Virtual Energy System

Common framework

Demonstrator data needs and gaps

March 2023

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Executive summary

Recommendations on the demonstrator data needs and gaps

Background

ESO have launched the VirtualES programme to enable the creation of an ecosystem of connected digital twins of the entire energy system of Great Britain, which will operate in synchronisation to the physical system. It will include representations of electricity and gas assets and link up to other sectors.

Through research, expert interviews, and industry-wide engagement, 14 key socio-technical factors were identified which are considered necessary for the development and delivery of the VirtualES today.

Following the example set by the National Digital Twin programme and the Digital Twin Hub through their Climate Resilience Demonstrator project (CReDo), the VirtualES is developing a demonstrator that is focused on a *whole-system flexibility* use case.

This document contributes to the development of this demonstrator, currently being progressed through an NIA-funded project in Alpha phase. Its purpose is to assess the current data landscape, determine the demonstrator data needs and identify the appropriate standards to facilitate data sharing between operators.

Approach

This report creates the link between the functional activities required to implement the demonstrator and the data that will enable them. Through the development of use case diagrams it explores the data flow between organisation and establishes the need for sharing of a base model and operational scenarios.

Through wide ranging stakeholder engagement and desk research we have established three data products that summarise the core data entities and parameters required for the power flow modelling that underpins the demonstrator.

A review of the current data sharing across the industry has identified significant gaps between the current state and what will be required for the demonstrator.

Recommendations

This report identified several recommendations that will enable and enhance the demonstrator's impact. It has also identified broader recommendations outside of the demonstrator's role, but should be considered by sector.

The complete recommendations are given in Section 5.

In addition to continuing with the development of the demonstrator, the top five recommendations are:

- ESO continues to promote the benefits of the use case and demonstrator across the industry, and seek continued buy-in for the VirtualES.
- Engagement with different working groups focussing on data standardisation and align findings from this data assessment with their work.
- Create process flow diagrams that expands on the data flow and use case diagrams. These should document interactions between different roles, between roles, and with VirtualES.
- Engagements with power flow modelling vendors to understand their development roadmap and align on data standards.
- Review of CGMES v3 with the CDPSM extension to determine it's applicability for the demonstrator.

Nomenclature

ADMS – Advanced Distribution Management System
AIS – Air Insulated Switch
AM – Asset Management
AMI – Advanced Meter Infrastructure
ANM – Active Network Management
BAU – Business As Usual
BESS – Battery Energy Storage System
BSP – Bulk Supply Point
CGMES – Common Grid Model Exchange Standard
CIM – Common Information Model
CDPSM – Common Distribution Power System Model
CReDo – Climate Resilience Demonstrator
DAFNI - Data Analytics Facility for National Infrastructure
DSR – Demand Side Response

DER – Distributed Energy Resource
DNSP – Direct Network Service Provider
DPLAN – Distribution Planning
DSO – Distributed System Operator
DSR – Demand Side Response
EAM – Enterprise Asset Management
EDSO – European Distribution System Operators
eNAMS – Electrical Network Access Mgt System
ER – Entity Relationship
ESRI – Environmental Systems Research Institute
GC – Grid Code
GEES – Green Energy & Environmental Solutions
GIS – Geographic Information System
GSP – Grid Supply Point
IEC – International Electrotechnical Commission

IEEE – Institute of Electrical and Electronic Engineers
KPI – Key Performance Indicator
LTDS – Long Term Development Statement
NGET – National Grid Electricity Transmission
NGESO – National Grid Electricity Systems Operator
PFD – Process Flow Diagram
PI – Personal/Plant Information
SGAM – Smart Grid Architecture Model
SGT – Super Grid Transformer
STCP – System Transmission Control Procedures
TNO – Transmission Network Operator
TO – Transmission Operator
TSO – Transmission System Operator
WP – Work Package

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Approach

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Context

What is the Virtual Energy System?

The Virtual Energy System

The ambition of the Virtual Energy System (VirtualES) programme is to enable the creation of an ecosystem of connected digital twins of the entire energy system of Great Britain, that will operate in synchronisation to the physical system. It will include representations of electricity and gas assets and link up to other sectors.

This ecosystem of connected digital twins will enable the secure and resilient sharing of energy data across organisational and sector boundaries, facilitating more complex scenario modelling to deliver optimal whole-system decision making. These whole-system decisions will result in better outcomes for society, the economy, and environment by balancing the needs of users, electricity and gas systems and other sectors.

Creating the VirtualES is a socio-technical challenge that requires a collaborative and principled approach, aligned with the National Digital Twin Programme, and other energy sector digitalisation programmes.

The VirtualES is delivered through three workstreams:

- Workstream 1 - Stakeholder engagement
- Workstream 2 - Common framework & principles
- Workstream 3 - Use cases

Workstream 2 - Common Framework & Principles

This report forms part of workstream 2.

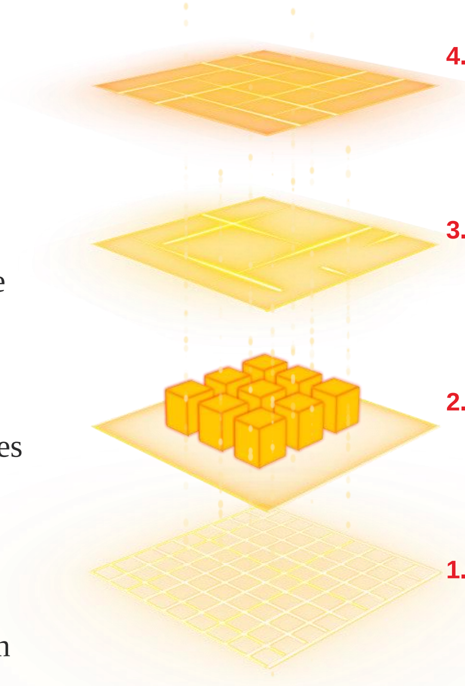
The objective of this workstream is to develop the socio-technical common framework that will form the foundation of the VirtualES – enabling the creation of this ecosystem of connected digital twins.

Through research, expert interviews, and industry-wide engagement, 14 key socio-technical factors were identified which are considered necessary for the development and delivery of the VirtualES today.

These 14 identified factors are grouped by the categories of People, Process, Data, and Technology**.** Six of these factors were prioritised based on their potential impact on the VirtualES objectives and their relative maturity across the wider energy sector.

Following the example set by the National Digital Twin programme and the Digital Twin Hub through their Climate Resilience Demonstrator project (CReDo), this workstream is now developing a demonstrator that is focused on a *whole-system flexibility* use case.

This document contributes to the development of this demonstrator, currently being progressed through an NIA-funded project in Alpha phase.



Virtual Energy System

Indicative components of the Virtual Energy System

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Developing a common framework

Published research and reports for the common framework

Throughout the development of the common framework, the approach has been industry-led, consultative, and collaborative.

This approach, coupled with explicit and proactive engagement within the energy sector and with cross-sector stakeholders, is necessary for the successful development of the common framework, delivery of the VirtualES, and ultimately in achieving sector-wide adoption.

All work has been conducted 'in the open', with the six reports completed to date all published online.

Following the SIF Discovery project (report #3), the demonstrator was further developed using the whole-system flexibility use case (report #4).

The demonstrator is currently progressing through an NIA-funded project in Alpha phase, and is being delivered in line with the project plan (report #6).

1. External benchmarking

Understanding the cross-sector and global best practice for connecting assets, systems, and digital twins.

Read the report

2. Defining the common framework

Determining the key socio-technical factors that need to be considered for the VirtualES to succeed.

Read the report

3. Demonstrating the common framework

Collaboratively prove and demonstrate, with industry, how the socio-technical principles work.

This was a Round 1 SIF Discovery project.

Read the report

4. Whole system flexibility use case definition

Further define the "whole-system flexibility" use case that is recommended as the initial use case to demonstrate the common framework.

Read the report

5. Demonstrator data standards, data portals, and data licensing

Identified data standards and outline data licensing considerations applicable to the use case. Initial review of currently available public energy sector 'data portals'.

Read the report

6. Demonstrator project plan & advisory groups

Proposed delivery plan, governance structure, advisory groups approach, and cross-workstream collaboration that will enable the successful delivery of the demonstrator.

Read the report

Delivery team

Supporting the development of the social-technical common framework

The development of the common framework has been delivered by Arup and supported by the Energy Systems Catapult and Icebreaker One. It has been sponsored by the Electricity System Operator (ESO) and National Gas Transmission (NGT) through the Network Innovation Allowance (NIA).

The purpose of the RIIO-2 NIA is to provide funding to Gas Transporter and Electricity Transmission Licensees to allow them to carry out innovative projects, that focus on the energy system transition or addressing consumer vulnerability, which are outside of business-as-usual activities.

- **Electricity System Operator (ESO):** ESO is responsible to ensure a reliable, secure system operation to deliver electricity when customers need it. ESO balances the supply and demand on the system day to day, second by second, and coordinates with networks to transfer electricity from where it is generated to where it is needed.
- **National Gas (NGT):** National Gas own and operate the national gas network in addition to maintaining and managing the 7,000,000 domestic industrial and commercial combined gas assets around the UK.
- **Arup:** An employee owned, multinational organisation with more than 15,000 specialists, working across 90+ disciplines, with projects in over 140 countries and the mission to 'shape a better world'. Arup have extensive energy and cross-sector digital twin expertise, actively contributed to the National Digital Twin programme, and are members of the Digital Twin Hub.
- **Energy Systems Catapult (ESC):** An independent, not-for-profit centre of excellence that bridges the gap between industry, government, academia, and research. Set up to accelerate the transformation of the UK's energy system and ensure businesses and consumers capture the opportunities of clean growth. ESC are responsible for the Energy Data Task Force (EDTF) & Energy Digitalisation Task Force (EDiT).
- **Icebreaker One (IB1):** An independent, non-partisan, non-profit organisation with a mission to 'make data work harder to deliver Net Zero' by creating open standards for data sharing across agriculture, energy, transport, water, and the built world.

Together the five organisations assembled a delivery team to effectively collaborate and deliver the objectives of this workstream.

