential deferment for unrelated emergency works in other areas of the network as well as Emergency Return to Service (ERTS) requirements. This is being mitigated by constructing the bays off-line, with only the final connection and commissioning requiring outages.

Freight costs: Expenses may be higher than anticipated and are reimbursable to the supplier. This could be due to the health condition of 3rd party assets, such as Highways England owned bridges as well as privately owned assets along the agreed route. This could dictate replanning of the route and hence incur additional costs. This is being mitigated by additional surveys and inspections where appropriate which also have the potential to increase the overall project costs.

Site-based risks – Ironbridge: There are a number of general site-specific risks, including encountering unforeseen buried services during works, asbestos, and unforeseen ground conditions – particularly as works are occurring largely in a greenfield area and within some areas of the existing 1960s-build substation where records of what is below the ground may be limited. These risks would require additional time and cost to remove. These risks have been mitigated as much as possible by conducting thorough surveys, ground investigations and constant assessment of the site through the demolition process

- **Structural Integrity of previously owned power station access bridge:** The existing heavy access route through the old power station involves crossing a river. This area (including the bridge spanning the river) has [redacted] The bridge has not been maintained to the required standard for heavy loads. Further surveys are being undertaken to evaluate the suitability of this structure. Additionally, an alternative route has been identified and is being evaluated in parallel for the safest and most cost effective solution.
- **Decommissioned Coal Travelator:** There is a decommissioned coal transport system between the access point and the shunt reactor plinth. Structural surveys are being undertaken to ensure that this is suitable to be crossed without modification. The outcome of these surveys will identify if any further works are required such as subterranean supports or structural reinforcements.

Site-based risk – Willington East: Similar to Ironbridge, the works are within the existing substation where records may be limited however, enabling works to demolish and clear the MSC bay have been completed ahead of time so that the bay is clear for the main works contractor to start their works. Two significant risks include:

- **Structural integrity of [redacted] bridge on shunt reactor transportation route:** [redacted] downgraded bridge on the transportation route for the shunt reactor late 2024 which could affect any large deliveries in or out of Willington East 400kV substation. Further structural assessments have been procured and a 'bridge over bridge' solution is being investigated as a contingency plan. NGET are liaising with [redacted] to mitigate this risk.

- **Interface between free issue suppliers and main works contractor:** Potential programme delays due to splitting of work packages between [redacted] Equipment was procured ahead of time to mitigate delays due to manufacturing lead times however, the main works contractor would usually coordinate this design and construction of switchgear and protection equipment. Coordination of design and delivery of work packages is critical to avoid this risk and a thorough Division of Responsibility has been produced and reviewed by all parties to mitigate delays.

Following direction from NESO, NGET is delivering a series of shunt reactors across England to ensure the grid has the necessary assets to keep voltage within defined tolerances. This paper demonstrates the assessment undertaken to consider options to install two of these new shunt reactors – one at the Ironbridge substation and one at the Willington East substation. The assessment process for each shunt reactor sought to balance the need to deliver the connections within timeframes, utilise existing assets and land, and provide an efficient long-term solution for the network.

The conclusion of NGET's analysis is its proposed construction of a new 400kV 200MVAr shunt reactor unit at Ironbridge substation's former generation 1 bay, and another new 400kV 200MVAr shunt reactor at the Willington East substation by repurposing a vacated MSC1 bay.

2. Introduction

2.1 Project background

The purpose of this submission is to provide evidence for the investment needs case and consumer benefit of NGET's proposed solution for two new shunt reactors in the Midlands. The shunt reactors will play a key role in voltage management during load variations and providing reactive power compensation.

The project will deliver strong value to consumers by avoiding network inefficiency and potential constraint costs which could otherwise lead to cost increases.

2.1.1 MSIP eligibility

These investments were not included in NGET's RIIO-T2 baseline plan. As outlined in Section 1.2, these two shunt reactors are part of a portfolio of seven shunt reactor units. Five of these seven units are being funded through the RIIO-T2 T2 baseline, however, no funding exists to deliver these additional two units.