Introduction

Purpose of this document

Purpose

This document presents the findings of **WP2.1 - Data assessment & preparation**, developed as part of the common framework demonstrator Alpha phase.

Its purpose is to establish which key data sets are required to be sharable across the industry with the appropriate detail, frequency and granularity required for it to be used to fulfil the needs of the whole-system flexibility use case.

This document contains the following deliverables:

- Data needs and gaps report (M1)
- Data relationships developed & tested (M2)

Electricity and gas network use cases

This NIA-funded Alpha phase is supported by ESO and National Gas.

The objective of the VirtualES is to include and consider both the electricity and gas networks.

Given ESO's role in the energy system is currently electricity focused, the research and reports published to date have also been focused on the electricity network. This includes the whole system flexibility use case definition proposed for the demonstrator, and the data needs and gaps that have been identified and evaluated in this document.

In recognition of the future energy system, a separate demonstrator use case has been developed for the gas network. A separate data needs assessment will also be required.

It is considered that in the future the electricity and gas use cases will converge into a whole energy system demonstrator.

Summary

The use case chosen for the VirtualES demonstrator identifies a very specific opportunity to close normally open switches on the network and shift electricity between two parts of the grid. In doing this it is able to demonstrate grid flexibility and, for example, reduce curtailment of renewable generators.

This document expands the use case and identifies the key actors, processes, and data that will be necessary to implement the demonstrator.

Our work has identified the need for DNOs, TNOs, and the ESO to share data with one another. This data consists of base models of the transmission and distribution networks along with operational scenarios that document the specific running arrangements along with load and generation forecasts.

A review of the existing data landscape has identified the need for more comprehensive sharing of data between organisations but there are potential blockers with regards to data quality and standards that must be addressed.

Methodology

Repeatable approach for identifying and evaluating the data needs and gaps for VirtualES use cases

Approach overview

The methodology consists of a five-step process used to identify and evaluate the data needs and gaps for the whole-system flexibility use case.

The approach, as shown in the diagram opposite, is repeatable and can be applied to any future VirtualES use case. The five-step considers:

1. **Review of existing literature and data:** Establish the baseline information and data available for the proposed use case.
2. **Stakeholder engagement:** Establish, through user research and interview, the pain points experienced and the existing "as-is" landscape for the use case.
3. **Use case refinement:** Refine the use case and the data sets required to address it.
4. **Data needs:** Summarise the identified data needs for the use case and outline the conclusions and recommendations to progress.
5. **Gap analysis:** Conduct a gap analysis between the literature, data, and insights gained through the stakeholder engagement and user research.

Demonstrator use case overview

The five-step methodology was applied to the whole-system flexibility use case.

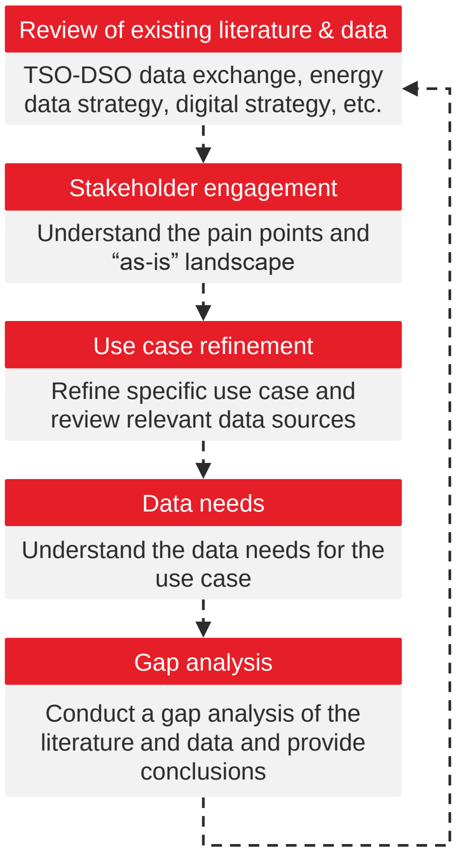
The use case evaluated in this report is specific to only the electricity network. A separate demonstrator use case has been developed for the gas network, and will require a separate data needs assessment to be completed.

The review of literature and data was informed by the published VirtualES whole system flexibility use case definition (electricity network use case) & demonstrator data standards, data portals, and data licensing reports.

Interviews were conducted with 16 key stakeholders, representing data governance leads, architects and planning roles across both electricity and gas networks. The stakeholders developed the understanding of the data and technology needs from network modelling, operational planning, and real-time operations perspectives, and enabled the use case to be refined.

The gap analysis and data needs were then conducted. The results of which are detailed in the following pages.

The list of organisations and stakeholders interviewed for this use case are given in Appendix A.3.



Iteration & continuous improvement until user and business needs are sufficiently addressed

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Demonstrator use case

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Demonstrator use case

Summary of the use case

Overview

The demonstrator is based on the published VirtualES whole system flexibility use case definition (an electricity network use case).

The use case considers the changing patterns of energy generation and demand and the need for a flexible grid that can be optimised to, for example, reduce the curtailment of renewable energy sources and facilitate bi-directional power from increased use of PVs and EVs.

The use case explores the opportunity to re-route electricity between grid supply points (GSPs), in certain configurations, by using existing infrastructure commonly used for maintenance.

Changing the network running order in this way would enable demand or generation to be moved between different locations, providing an example of achieving flexibility through a location shift.

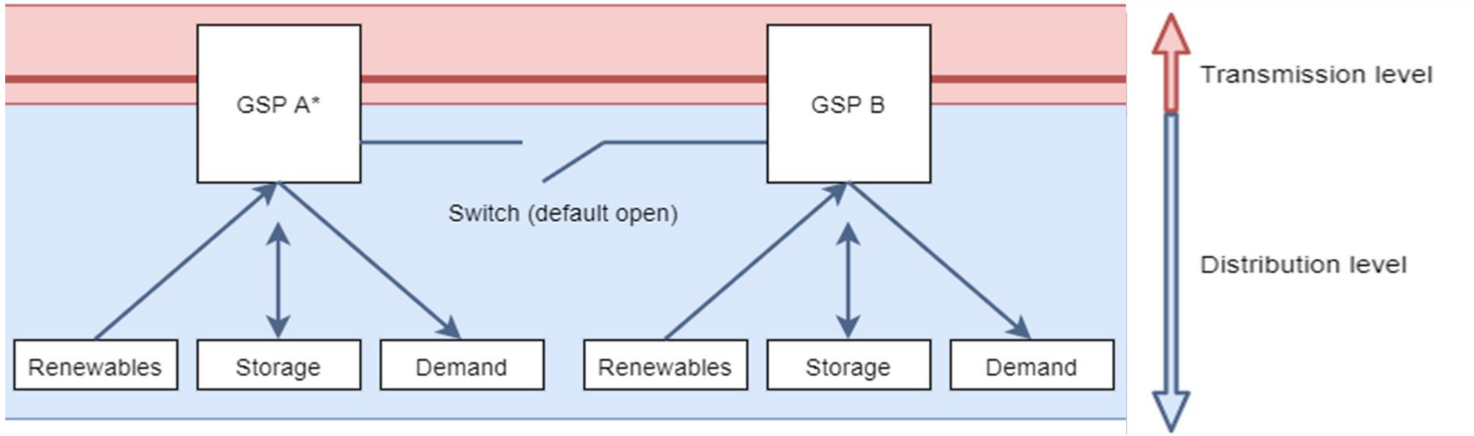
In instances of planned network outages, this bypass can re-route electricity from adjacent GSPs to provide resilience to the network. This will transfer all or part of the load from one GSP to the other, while keeping an electrical split. Or connect the two GSPs to operate as an interconnected group.

This reconfiguration currently requires weeks of planning and agreement in advance, through the outage planning processes of the Grid Code and System Operator / Transmission Owner Code.

Similar considerations in the operational planning process are required for interconnected, loosely coupled or radial GSP configurations, to maximise system availability and minimise system risk. This includes minimising generation restrictions, through an improved understanding of demand behaviour and flexibility services, using GSPs within a zone.

As more renewable generation comes online there are potential advantages to using this connection reconfiguration more actively.

This data assessment only considers the electricity use case. In recognition of the future energy system, a separate demonstrator use case has been developed for the gas network. A separate data needs assessment will also be required.



Example GSP configuration (GSPs can be owned by the TNO or the DNO)

Demonstrator use case

Summary of the use case and use case diagrams

A key purpose of this demonstrator is to showcase the feasibility of implementing a technological solution. To constrain the scope, the demonstrator considers the requirements of operational timescales from 3 weeks ahead to near real-time.

Critical to the use case is the assessment of the potential interconnections of GSPs. This requires visibility of the assets involved, their capabilities and the expected behaviour of demand and generation. This assessment is currently carried out by operators through the use of power flow modelling, e.g. PowerFactory.

The use of modelling to determine the impacts of future running arrangements and resolve potential issues is widespread across the energy landscape. Operators develop and run operational scenarios that determine the arrangements of their network. Currently this is done on an organisation-by-organisation basis with minimal data sharing between operators.

Data that is shared, e.g. the "week 24" data submission made to ESO, provides limited granularity of the network at a single snapshot in time, with peak load and generation data profiles. The existing processes do not meet the requirements of the use case.

Use case diagram

The demonstrator identifies the need to share these models and scenarios across organisational boundaries, to allow operators access to each other's models and insights.

This will enable operators to assess the effects of projected demand and supply on current operational plans for the network, thereby enabling faster approval or modification of current arrangements.

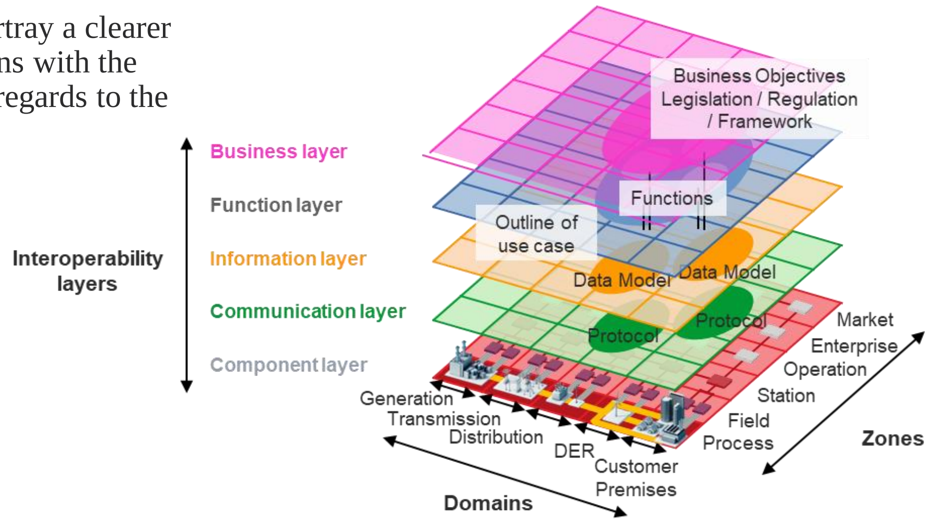
Use case diagrams have been created to portray a clearer understanding of the actors, their interactions with the system, and the activities they carry out in regards to the use case.

These diagrams represent:

- Future operating state
- Base model publishing
- Operational scenario publishing

The diagrams translate the technical feasibility of the use case into an applicable business process. They are part of the suite of artifacts and assets created to better understand and enable VirtualES

Use case diagrams are a key part of the Smart Grid Architecture Model that define the Function layer and help in further developing the Information layer.



Smart grid architecture model

Assumptions

Assumptions made during the development of this data needs assessment

The following assumptions have been considered:

- The activities and processes described in the use case diagrams are not necessarily linear. The use case diagrams present an overview of activities and actors, and their associated interactions.
- The approach set out here recognises that there is likely to be top down (ESO/TNO) and bottom up (DNO) modelling that will need to converge. Iteration of modelling between organisations may be required and will need to be explored further.
- Boundary conditions cannot be created for every potential modelling scenario instead the TNO will provide regular updated boundary conditions as part of a base model. The responsibility is then on the DNO to configure these for their specific operational scenario.
- The use case diagrams incorporate existing internal and inter-organisational processes. Changes to these processes, such as specified in the STCP 11-1 or Grid Code, are out of scope for the demonstrator and have not been addressed in this report.
- The use case diagrams have proposed approaches that are technology agnostic and do not specify how models from different operators should be merged just that there is a requirement to do so. Technology considerations for the demonstrator have been addressed in the separate technology review report.
- The scope of modelling is limited to load flow analysis and that modelling will be limited to assets above the primary substation level. Modelling will be required to consider AC steady-state analysis, contingency analysis and voltage step-change analysis.
- Broad amounts of the *Network* data product could be considered static data due to the physical network that it represents however as there may always be some change it must be considered as dynamic data. This places a requirement that the base model be updated regularly.
- It is considered that there is capability to perform a node-branch reduction of the asset level model as part of the process.

Use case diagram – future operating state

Representation of the future operating state of the system

Stakeholder engagement has determined that to enable the use case, and agreement between operators on running arrangements, with closed switches between GSPs, the modelled operational running arrangements as well as forecasted load and generation would need to be shared between DNOs, the ESO and the TNO.

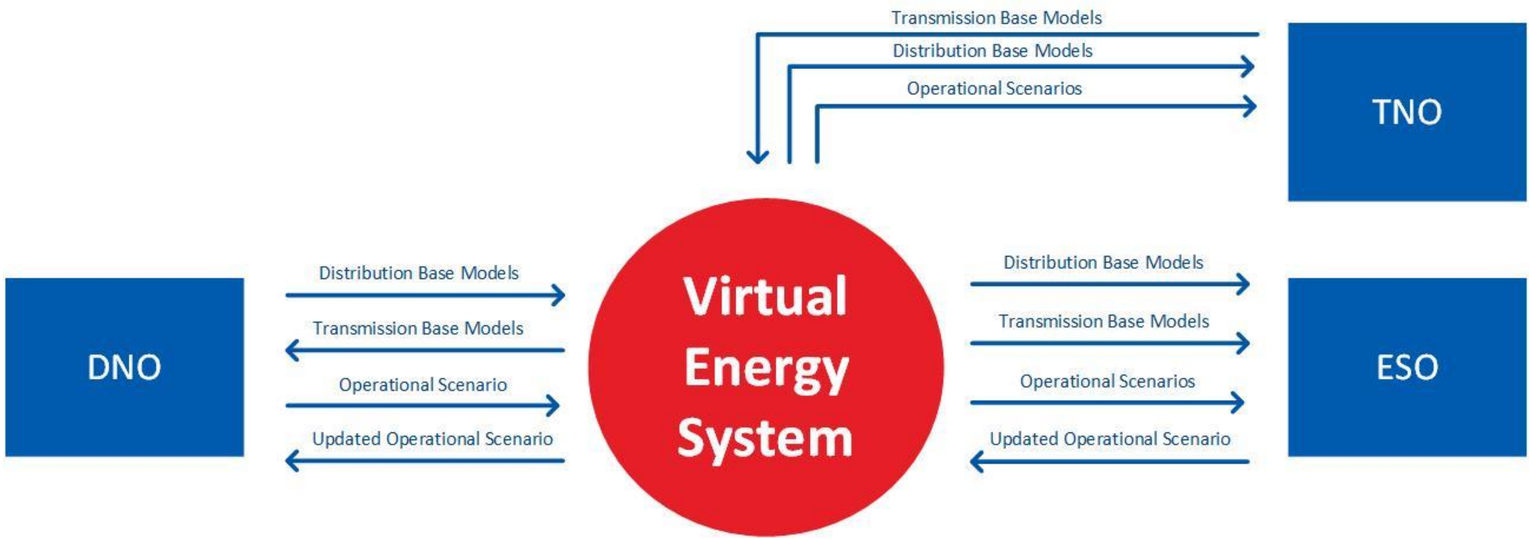
The network, asset and operational scenario data that is currently open or shared as part of an operator's mandated requirements, such as the week 24 process, was not deemed sufficient to deliver the use case.

Instead a valid, digital representation of the network, with the proposed running arrangements, and the forecasted load and generation for a modelling period is required.

Our approach proposes that operators publish a base model that represents the networks normal running arrangements at a fixed point in time alongside an operational scenario that contains specific network changes, load, and generation data for the modelled time period.

This approach reduces processing time and data transfer, ensuring better data quality, and flexibility for operators in publishing, accessing and modelling scenarios.

A data flow diagram has been created that sets out the key data transactions between operators.



Data flow diagram

Use case diagram – base model publishing

Representation of the base model state of the system

This use case diagram describes the process of organisations publishing their base network model and enabling other organisations to access it. The diagram is a simplification but sets out the key steps of the process.

The first four activities relate to internal organisational asset management, maintenance activities that are required to ensure the base model is a best representation of the operator's network.

These asset management processes are internal organisational processes and may be triggered by planned or unplanned maintenance or wholesale replacement of assets due to capital projects.

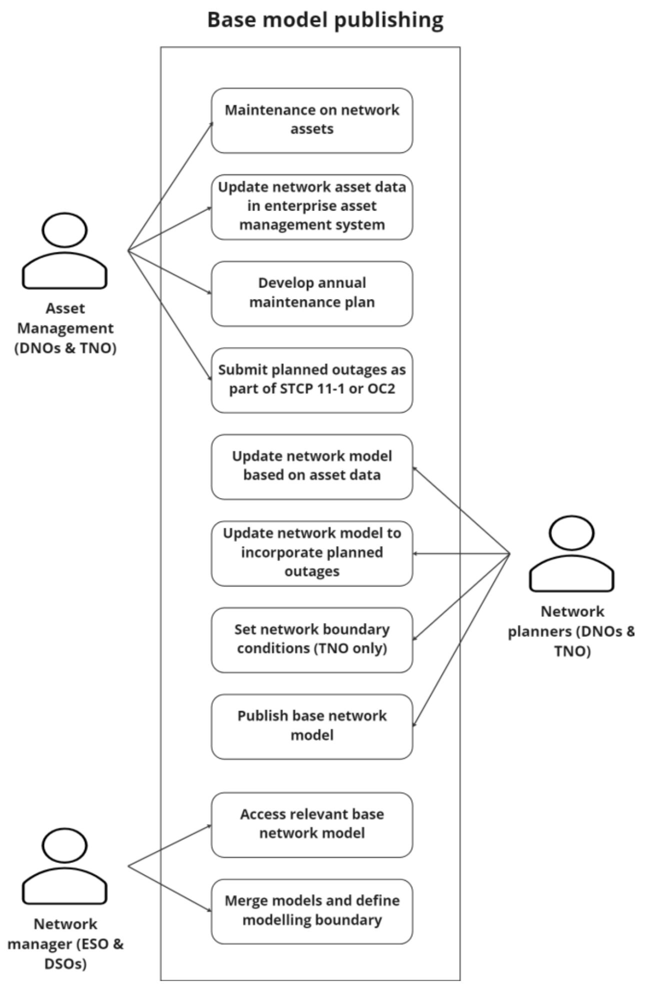
There are existing industry processes set out in Grid Code (OC2) and STCP11-1 that operators need to align to when submitting network outages. The use case does not consider changes to these existing processes.

These asset and network outage updates would be applied to a base network model that would then be published by the operator.

Further work should be carried out to understand the frequency with which the base model should be published to best respond to the needs of the use case.

For the transmission network model, the TNO must publish regularly updated boundary conditions. This should enable DNOs to determine the impedance reduction necessary for their operational scenario.

Network managers from other operators would have access to all models and build out a network that best aligns to their needs. Consideration must be given as to how merging of the networks is implemented. This requires alignment on data and technology.



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Use case diagram – operational scenario publishing

Representation of the operational scenario state of the system

This use case diagram describes the process of sharing the proposed running arrangements with forecasted load and generation for a future time period.

The process is initiated by DNO operational forecasting teams who will develop future demand and supply forecasts, these will be shared with their internal operational planners who will load them into their network.