These investments require MSIP funding as they are not eligible for the demand or generation uncertainty mechanism volume drivers. These shunt reactors will not export power in the form of MW as a generator would, or import power which is measured in MVA via a Super Grid Transformer (SGT) like a typical demand customer. As such, neither the demand not the generation Uncertainty Mechanism can be applier, as there is no output upon which to calculate allowances.

NGET are subsequently seeking allowances for these investments under clause 3.14.6 (f) of the MSIP reopener mechanism.

2.1.2 Chronology to the request

NESO and NGET have worked collaboratively to assess network compliance in England and Wales during summer 2025. The outcome of this work is the requirement for seven 400kV 200MVAr shunt reactors. Three of these shunt reactors (including Ironbridge) are required to maintain compliance with the deterministic criteria of the SQSS for voltage stabilisation to ensure voltage stays within requirements. Four units (including Willington East) have been requested by NESO to reduce balancing cost. These units would offset the need to run a generator, which NESO estimate could reduce operational costs in 2025 [redacted]

NGET has RIIO-2 Baseline allowances to develop and deliver five shunt reactor units, with the remaining two (Ironbridge and Willington East) being considered under this MSIP submission.

On 13 April 2022, the then National Grid Electricity System Operator (now NESO) submitted a planning request [redacted] The request was for NGET to investigate and advise NESO if the NGET network is expected to be compliant with SQSS planning limits in summer scenarios for 2025. NGET worked closely with NESO to determine an appropriate background and completed the necessary studies to assess compliance against the deterministic criteria of the Security and Quality of Supply Standards.

NESO proposed the requirement for seven new shunt reactor units. This comprised of three to comply with the SQSS requirements and four for economic management of the network. The selected regions were the West Midlands (2 units), East Midlands (2 units), South East, South West, and South Central.

2.1.3 Importance of the investment

Traditionally, reactive power services have been provided by large thermal generators like coal and gas owners. However, as the UK continues to transition towards low and zero carbon electricity sources and access to large generators is reduced, NESO need new ways to manage the changing patterns of reactive power and maintain voltage control. NESO have reported a continual increasing need to absorb reactive power and prevent high voltage levels.[2] Reactive power services provide the mechanism to ensure voltage levels on the system remain within a given range, as mandated in the SQSS.

2.2 Regional and strategic context

The transmission system in the Midlands consists of 400kV North-to-South circuits in the East and a 400kV outer ring and 275kV inner ring in the West. The West Midlands is a large demand centre and acts as a "transfer bar" for northern generation flows reaching demand centres south of the Midlands. It has the highest concentration of manufacturers of any region and accounts for 9% of all manufacturing employment in Britain.

The West Midlands region is reliant on generation which is located a long way from this region. The region has the second steepest increase in reactive power injection from the distribution networks.

Substantial alterations to the electricity network along the route to decarbonisation in 2030 will impact flows on the network and the way reactive power is utilised across the network, and therefore will have consequences on the system voltage profile. In addition, as more generation moves to the edge of the network with the growth in offshore wind connections, and with a diminishing reliance on conventional generation from the middle of the network, there will be an increasing need for new reactive compensation solutions.

Decarbonisation will also increase the variability in demand and generation (particularly weather dependent generation), which will subsequently lead to much more variable power flows across the network, as supported by NESO Clean Power 2030 report. High wind scenarios will result in large North – South power transfer which will pull voltages down; whilst growth in embedded generation such as solar and wind will create more lightly loaded scenarios leading to higher network voltages.

To maintain voltages within limits, whilst enabling power transmission from generation to customers, reactive power compensation is required around the network (voltage issues are localised, as reactive power does not travel). NGET has an obligation under our Transmission Licence to design the network adhering to the requirements of the SQSS. This includes planning and developing the network to enable it to meet the voltage limits defined within SQSS Chapter 6.

Shunt Reactors are an established asset-based solution to address high voltages on the electricity transmission network. A dedicated substation bay is required for this size of the units (200MVAr) being considered as part of this MSIP.

2.3 T3 interactions

While this MSIP is being submitted under the RIIO-T2 price control period, it interacts with and complements initiatives outlined in NGET's RIIO-T3 Business Plan. As outlined in our T3 Business Plan, we are developing new infrastructure and enhancing existing networks in the Midlands to ensure adequate capacity for electricity transmission in and out of the region.

Shunt reactors play an important role in maintaining the stability of the system, particularly as the share of variable renewable energy sources entering the grid network increases. Noting the volume of variable renewable energy sources coming online, as outlined in our Business Plan, enabling reactive power capabilities is an important mechanism in ensuring a compliant network. [redacted]

Table 1 - Alignment with Ofgem T3 consumer outcomes

Infrastructure fit for a low-cost transition to net zero	Shunt reactors play an important role in this by absorbing reactive power. There is a growing need for greater voltage control as the share of variable renewable energy in the grid increases. This investment will therefore support the increase

[2] https://www.neso.energy/news/noa-voltage-pathfinder-pennine-tender.

	of renewables on the grid and supports the delivery the infrastructure needed for a net zero electricity grid.
Secure and resilient supplies	By helping to increase the energy efficiency and stability of the system, these shunt reactors will play an important role in enabling a resilient and efficient grid.

3. Establishing Need

3.1 Overview

This section sets out the key driver of the investment need. This is summarised in Table 2 below. As these investments come as a result of NESO direction, we have worked collaboratively with NESO to agree the most appropriate site for the shunt reactor units to enable voltage control and avoid constraint costs.

Table 2: Summary of Investment Drivers

Summary of Primary Drivers		Delivery date
SQSS compliance	Ensuring the timely delivery of the Ironbridge shunt reactor unit helps NGET maintain compliance with the Transmission Licence.	[redacted]
Economic benefit	Delivering the Willington East shunt reactor unit on-schedule will help reduce end user costs by avoiding potential generation constraints.	

3.2 Existing and planned future network

Upgrades have been planned to improve power flow through the Midlands into Southern England. Up to 2033, NESO expects that power will generally flow from North to South in the Midlands region. The Midlands is predominantly a net importer whereby excess power on the transmission network flows into this region due to the high load demands in and around the regional centres and manufacturing plant. Circa 16% of national power demand is within the Midlands (East & West). West Midlands specifically took 8.5% of the national power demand in 2022.

Eight major substation interventions are planned across the region for the RIIO-T3 period, including NGET's Chesterfield to Willington project – part of the Great Grid Upgrade – to help connect new low carbon projects and increase energy security.

The Willington 400kV substation is located 9km southwest of Derby, DE65 6DG. The substation is located between River Trent to the South with the railway and Trent & Mersey canal to the north. [redacted]

4. Optioneering

This section summarises the options we considered to address the needs case established in the previous section, in a way that best serves the interest of current and future consumers.

In line with our standard optioneering process, we identified the following high-level options:

A. Identification of a do-nothing option as the counterfactual option.
B. Identification of a market-based solution.
C. Identification of a non-transmission, whole system solution.
D. Identification of options which make use of existing assets.
E. Identification of possible options for new assets.

In summary:

- **Options A-C** were discounted because they would either not deliver an SQSS compliant solution or have the potential to result in increased costs to consumers due to generation constraints.
- **Option D** was discounted because, in line with NESO analysis, enabling SQSS compliance and economic benefits requires the delivery of new shunt reactor units.
- Under **Option E**, NGET considered three sub-options to construct a new asset (a new shunt reactor) at two prospective existing substations (Ironbridge and Hams Hall), and two sub-options to construct a new asset at Willington East.

For the **Ironbridge** shunt reactor unit, NGET first considered site selection – specifically whether to locate the shunt reactor at Ironbridge or Hams Hall noting both locations would provide equivalent reactive benefit. Initial options were:

- Option E-1: New asset at Ironbridge Generator 1 Bay.
- Option E-2: New asset at Ironbridge Generator 2 Bay.
- Option E-3: Construct a new asset at Hams Hall.

Following this initial optioneering process, NGET determined that whilst both sites would be electrically suitable, Ironbridge had an existing spare bay that could be utilised whereas Hams Hall would require substantially more construction works.