Operational planners will incorporate the latest boundary conditions from the TNO and run their own internal forecasts to identify potential imbalance or curtailment on the network. Through this they will identify opportunities, including closing switches between GSPs, to resolve and minimise the impacts.

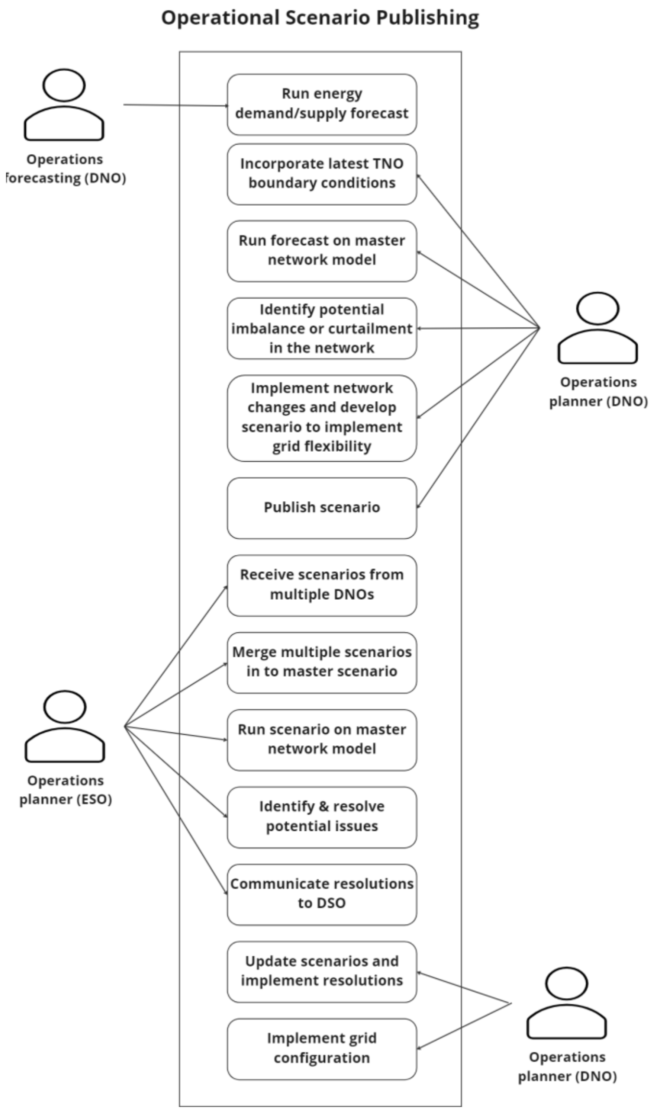
At this point there may be model iterations to determine the most appropriate scenario and this may include model reduction to determine impacts on specific parts of the network.

Following this the operational planner will publish the proposed scenario.

Once scenarios are published operational planners from other organisations will access and merge the scenarios relevant to their activities and responsibilities.

These merged scenarios will be run on the combined network model and any issues or imbalances can be presented to all parties including the originator.

Finally scenarios could be updated and the process would iterate until the issues were resolved. Where necessary, authorisation would be agreed and the operators would then be able to implement the proposed running arrangements.



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Data needs

Demonstrator data needs

Summary of the data needs

Overview

The Smart Grid Architecture Model sets out five layers that traverses from the Business Layer through to the Component Layer. This report seeks to provide a link between the Function Layer and the Information Layer by developing out a use case, and through this identifying the data flows and data needs to deliver the use case activities.

The data flow and use case diagrams have set out the need for data to be exchanged between DNOs to the TNO and ESO, as well as data from the TNO and ESO to the DNOs.

The use case diagrams also developed the concept of a base model and operational scenarios for sharing of data between organisations. This section of the report will expand on the sharing of data and will specify the data products required.

The data assessment has been carried out through desk research and stakeholder interviews.

It has reviewed the current state of data sharing amongst organisations and the various industry roadmaps and in-flight projects that are looking to address these challenges.

Key artefacts have been developed as part of the data assessment and serve to help define the data needs.

- **Data flow diagram:** The diagram on page 15, showing the data flows between the TNO, DNO, ESO and the VirtualES.
- **Data hierarchy:** A hierarchy has been created to structure and relate data. The hierarchy uses the concept of data products and is further explained in the following pages of this report.
- **Data catalogue:** A data catalogue has been developed that lists all the parameters specified in the assessment. The catalogue provides the name and description of the parameter. See Appendix A.1.
- **Entity data relationship:** The EDR is a conceptual data model drawn in UML that represents entities and their relationships to one another. Parameters are listed under each of the entities. See Appendix A.2.

Data hierarchy

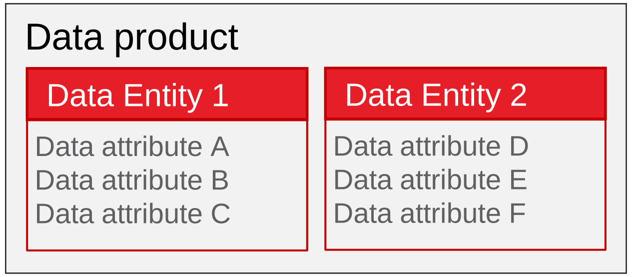
Hierarchy of data products to structure and relate data

Overview

It was necessary to create a data hierarchy to appropriately categorise and structure data for the data needs assessment.

It was observed through the stakeholders interviews that the organisations considered their data to have value and an asset that responds to a specific need. This can also be referred to as data products.

Data products treat data as a product, ensuring that data can be shared with and used by consumers. They are defined by sets of data that are typically related.



Data hierarchy

The data hierarchy has several levels, as show in the adjacent diagram.

- **Data product:** A data product is the highest level on the hierarchy and summarises data that describes an aspect of the business, infrastructure or operations. The term product is used to convey the notion of a managed grouping of related data assets, that deliver tangible business value. A data product should respond to specific business requirements, should be reusable, understandable, have clear ownership, and be discoverable.
- **Data entities:** A data product contains multiple related data entities. A data entity describes a single, real-world object such as an asset or organisation. Data entities will generally have relationships to other data entities, and these are formed through common attributes.
- **Data attributes:** Data attributes are properties or characteristics of an object and help describe that object. Examples of attributes could include an asset ID, a maximum or bespoke voltage rating, equipment classification, or a measured value.

Application to the demonstrator use case

This report has explored the implementation of the demonstrator use case and the data sharing that would be required to enable it.

Through this understanding, and in line with the data hierarchy, three data products have been identified that are critical to the implementation of the demonstrator.

These data products are:

- *Assets*
- *Networks*
- *Operational Scenarios*

Each of these **data products** contain a number of **data entities**, with further **data parameters**. The data products are described in further detail on the following pages.

A **data entity relationship model** has been developed, that describes the data entities and their relationships. Data products are represented by their grouping of related entities and these diagrams.

The complete data entity relationship diagram is provided in Appendix A.2.

Data product – Asset

Description of the data product, and related data entities and attributes

Overview of the data product

Critical to the modelling of the network is comprehensive data on the assets deployed across the network. The *Asset* data product summarises a collection of essential asset types that must be represented in a power flow model.

The *Asset* data product is required to be published alongside the *Network* data product. Together they complete the base model network for the use case and produce a replicable network for power flow modelling. The data product, through its entities and attributes, provides information on asset type, ratings, limits, and other physical properties.

By creating an asset-specific data product to represent physical assets, the data ontology is simplified. This ensures that the line and node entities can perform the function of physically representing the network either as a drawing or geographically.

Related data entities and attributes

The data entities for the *Asset* data product describe either aggregated collections of assets or individual assets on the network.

The entities that have been explored and documented as part of this assessment have been limited in scope to the most essential for the purposes of the use case.

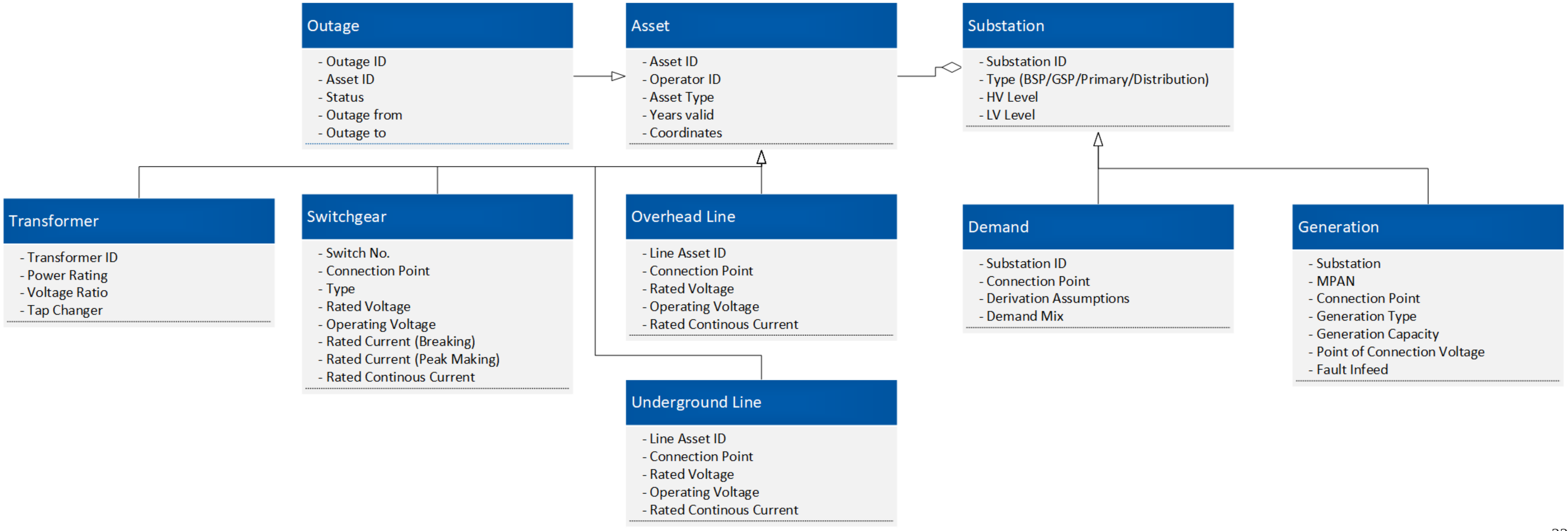
- **Substation:** Substations represent collections of assets at a point on the network where two different voltage levels are being linked. The entity includes a substation type, which classifies the role of the substation, identifies the high and low voltage levels that the station is linked to and also inherits the properties of the assets located at the substation. Depending on the granularity of modelling the substation may not be included within the network, as it may instead be represented by individual assets.
- **Asset:** The *Asset* entity summarises the collection of assets found on the network by their unique asset ID and categorises assets by their type. This entity is also used to map to both the higher level substation entity as well as mapping to the lines entity found within the Network data product.
- The entity classes of **Transformer, Switchgear, Overhead** and **Underground Line** all independently document the physical properties of their respective assets. These classes identify assets using a unique ID and specify their ratings and parameters for properties including rated voltage, power rating and operating voltage. The entities described here summarise the key assets found on the network but this is by no means an exhaustive list, as this would be too large an exercise for the scope of this study.
- **Generation capacity:** This entity class maps the variety of generation assets that are connected to the electricity grid. This class includes centralised generation assets such as thermal power stations as well as distributed energy resources such as solar or wind, and storage such as BESS technology. This entity includes attributes on the generation type as well as the generation capacity of assets. For modelling purposes the generation capacity would be aggregated to the primary substation level and relates to a substation.
- **Demand:** Flexible demand will have a big impact on load flow profiles and including data on the different flexible demand assets will provide additional contextual information.

Data product – Asset

Data entity relationship model

The below data entity relationship model describes the data entities and their relationships. Data products are represented by their grouping of related entities and these diagrams.

The complete data entity relationship diagram is provided in Appendix A.2.



Data product – Network

Description of the data product, and related data entities and attributes

Overview of the data product

In the context of this demonstrator, the *Network* data product satisfies part of the requirements of the base network model for power flow modelling, as defined in the use case diagram. The data represents a simplified view of the physical electricity network using nodes and lines to represent assets.

The stakeholder engagement process revealed that operators are working towards a single version of the truth, with respect to their network model but that currently data is hosted in varying locations dependant on their business need.

Central EAM systems held asset and maintenance data, locations of the asset were stored in geospatial information models and the power flow models were stored in the operators selected proprietary modelling software.

Established organisational processes for updating network model data within the power flow modelling software were in place. These models were in use for network and operational planning purposes.

Related data entities and attributes

Within power flow modelling, network data is represented through the use of single line diagrams. Depending on the voltage level being modelled the diagram will depict the asset(s) at different granularities.

The entities under the *Network* data product serve the primary purpose of physically representing a network, as a single line diagram at a selected level of aggregation.

They inherit rather than own the physical properties of the network through relationships with both the *Asset* and *Operational Scenario* data products.

The *Network* data product for this demonstrator represents the graphical depiction of the network, as a line diagram to be drawn in power flow modelling software.

The data product contains the following entities:

- **Network:** The *Network* entity provides high-level information on the network including a unique network ID, operator ID, date of the latest update, version, and description.
- **Nodes:** Nodes are individual points with a globally unique and persistent ID that serve to connect lines. Nodes will relate to lines and a combination of nodes and lines may represent a combination of assets.

  The ability to merge models from different operators will rely on a common naming approach for Node IDs. Boundary nodes must be mapped between organisations to allow for seamless integration.

  Nodes convey location properties both for drawing the network within power flow models as well as representing the network geospatially.

  Load and generation data are applied to nodes during power flow modelling.

Data product – Network

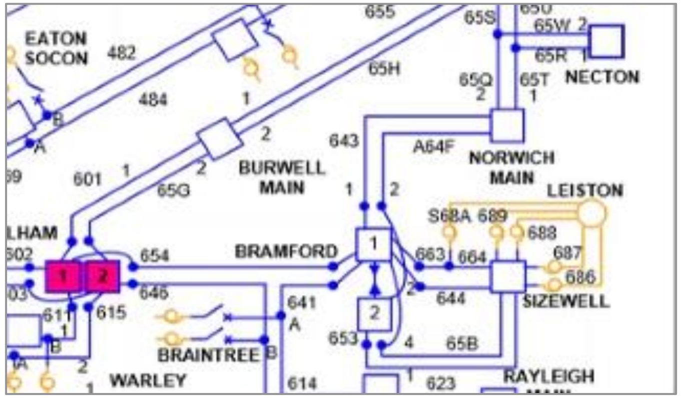
Description of the data product, and related data entities and attributes

Related data entities and attributes (continued)

- **Lines**: Lines connect between node pairs to determine relationships and provide the graphical representation of the network.

  Lines can either represent individual assets, such as switchgears or transformers, or combinations of lines may represent collections of assets, such as substations.

  Lines inherit the properties of the assets that they represent and are used within power flow modelling to set primary network conditions and resolve for line flows and system losses.



- **Groupings:** Different users may want to model scenarios at different voltage levels, depending on their requirements. To ensure the appropriate elements of the diagram are drawn for the appropriate level of aggregation, each line and node will belong to a grouping. For the use case, modelling between the transmission level and the distribution level down to primary substations is being considered.

  The network reduction enabled by the Groupings entity would need to be limited and this would likely be to two levels of aggregation, from the primary substations up to GSPs. This should be explored further as part of the Beta phase.

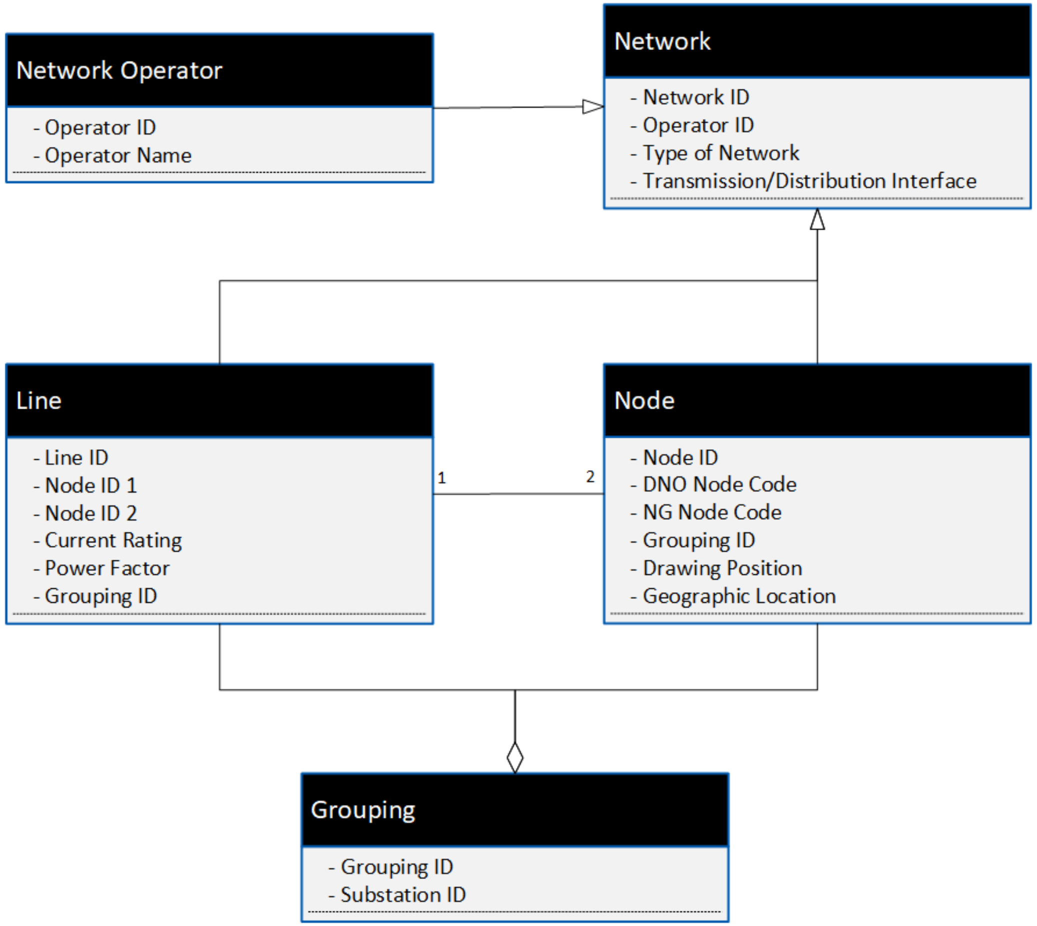
  Using groupings would require that the impedance and injection of the reduced part of the network be modelled separately.

Data product – Network

Data entity relationship model

The data entity relationship model describes the data entities and their relationships. Data products are represented by their grouping of related entities and these diagrams.

The complete data entity relationship diagram is provided in Appendix A.2.



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Data product – Operational Scenarios

Description of the data product, and related data entities and attributes

Overview of the data product

The *Operational Scenario* data product responds to the need, as set out in the use case description, of only sharing the necessary data for the modelled period. The data published as part of this product is future looking and is based on forecasted demand and supply for the given model period.

The use case sets out the process for DNOs to develop their proposed running arrangements, which may include the closing of switches between GSPs to reroute power. Once their preferred running arrangements have been determined they will share the proposal with ESO. This data product summarises the load and generation for the modelled period, as well as the changes to the base model network to facilitate the proposed running arrangements.

A key consideration for this data product was the recognition that an operator may want to combine scenarios from multiple other operators, such as the ESO combining multiple DNO scenarios. This was seen as particularly likely when high degrees of distributed energy were forecast, meaning operators would seek to reduce curtailment by implementing non-normal running arrangements. Modelling the impact of multiple DNOs running in this way was seen as highly valuable.

Related data entities and attributes

Entities within the *Operational Scenario* data product are applied to the base model network and provide the necessary parameters for power flow analysis to be run.