Having identified Ironbridge as the preferred site, NGET evaluated 2 shortlisted options to install a new 400kV 200MVAr shunt reactor unit at Ironbridge: Option E-1 and Option E-2. While NGET determined that both options would have analogous cost profiles for delivery, the key difference between the two related to the ease of buildability and safety, noting that Option E-2 would see the shunt reactor located adjacent to live equipment.

For the **Willington East** shunt reactor, NGET considered 2 options:

- Option E-1: Reuse the vacated MSC1 bay at Willington East for shunt reactor.
- Option E-2: Installing the shunt reactor in a location further east in an extension of the substation as part of the Willington [redacted] works.

The initial phase of the Willington East shunt reactor project began with a design proposal that identified the reactor's location as part of a broader substation extension. The initial plan was to install the shunt reactor in a spare bay within the new Willington Rebuild substation extension (Option E-2). [redacted]

As a result, a different location was selected, requiring a previously decommissioned MSC to be disconnected and removed from site to make space for the new shunt reactor (Option E-1 [redacted]

[redacted] Any solution selected needed to support future expansion and avoid the site's capacity being constrained by the reactor's placement or related infrastructure.

4.1 Description of the options

4.1.1 Ironbridge: Shortlisted options

Two prospective sites were considered for the new shunt reactor unit to be installed at the Ironbridge substation.

Option E-1: This option would involve placing the new shunt reactor in a spare space within the existing Generator 1 Bay. It would include the reuse of Main and Reserve busbar disconnectors and earth switches, as well as civil works for switchgear and wall bushings. The physical space to accommodate the new shunt reactor would be limited, with potential use of the grassed area outside the current perimeter fence required.

Option E-2: This option proposes locating the new shunt reactor in the vacated Generator Bay 2. Similar to Option E-1, the physical space available for the new shunt reactor would be limited. During construction, the MSC2 connection busbars would need to be removed, resulting in an extended construction outage for the duration of the works. Additionally, construction access would be restricted and may necessitate a significant outage of the SGT bay.

[redacted]

5.1.2 Willington East: Shortlisted option

Initially, the Willlington East shunt reactor was allocated a spare bay in the new substation extension. [redacted] In order to progress the shunt reactor [redacted] further development work was required to remove a redundant MSC and locate the shunt reactor in that vacated bay.

[redacted]

[redacted], [redacted]

4.2 Qualitative option description

Table 3 below provides a summary of our qualitative assessment of key differentiating criteria considered at each site. As only one option was ultimately shortlisted for Willington (noting Option E-2 was no longer deemed viable, as outlined in section 5.1.2) only one option is presented for the Willington shunt reactor. Across shortlisted options, NGET determined that there was no difference between options in terms of environmental impact, cost, operation and maintenance requirements, third party impact and network coordination.

Table 3: Summary of qualitative analysis of shortlisted options

Option #	Ironbridge E-1	Ironbridge E-2	Willington East E-1
Option title	**New asset at Generator 1 Bay**	**New asset at Generator 2 Bay**	**Reuse vacated MSC1 bay for shunt reactor**
Time Preferred option: E-1	E-1 is deemed to be more time efficient than E-2, as it requires less system access and minimal dismantling and rebuilding of existing assets.	Requires an extended outage period (circa 9 months) compared to E-1, reducing the likelihood of securing the outage. Existing equipment would be required to be removed, reinstalled and recommissioned to facilitate the reactor build hence increasing the programme duration.	Utilising the existing MSC bay will allow the shunt reactor instillation process to progress [redacted]
Safety, health and security Preferred option: E-1	Option E-1 involves less live in-service adjacent equipment. Cables in grass verge. Temporary works during skidding of unit. Existing piled foundations left in situ.	Hemmed in by adjacent bus bars during construction and operational/maintenance phases. SGT bus bars pass over delivery route. Existing piled foundations left in situ.	Offline build in northeast corner of the site with adequate space for construction around the bay.
Planning, land and consent Preferred option: No overall advantage to either option.	Within National Grid operational land (subject to checks on requirements on grass verge).	Within National Grid operational land.	On National Grid operational land within existing operational substation boundary.
Design and technical complexities Preferred option: E-1	Operational preference due to outage availability in future.	Legacy circuit difficult to get outages. Increased commissioning resource requirements due to MSC2 interactions.	Locating the shunt reactor in this vacated bay means it will be physically closer to existing assets.

4.3 Preferred solution

Based on our analysis we have recommended **Option E-1 for the Ironbridge shunt reactor** and **Option E-1 for the Willington East shunt reactor**.

Overall, NGET are confident that these two investments will benefit current and future consumers by delivering the required outputs in the most efficient way, repurposes existing infrastructure while minimising disruption to ongoing site operations. These options will enable NGET to deliver an outcome that aligns with NESO's directive to improve voltage management on the transmission system.

The process of assessing the location and connection of shunt reactors at each location did not require a detailed cost benefit analysis due to the comparability of the works to be undertaken. It was deemed that carrying out a CBA was not proportionate to making and investment decision. Our assessment of the options has shown that the preferred option selected offers the safest and most efficient solution for consumers, enables the earliest customer connection date, and enables safer installation.

[redacted]

The preferred option is to install a new 400kV 200MVAr shunt reactor unit at the Ironbridge substation, utilising the site's former generation 1 bay. This solution avoids the need to expand the site to accommodate the unit, providing a realistic and straightforward solution. This solution incorporates efficiencies by focusing on refurbishment and reuse of space on site, as opposed to requiring extensive rebuilds. NGET determined this option offered greater buildability when compared to the option to place the shunt reactor at the site's former generation 2 bay, as there is less adjacent equipment, meaning building is easier, safer and more efficient.

The scope of work for the preferred option comprises design, supply, construction and commissioning of:

[redacted]

[redacted]

The preferred option is to install a new 400kV 200MVAr shunt reactor at the Willington East substation by repurposing a vacated a mechanically-switched static capacitor (MSC) bay. This solution is preferred because it efficiently repurposes existing infrastructure while minimising disruption to ongoing site operations.

The preferred solution utilises existing space within the substation, reducing the need for substation extension which would increase costs. The solution also involves the reuse of existing assets and site infrastructure where possible. Removal and demolition of the existing redundant MSC1 bay was completed in August 2024, with the removed assets being moved to National Grid's Eakring Training Centre to assist for new training courses in the future.

The Willington East shunt reactor project will be delivered alongside the site extension by the same project team and principal contractor, [redacted] This increases efficiency by avoiding the need for repeated works at site.

The scope of work for the preferred solution comprises design, supply, construction and commissioning of:

[redacted]

[redacted]

5. Detailed cost for preferred solution

5.1 Detailed costs for Ironbridge Shunt Reactor

5.1.1 Introduction

This section provides a breakdown of the overall costs for Ironbridge shunt reactor including an expenditure profile for all Regulatory Years of delivery.

The following cost estimate breakdown represents our latest view of costs for the proposed investment and all costs are presented in 2018/19 price base, unless otherwise stated.

Appendix A Cost Model submitted alongside this document provides a breakdown of the costs in more detail and should be reviewed alongside this chapter.

This section is broken down into the following sections:

- Total Allowance Request
- Cost Summary
- Cost Firmness.

5.1.2 Total Allowance Request

Total project costs are [redacted]. NGET requests [redacted] allowance is provided through the MSIP reopener mechanism to recover the direct portion of costs and deliver works described above. The MSIP reopener mechanism is subject to the Opex escalator and therefore indirect costs will be funded under this route.

Table 4 - Allowance request – Cost Model tab reference 1.0

	2018/19 price base (£)			
	2023/24	2024/25	2025/26	Total
Total Project Costs	[redacted]	[redacted]	[redacted]	[redacted]
CAI	[redacted]	[redacted]	[redacted]	[redacted]
Allowance Request (Direct Only)	[redacted]	[redacted]	[redacted]	[redacted]

5.1.3 Cost Summary

The total cost to develop and deliver the Ironbridge shunt reactor project is [redacted] including indirect costs and costs incurred to date.

The table below shows a summary of total project costs.