- **Operational Scenario:** The parent entity for this data product summarises the descriptive elements while also establishing key parameters of the scenario. The parameters of Scenario ID, Name and Description provide information that help users identify the unique scenario.

  It is expected that there would be certain peak scenarios such as winter or summer peaks as well as operational scenarios for 3-week ahead period.

  Scenarios must contain the date that they were developed and the forecast horizon used, this will help inform users and provide transparency. Furthermore they must specify the Start datetime, Duration and Time interval to provide the temporal parameters of the scenario.

  The Time interval parameter sets the rate of change of load and generation data through the scenario period. This is expected to be half-hourly in line with meter data used within forecasting.

- **Network Modifications:** The network modifications entity summarises the changed switch positions required from the base model to represent the planned running arrangements. These changes to the network are implemented by lines being deleted and new lines created between specified nodes.
- **Load:** The Load entity summarises the electrical demand placed on the network at specific nodes. For the purposes of the demonstrator, this load will be derived from the forecasted scenarios and provided for in half hourly periods through the modelled period.
- **Generation:** The Generation entity is a parent of the different generation sources that deliver power to different nodes on the grid. This includes generation from thermal and nuclear power stations as well as from wind, solar and other sources.

  The data contained within the *Operational Scenario* data product effectively enables the sharing of proposed running arrangements and forecasted operational expectations, while keeping data transmission to a minimum.

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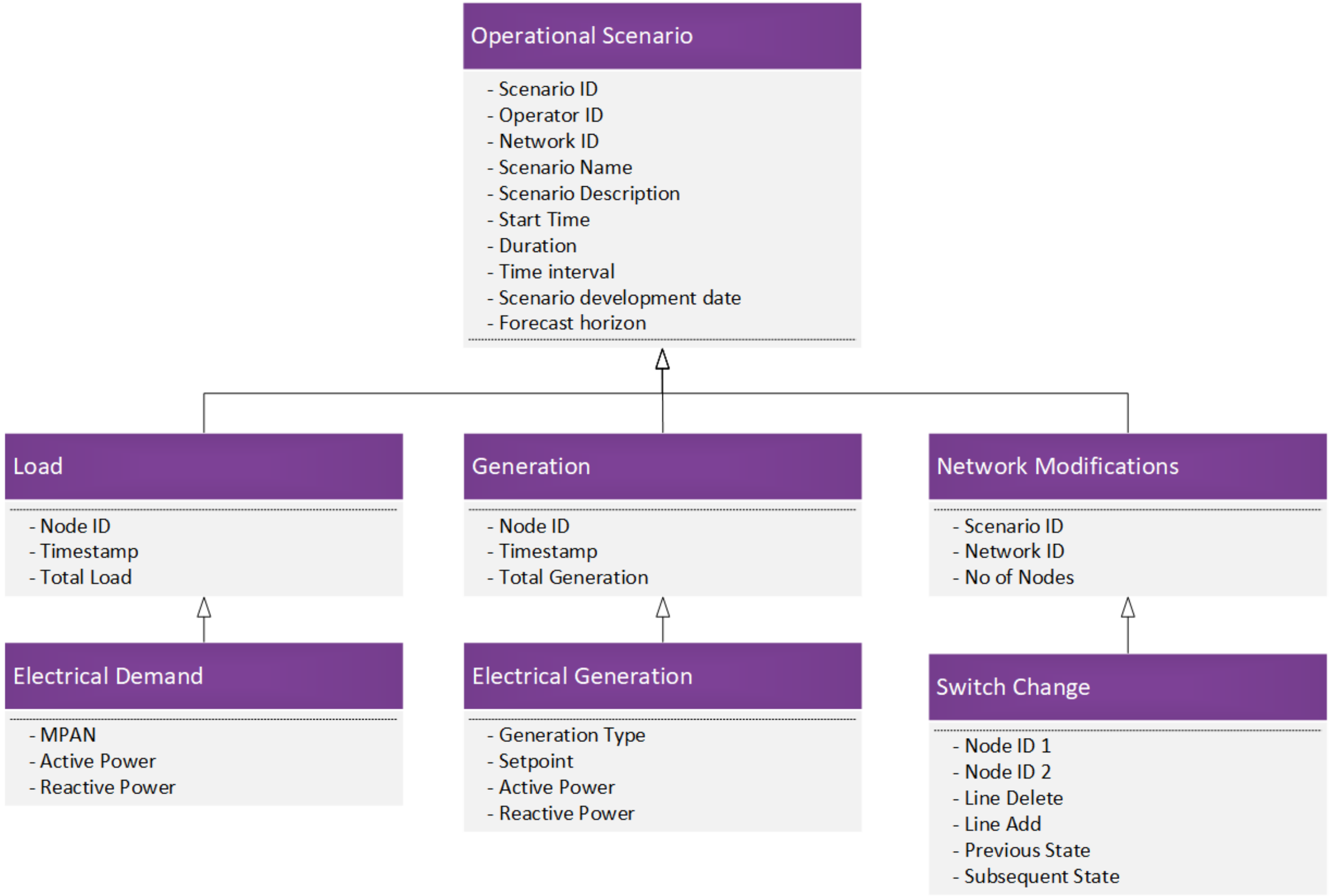
Data product – Operational Scenarios

Data entity relationship model

The data entity relationship model describes the data entities and their relationships. Data products are represented by their grouping of related entities and these diagrams.

The complete data entity relationship diagram is provided in Appendix A.2.



4

Gap analysis

Existing data landscape

Observations regarding existing processes, models and systems to share data

Introduction

In documenting the existing energy data landscape it was evident that there was a mix of regulated data sharing and interchange between different organisational bodies as well as publishing of open data through a variety of web platforms.

Initiatives and data portals such as Open Networks by the Energy Networks Association (ENA), Open Energy by Icebreaker One, the ESO Data portal, alongside other DNO data portals evidence the ambition of the energy marketplace and its recognition that data can help transform operations, enable a more flexible grid and help deliver net zero.

A comprehensive list of data standards, portals, and licensing that could be relevant to the use case were compiled and documented in the published VirtualES demonstrator data standards, data portals, and data licensing report.

This report provided valuable insights and recommendations, serving as a starting point for the data assessment undertaken.

Data exchanges

At present the key identified data exchanges are between DNO and ESO and TNO and DNO, with adherence to Grid code processes. The primary data sharing relevant to the use case is that of the Week 24 submissions.

This requirement requires DNO's to provide network planning data to NGESO by week 24 and 50 of the calendar year. Submissions cover the DNOs system maps and network demand data, some of which is used for forecasting future demand scenarios.

The submission covers four main areas including

- **Demand & Energy Data** which requires the submission of the operator's peak demand profile, the GB grids peak demand profile, the GBs minimum demand profile, various connection point profiles, and embedded small power station details.
- **Network Data** including Single Line Diagrams, Node and Line demand, and parameter spreadsheets.
- **Equipment Data** which provides ratings data on switchgears and substations
- **Emergency Demand Disconnection Data** covering demand related disconnection information.

Data relating to the transmission network is submitted to DNOs by NGET through the week 42 provision of transmission system data. As well as the week 24 submission other submissions by the DNO include data on the Embedded Capacity Register that details a list of generation projects accepted to connect or already connected to networks with a capacity of >1MW.

Finally long term planning data is published by operators in their Long Term Development Statements (LTDS) and in their Future Energy Scenarios that detail long term forecasts of local demand and generation.

In progress projects that aim to enhance the existing data exchanges between operators include:

- Grid Code modification 139 proposes enhancements to the scope and frequency of data exchange between DNOs and NGESO. Providing improved details of the sub transmission network, distributed energy resources, their impact on energy flows, and principal demand profiles.
- Ofgem's review of LTDS to require implementation of a GB CIM.
- ENA through Open Networks programme to expand visibility of operator data.

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Existing data landscape

Observations regarding existing standards, governances, and data formats

Findings and observations

The data exchanges that operators provide as part of their license obligations do not reflect the full picture of data owned and managed by the operators. Numerous organisational wide systems are in place to respond to operational functions and these systems all store and own data.

The stakeholder engagement process provided an opportunity to understand operators' roadmaps for integrating and managing data. A shared focus was the development of a common network model. This cloud hosted model would act as the master network data model and provide a single view of the operators' network. The model integrates data from core operational systems covering asset management, metering registration, network management, control, outages, GIS, power system analysis tools and more.

The model underpins operators' ability to productionise and share data via their web portal and is seen as critical for improving data access and quality.

It was recognised that across existing organisational systems there was risk of duplication and divergence when it came to asset data.

The network and operational data required for the use case had not been integrated into a common network model and instead was mastered in proprietary systems, such as PowerFactory.

The use case relies on this data being shared, this could be done either through the proprietary data formats or converted in to a CIM compliant format.

Both approaches had drawbacks but CIM was seen as the necessary standard due to it's interoperability and the need for the industry to adopt a standard that delivers for everyone.

Converting proprietary data formats into a CIM compliant CGMES (Common Grid Modelling Exchange Specification) format was considered the appropriate approach for sharing across organisations. However, there were recognised issues, such as:

- CIM export profiles offered by vendors vary between different proprietary tools. This requires manual workarounds and updates to ensure data is in the correct format.
- There was no standard approach to naming of node and asset IDs or of asset types and their respective properties; therefore. A manual mapping exercise is required to align data.

Governance considerations

A key consideration given by all stakeholders was the necessity of necessary data governance to be in place to enable data sharing between organisations who are at different levels of data maturity.

There was a recognised risk of organisations being apprehensive in sharing their data due to the perceived data quality issues. Data quality was of particular concern at the low voltage level, sub 11kv, where it was considered to be lacking in completeness.

Documentation of data was in progress and again varied depending on the organisation.

Organisations were all in the progress of documenting their data assets in centralised data catalogues, employing the Dublin Core metadata standards.

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Data gaps

An assessment of missing data that would enable the use case

Overview

The stakeholders engaged are on a journey with their data to improve standardisation, quality, completeness and access. This is partly driven by the requirements set out in ED2 and the transition from DNO to DSO which will enable more proactive and dynamic management of the distribution network

The current sharing of data arrangements between DNOs, NGET and NGESO is limited and does not fulfil the needs of the use case.