Table 5 - Cost Summary – Cost Model tab reference 1.1

Element	Total (2018/19 price base, £)	CAI/direct
[redacted]		
[redacted]	[redacted]	[redacted]
[redacted]		
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
Total	[redacted]	

5.1.4 Cost Firmness

Table 6 below shows the assessment of cost firmness using the classification outlined in the Ofgem LOTI reopener guidance document published on 29th March 2021. [redacted]

Table 6 - Cost Firmness – Cost Model Tab reference 1.9

Cost Firmness	Total (£)	Notes
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	
[redacted]	[redacted]	

Estimated costs relate to National Grid resource costs, calculated based on forecast days and standard rates, as well as risk for the remainder of the project.

5.2 Detailed costs for Willington East Shunt Reactor

5.2.1 Introduction

This section provides a breakdown of the overall costs for the Willington East shunt reactor project including an expenditure profile for all Regulatory Years of delivery.

The following cost estimate breakdown represents our latest view of costs for the proposed investment and all costs are presented in 2018/19 price base, unless otherwise stated.

Appendix A Cost Model submitted alongside this document provides a breakdown of the costs in more detail and should be reviewed alongside this chapter.

This section is broken down into the following sections:

- Total Allowance Request
- Cost Summary
- Cost Firmness.

5.2.2 Total Allowance Request

Total project costs are [redacted] NGET requests [redacted] allowance is provided through the MSIP reopener mechanism to recover the direct portion of costs and deliver works described above. The MSIP reopener mechanism is subject to the Opex escalator and therefore indirect costs will be funded under this route.

Table 7 - Allowance request – Cost Model tab reference 1.0

	2018/19 price base (£)			
	2023/24	2024/25	2025/26	Total
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

5.2.3 Cost Summary

The total cost to develop and deliver the Willington East shunt reactor project is [redacted] including indirect costs and costs incurred to date.

Table 8 below shows a summary of total project costs.

Table 8 - Cost Summary – Cost Model tab reference 1.1

Element	Total (2018/19 price base, £)	Classification
[redacted]		
[redacted]	[redacted]	[redacted]
[redacted]		
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

5.2.4 Cost Firmness

Table 9 below shows the assessment of cost firmness using the classification outlined in the Ofgem LOTI reopener guidance document published on 29th March 2021. [redacted]

Table 9 - Cost Firmness – Cost Model Tab reference 1.9

Cost Firmness	Total (£)	Notes
[redacted]	[redacted]	[redacted]

Cost Firmness	Total (£)	Notes
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

Estimated costs relate to National Grid resource costs, calculated based on forecast days and standard rates, as well as risk for the remainder of the project.

6. Deliverability and risk

6.1 Deliverability

This section sets out a summary of the key activities pertaining to the delivery of the project, including the current high-level programme plan, procurement strategy and anticipated risks.

6.1.1 Delivery Programme

For the **Willington East** unit, the main works contract was awarded on [redacted] First site access is scheduled for [redacted] with the shunt reactor scheduled to be delivered [redacted] ACL for the project is 20 February 2026.

For the **Ironbridge** unit, [redacted] the most efficient and effective delivery model was to deliver the scheme in-house. First site access occurred on [redacted] with the shunt reactor scheduled to be delivered on [redacted]. While ACL was originally scheduled for 31 March 2025, this has shifted to 22 July 2025 due to [redacted]

6.1.2 Procurement and Contracting Strategy

The Procurement Strategy for both projects was driven by the initial decision to deliver the shunt reactor project via an In-House Delivery model whereby ET Asset Operations will undertake the role of Principal Contractor and utilise existing frameworks for the most efficient delivery of the works similar to the previously proven Pennine Pathfinder delivery model. [redacted]

Due to extensive future works at Willington East 400kV substation, the Procurement strategy for the Willington East shunt reactor has been revised to align the project to the future site extension works. There will be efficiencies from using the same Client Project Team, Principal Contractor and similar procurement route. [redacted]

6.1.3 Risk and Risk Management

A risk management process has been used for managing reasonably foreseeable risks. The process employed is in line with ISO 31000:2009, Risk Management – Principles and Guidelines.

Table 10 and Table 11 below list the key risks identified for the project. The full Risk Register is included in tab 4.1 of the Cost Model appended to this submission.

Table 10: Delivery risks for Ironbridge

Risks	Mitigation
Site Access route for Reactor delivery constraint due to surrounding land redevelopment.	We have identified a potential secondary route. [redacted] Structural surveys are being undertaken to ensure that this is suitable to be crossed without modification.

Risks	Mitigation
Supplier Primary Equipment Delays due to market saturation.	We are engaging in early procurement activities and proactive supplier management. We are looking utilise existing equipment where possible and/or relocate for other schemes with further out energisation dates.
Unknown Services and Ground Conditions.	We are conducting early detailed surveys, ground mapping and investigations. We are reviewing existing information with special consideration for previously removed equipment and historical construction records.

Table 11: Delivery risks for Willington East

Risks	Mitigation
Supplier Primary Equipment Delays due to market saturation.	We are engaging in early procurement activities and proactive supplier management. We are looking utilise existing equipment where possible and/or relocate for other schemes with further out energisation dates.
Unforeseen ground conditions/obstructions encountered during excavations	We are reviewing existing records, GPR TOPO surveys and ground investigation i.e. trial holes and trenches.
Outage availability	Confirming outage, Cancellation, Reduction and Emergency Return to Service (ERTS) due to other Risk factors.
Freight cost and delivery delays	[redacted]

6. Conclusion

This document is NGET's MSIP re-opener submission to Ofgem for the delivery of two new 400kV 200MVAr shunt reactor units in the West Midlands – one at the Ironbridge substation, and the other at the Willington East substation. It is submitted with reference to Special Condition 3.14 (paragraph f) of NGET's Transmission Licence.

Table 12 below summarises the main investment driver, the selected option, estimated costs and expected outputs.

Table 12: Ironbridge and Willington East Central Reactive Investment Summary

<table>
<tr><td>Main drivers</td><td colspan="3">To enhance voltage control and comply with SQSS, NESO has directed NGET to install two new 400kV 200MVAr shunt reactors, one at Ironbridge and one at Willington East substations. Delivering these new shunt reactors will provide voltage management, ensure network compliance, mitigate potential constraint costs and provide cost-efficiency for consumers.</td></tr>
<tr><td>Selected Option</td><td colspan="3">Deliver one new shunt reactor unit at Ironbridge substation's former Generation 1 Bay.
Deliver one new shunt reactor at Willington East in a vacated MSC bay.</td></tr>
<tr><td rowspan="2">Estimated Cost</td><td colspan="3">Ironbridge: The current total cost of the project is [redacted] The current direct cost of the project, and funding and funding allowance being sought, is [redacted]
Willington East: The current total cost of the project is [redacted] The current direct cost of the project is [redacted].</td></tr>
<tr><td>T2 (FY2022 – FY2026):
Ironbridge: [redacted]
Willington East: [redacted]</td><td>T3 (FY 2027 – FY2031):
Ironbridge: [redacted]
Willington East: [redacted]</td><td>T4+ (FY 2032+):
Ironbridge: [redacted]
Willington East: [redacted]</td></tr>
<tr><td>Outputs</td><td colspan="3">Two new 400kV 200MVAr shunt reactor units for voltage control.</td></tr>
</table>

Following direction from NESO, NGET is delivering a series of shunt reactors across England to ensure the grid has the necessary assets to keep voltage within defined tolerances. This paper demonstrates the assessment undertaken to consider options to install two of these new shunt reactors – one at the Ironbridge substation and one at the Willington East substation. The assessment process for each shunt reactor sought to balance the need to deliver the connections within timeframes, utilise existing assets and land, and provide an efficient long-term solution for the network.

The conclusion of NGET's analysis is its proposed construction of a new 400kV 200MVar shunt reactor unit at Ironbridge substation's former generation 1 bay, and another new 400kV 200MVAr shunt reactor at the Willington East substation by repurposing a vacated MSC1 bay.

7. RIIO-T1 and RIIO-T2 allowances

There were no investments proposed for this project during either RIIO-T1 or RIIO-T2 business plans submissions. The Project does not have funding through any other price control mechanism.