On-going initiatives such as ENA's Operational DER visibility and Monitoring workstream as well as future data sharing commitments as part of the ED2 business plans will vastly improve the breadth of data published by operators.

Use of standards and process varies greatly across operators. There is not a clear consistency regarding technology readiness levels and no clear sharing agreement currently in place between DNOs.

Network topology

As previously noted in the review of the existing data landscape, there is poor data below the 11kv voltage level. As such, it is recommended that the network be shared down to substations at the 33kv level. This will avoid incorporating poor quality data, while reducing the quantity of data that is needed to be transferred.

However, limiting the network to the 33kv will not remove all constraints. Visibility of embedded assets data (heat pumps, EV charging points, solar, wind etc.) at the lower voltage levels is poorly understood. Often generic loading and supply metrics are used rather than a split of generation or load types. This constraint may have less of an impact for the purposes of a demonstrator but will need to be addressed if this use case is to be delivered in full as it will be critical in understanding the capacity of DERs and their impact at different points on the network.

Alongside the data and standards gaps there is also no appropriate mechanism for sharing data between organisations. Current data sharing as part of the license requirements are completed through a combination of single-line diagrams and Excel workbooks which is not scalable. The VirtualES demonstrator technology review report addresses this issue

CIM standard

CIM has been considered to benefit more seamless data exchange but some limitations have been identified. It includes limited data entities or attributes.

This can result in the following:

- Lack of all data being imported/exported
- Missing data, particularly if a later version becomes available, as CIM conversions have standards, which can omit data. For example electrical details for unbalanced load flows and bespoke ratings.
- Not well equipped for real time data. Currently SCADA is better suited for this
- CIM is considered only suitable for scenario planning

There are currently different versions of CIM and as part of this research, carried out a review of the standard and ongoing projects to formalise it's use for the GB electricity network.

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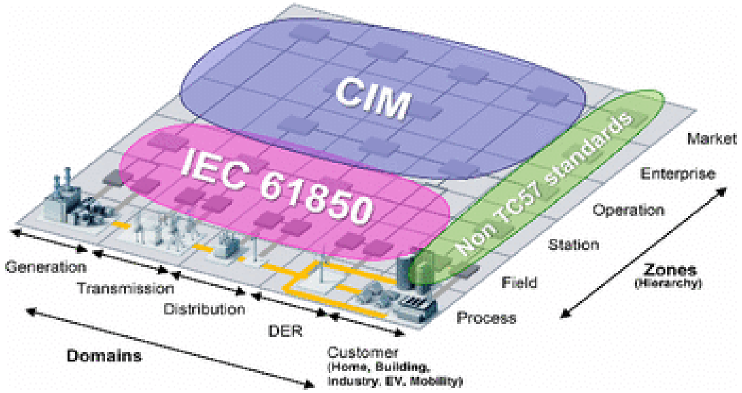
Common Information Model (CIM)

A summary of CIM and its relationship to VirtualES use case

Overview

The Common Information Model (CIM) is a combination of IEC standards that specify a common data vocabulary and ontology for information on an electrical network. CIM is a combination of three IEC standards; 61970, 21968, 62325.

Various extensions to CIM have been developed to suit specific user needs. Of interest to this use case is the Common Grid Model Exchange Standard (CGMES) library developed by ENTSO-E. This library was developed to facilitate data exchange of operational and planning information between transmission operators.



CGMES has grown in popularity over the last 10 years and there has been a general alignment to the standard. This has in its own right created the need for extensions to be added such as the Common Distribution Power System Model (CDPSM) that extend CIM to more appropriately cover the distribution network.

Ofgem, the energy market regulator, are currently undertaking work to align on a GB CIM that is specific to Great Britain and responds more comprehensively to the distribution network.

This version will be mandated for network data exchanges and will be adopted through the Long-Term Development Statements (LTDS).

CIM Appropriateness

The structure used to describe CGMES mirrors that which has been set out in the data assessment but under a different nomenclature. Data products are akin to profiles, entities align with classes and parameters with members.

CGMES, as would be expected, contains a broader and more comprehensive summary of data assets than documented in the assessment. Critically however there is broad alignment between the data assessment and the CGMES profiles.

The development of a GB CIM and the recognition across industry that a common standard rather than a proprietary standard is preferred makes CIM appropriate to use for the demonstrator.

As stated by Ofgem, CGMES v.3 should be the core standard and, where necessary, extensions such as CDPSM deployed alongside.

Future work is required as part of the demonstrator to complete a full review of the standard and any appropriate extensions.

The review should identify interoperability issues between the existing versions of CIM that proprietary systems export, it should determine the manual interventions required and how these may be resolved and it should examine requirements for joining networks from different operators.

Feasibility assessment

A review of data availability and data sharing capability of organisations as it relates to the use case

Overview

This assessment determined the impact of the data gaps identified previously and to what degree they prevent implementation of the use case.

The assessment considers the feasibility of the use case through the following two criteria:

- **Data availability** – Do organisations have access to the necessary data to allow them to model the scenario set forth in the use case and understand the full impacts of closing a switch to r-route electricity.
- **Data sharing –** Are organisations able to share the data in a common format that would allow another organisation to import a network model and an operational scenario to carry out their own modelling and assessment. This aspect focusses on required data quality and standards rather than the mechanism of sharing.

Data availability

The DNOs that were engaged as part of this assessment recognised the value of data and were on a journey to improve their data capture, processing and quality.

The data required to implement the demonstrator, as set out in this assessment, is not seen as being a limiting factor. DNOs had established modelling capabilities for network and operational planning decisions. This is seen as the essential data required to enable the use case.

There was a recognition that data quality below the primary substation level was poor but limiting the modelling scope to this level would not inhibit the use case and would have the benefit of reducing the size of the data being transferred.

The key data gap identified in relation to data availability was the lack of documented DER capacity at lower levels of the network. In particular flexible demand assets such as EV chargers and heat pumps which are likely to impact future demand profiles.

There were no further identified issues regarding data availability and those that were identified were not seen to impinge on the use case.

Data sharing

There were two core concerns regarding the sharing of data that will need to be addressed at the Beta phase. They concern the data quality and standardisation.

An obstacle that the use case may encounter is the willingness to share data between organisations where the data owner has concerns regarding their data quality.

Feedback was given by stakeholders interviewed that the data quality may be satisfactory for internal operational processes but that data owners may see risks in sharing the data with other organisations for uses outside of their control.

A second consideration that needs to be addressed is the standardisation across organisations of the data. This was considered in respect to both the data standards to be applied but also of the variation within organisations regarding asset naming and numbering as well as how assets are depicted when modelled.

These are by no means blockers to implementation but they will need to be addressed. Critical will be willing partners to engage in the use case and who see the value that the sharing of this data can unlock.

5

Recommendations

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Recommendations – demonstrator

People, processes, data, and technology recommendations for the demonstrator

This report identified several recommendations that will enable and enhance the demonstrator's impact. In addition to continuing development of the demonstrator, these are:

People

1. ESO continues to promote the benefits of the use case and demonstrator across the industry, and seek continued buy-in for the VirtualES.
2. Engage with different working groups focussing on data standardisation and align findings from this data assessment with their work.

Technology

1. A technology platform should be selected to facilitate data sharing between parties. This requirement is considered in the VirtualES demonstrator technology review.
2. Engage with power flow modelling vendors to understand their development roadmap and align on data standards.

Process

1. Produce process flow diagrams that expands on the data flow and use case diagrams. The diagrams should document interactions between different roles, between roles, and with VirtualES.
2. Investigate the potential for developing a certification process for validating CIM compliant networks. The certification process would validate internal data governance and quality processes and confirm compliance with selected standards.
3. Develop an operator wide process for assigning globally unique IDs to nodes, lines and assets.
4. A consistent process for implementing boundary impedance conditions when modelling reduced network arrangements is required. The demonstrator should develop best practice documentation for future users.
5. The demonstrator should investigate how to merge networks from different operators. It could consider a node mapping matrix, and common boundary nodes present in neighbouring networks.

Data

1. For the demonstrator, and in line with Ofgem's recommendation, CGMES v3 with the CDPSM extension should be considered. Ofgem's review of CIM as part of LTDS should be considered.
2. A review of CGMES v3 with the CDPSM extension should be carried out to determine it's applicability for the demonstrator.
3. Conduct an assessment into interoperability and data loss challenges with proprietary CIM vendor solution exports.
4. Investigate requirements and the stakeholders to engage to initiate greater alignment to a data standard that will reduce manual manipulation of the data and facilitate ease of access.

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Recommendations and observations – system-wide

People, processes, data, and technology recommendations and observations for the sector to consider

This report has also identified broader recommendations that are outside of the demonstrator's role to address, but should be considered by the sector. This are as follows:

People

1. Industry should work to promote a specific and exclusive role committed to CIM development and standardisation within each organisation. Consider developing a working group to engage with Ofgem's ongoing work with GB CIM.
2. The sector should develop targeted training and development to upskill in GB CIM before it becomes mandated.
3. Continue to engage with EDSO and EU SysFlex on development of CGMES and best practice across Europe.

Process

1. The speed of data exchanges is not currently sufficient for the demonstrator use case. New approaches to model sharing processes should be designed and tested.
2. A systematic review of the energy sector codes to ensure they reflect current technology and organisational capabilities for data exchanges.

Technology

1. Develop a to-be architecture for the automation of data pipelines, prioritising those required for the use case.
2. Develop tools or processes to better monitor the network at half hourly granularity.
3. A roadmap should be developed that plans how to achieve a shared, common network model of the whole GB electricity grid that is updated in real time.

Data

1. This work did not investigate internal organisational approaches to forecasting demand and generation. Further work should consider these processes and the data used to develop future scenarios.
2. Further work should consider how environmental, meteorological and market data could impact the broader use case and how this data could be shared between organisations.
3. Integration of systems such as eNAMS, which tracks network outages, should be considered. This would allow data to be updated by exception and provide visibility of all outages including those on the distribution network.