8. Assurance and Point of Contact

Attached to this submission is the assurance statement letter, providing written confirmation in line with the assurance requirements set out in Ofgem's Re-opener Guidance and Application Requirements Document, dated 17th February 2023. This confirmation is provided by the Head of Future Price Controls, Electricity Transmission.

They provide the following statements below regarding how this MSIP application has been prepared and submitted in relation to each of the three assurance points requested by Ofgem:

a. It is accurate and robust, and that the proposed outcomes of the MSIP submission are financeable and represent best value for consumers.

b. There are quality assurance processes in place to ensure the licensee has provided high-quality information to enable Ofgem to make decisions which are in the interests of consumers.

c. The application has been subject to internal governance arrangements and received sign off at an appropriate level within the licensee. NGET's designated point of contact for this MSIP application is Leo Michelmore, Strategic Upgrade Regulatory Manager (leo.michelmore@nationalgrid.com).

Appendix A: Cost Models

Please see the two accompanying Cost Models submitted alongside this MSIP: ‘Appendix A1: Ironbridge Shunt Reactor – MSIP Jan 25 – Cost Model’ and ‘Appendix A2: Willington Shunt Reactor – MSIP Jan 25 – Cost Model’.

Appendix B: Stakeholder Engagement

Ironbridge

The stakeholder engagement strategy has included the following elements:

- Internal engagement and governance approvals with senior managers/stakeholders from NGET Asset Operations who have been acting as principal contract under CDM, coordinating and managing effective project delivery.

External stakeholder engagement has centred on a few specific items:

- For Ironbridge, 3rd party land will be utilised to facilitate the delivery on the Shunt Reactor. This was previously a power station access road but has been procured by Hayworths who are redeveloping the area, so appropriate coordination and liaison will be required. Whilst NGET retain the legal access rights, ongoing discussions are required with Hayworths to ensure the route is not only retained but also fit for purpose.
- Additional statutory consultees such as Highways England and local councils are also being engaged for the delivery of abnormal heavy loads, as required.
- A formal noise assessment undertaken at Ironbridge identified the need for the inclusion of a noise enclosure. Given the noise enclosure was in the interest of keeping noise levels within suitable limits, NGET did not deem external stakeholder engagement necessary to make a decision for noise enclosure inclusion.

Willington East

The stakeholder engagement strategy has included the following elements:

- Internal engagement and governance approvals with senior managers/stakeholders to progress the project to contract award for the main works with Balfour Beatty who are acting as principal contractor under CDM.
- The Willington Shunt Reactor is being installed within the existing operational boundary of the site and will be accommodated within an existing bay. This has been agreed with NGET Asset Operations and negates the need for third party engagement in terms of land and consents.

External stakeholder engagement has centred on a few specific items:

- Network Rail and Highways England are being engaged for the delivery of an abnormal heavy load.
- [redacted] A formal noise assessment was undertaken, and it confirmed that a noise enclosure would not be necessary for this asset. The shunt reactor bund has been designed so it can be adapted to accommodate a noise enclosure in future if it was deemed necessary at any stage. [redacted]

Appendix C: Glossary

Acronym	Definition
ACL	Available for Commercial Load
AIS	Air Insulated Switchgear
BNG	Biodiversity Net Gain
CBA	Cost-Benefit Analysis
DNO	Distribution Network Operator
EA	Eligibility Assessment
ECI	Early Contractor Involvement
EIA	Environmental Impact Assessment
EPC	Engineering, Procurement and Construction
ESO	Electricity System Operator
FID	Final Investment Decision
FNC	Final Needs Case
GIS	Gas Insulated Switchgear
GVA	Gross Value Added
kV	Kilovolt
LDO	Local Development Order
MVA	Megavolt Amperes
NESO	National Energy System Operator
NDP	Network Development Process
NG	National Grid
NGET	National Grid Electricity Transmission
OEM	Original Equipment Manufacturer
OHL	Overhead Lines
SDS	System Design Specification
SF6	Sulphur Hexafluoride
SGT	Super Grid Transformer
SQSS	Security and Quality of Supply Standard
SWOT	Strengths, Weaknesses, Opportunities and Threats
tCO2e	Carbon Dioxide Equivalent

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