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Appendix

A.1

Data catalogue

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Data product catalogue – Asset

Summary of the data catalogue

Parameter	Parent Entity	Description
Asset ID	Asset	Unique ID of this Asset
Owner ID	Asset	Unique ID of the owner of this Asset
Asset Type	Asset	Asset type of this Asset
Years valid	Asset	Number of years Asset has been in valid operation
Switch No.	Switchgear	Unique ID of this Switchgear
Connection Point	Switchgear	Unique ID of Substation this Switchgear is attached to
Type	Switchgear	Type of Switchgear
Rated Voltage	Switchgear	Maximum voltage that can be safely applied to Switchear
Operating Voltage	Switchgear	Voltage value at which equipment is being operated
Rated Current (Breaking)	Switchgear	Maximum fault-current a Switchgear can successfully interrupt without being damaged
Rated Current (Peak Making)	Switchgear	Rated peak value attained at first cycle when Switchgear is closed.
Rated Continous Current	Switchgear	Current a Switchear can carry continously without tripping or exceeding temperature limits
Transformer ID	Transformer	Unique ID for this Transformer
Power Rating	Transformer	Highest Power input allowed to flow through Transformer
Voltage Ration	Transformer	Ratio between Voltages transformed
Tap Changer	Transformer	Information regarding the Transformer's tap changer (Range, Step Change, Type)

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Data product catalogue – Asset

Summary of the data catalogue

Parameter	Parent Entity	Description
Substation ID	Substation	Unique ID for this Substation
Type	Substation	Substation type (BSP/GSP/Primary/Distribution)
HV Level	Substation	High Voltage level of Substation
LV Level	Substation	Low Voltage level of Substation
MPAN	Generation	Unique ID for electricity meter
Generation Type	Generation	Generation type (PV, Solar, etc)
Generation Capacity	Generation	Connected capacity of Generation Asset
Point of Connection Voltage	Generation	Voltage at Point of Connection
Derivation Assumptions	Demand	Assumptions used to derive level of demand
Demand Mix	Demand	Mix of demand (Commercial/Residencial/Industrial)
Status	Outages	Status of affected Asset
Outage from	Outages	Start DateTime of Outage
Outage to	Outages	End DateTime of Outage

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Data product catalogue – Network

Summary of the data catalogue

Parameter	Parent Entity	Description
Line ID	Line	Unique ID number of this Line
Node ID 1	Line	Node ID of Node on one end of the Line
Node ID 2	Line	Node ID of Node on the other end of the Line
Current Rating	Line	Current rating of line
Power Factor	Line	Ratio of true power in Watts (W) to apparent power volt-amperes (VA)
NodeID	Node	Unique ID number of this Node
DNO Node Code	Node	Unique ID number of this Node given my DNO
NG Node Code	Node	Unique ID number of this Node given my NG
Drawing Position	Node	Node's position within network model diagram
Geographical Position	Node	Geographical coordinates of Node's physical position
Grouping ID	Grouping	Unique ID of this Grouping
Operator ID	Network Operator	Unique ID of this Network Operator
Operator Name	Network Operator	Official registered name of Network Operator

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Data product catalogue – Operational Scenario

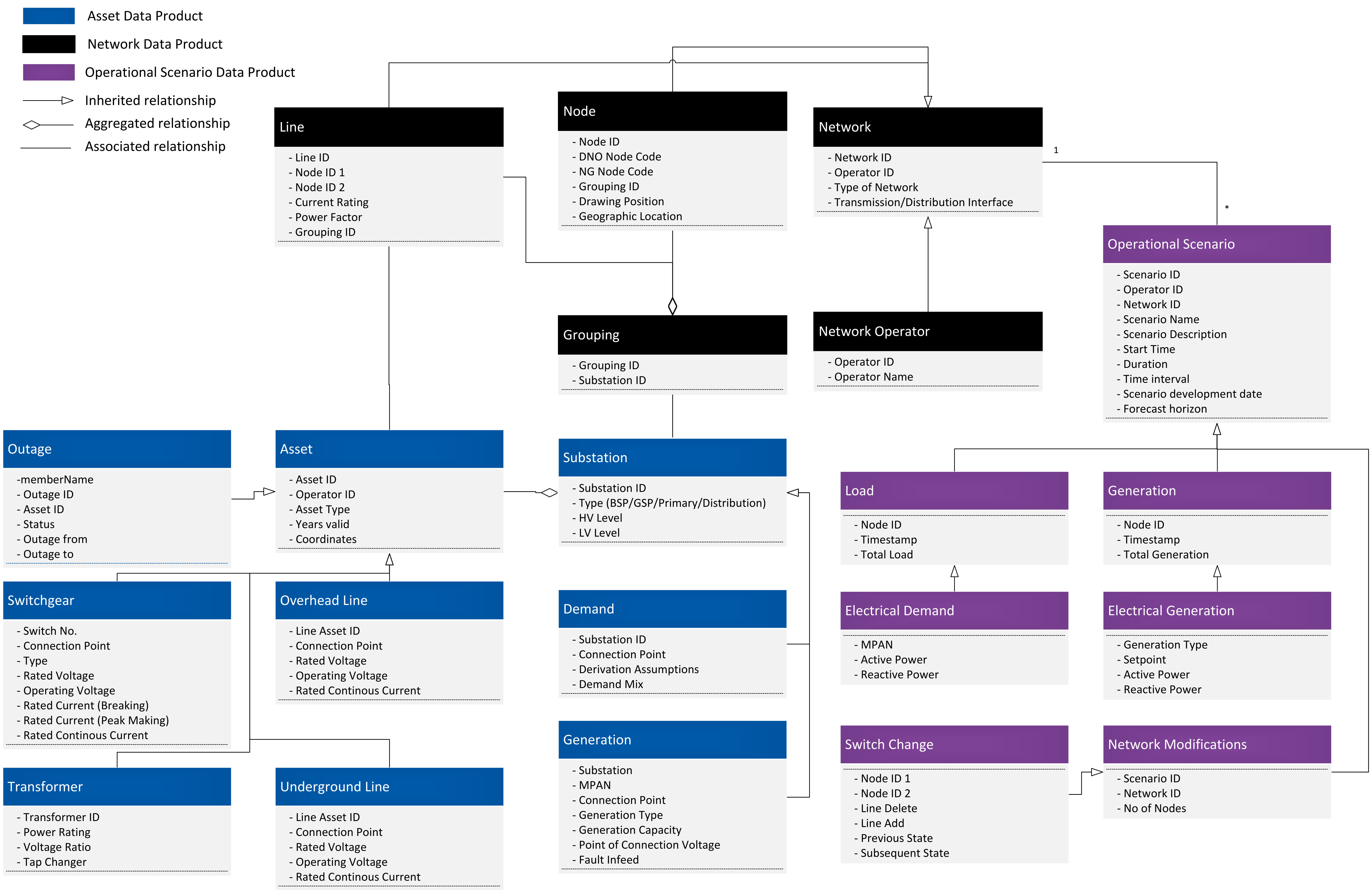
Summary of the data catalogue

Parameter	Parent Entity	Description
Scenario ID	Operational Scenario	A unique identifier for the scenario
Scenario Name	Operational Scenario	Name of the scenario
Scenario Description	Operational Scenario	Short description of the scenario
Start Time	Operational Scenario	Start DateTime of the scenario
Duration	Operational Scenario	Time length of the scenario
Time Interval	Operational Scenario	Time interval of the scenario
Scenario Development Date	Operational Scenario	Date the scenario was created
Forecast Horizon	Operational Scenario	Days between the scenario development date and the scenario start time
Timestamp	Load	DateTime of forecasted Load data
Total Load	Load	Aggregated forecasted load related to a specific node
Active Power	Electrical Demand	Active Power of Electrical Demand
Reactive Power	Electrical Demand	Reactive Power of Electrical Demand
Total Generation	Generation	Aggregated forecasted Generation of this NodeID
Setpoint	Electrical Generation	Generator voltage setpoint
No of Nodes	Network Modifications	Number of Nodes affected by Network Modifications
Previous State	Switch Change	Switchgear state before the Network Modification
Subsequent State	Switch Change	Switchgear state after the Network Modification

A.2

Data entity relationship

Appendix A.2 – Data entity relationship model



A.3

Stakeholders interviewed

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Stakeholders interviewed

Roles and organisations interviewed in the development of this demonstrator data needs and gaps assessment

Interviews were conducted with 16 key stakeholders, representing data governance leads, architects and planning roles across both electricity and gas networks.

The stakeholders assisted in developed the understanding of the data and technology needs from network modelling, operational planning, and real-time operations perspectives, and enabled the use case to be refined.

Only the roles category and organisations of the stakeholders are listed.

Role	Organisation
Data Governance	SSEN
Lead IT Architect	SSEN
Whole System Development	SSEN
Enterprise Architect	SSEN
Lead Network Planning Engineer	UKPN
Network Data Manager	UKPN
Operational Planning	National Grid ESO
Data Governance team (2x stakeholders)	National Grid ESO
Common Framework Workstream Lead	National Grid ESO
Data Quality and Governance	National Grid ESO
Operational Performance	National Grid Gas
Networks team (2x stakeholders)	National Grid Gas
Operational Planning	National Grid Gas
Real-time Operations	National Grid Gas
Energy Systems Data Architect	Ofgem

A.4

Interview guide

Appendix A.4: This page forms part of the interview guide shared with stakeholders to provide them with the background and context to the project and interview.

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Virtual Energy System

Workstream 2 - Common framework

NIA Alpha - Research Interviews

December 2022

ESO

Virtual Energy System
Powered by National Grid ESO

Appendix A.4: This page forms part of the interview guide shared with stakeholders to provide them with the background and context to the project and interview.

ARUP

Introduction

Purpose of this document and the demonstrator

Purpose of this document

This document provides the background and context for the research interviews that are being conducted as part the Virtual Energy System (VirtualES) Alpha phase, funded by NIA. This phase is a joint project between National Grid ESO and National Grid Gas Transmission.

VirtualES background

National Grid ESO have launched the Virtual Energy System (VirtualES) programme. Its objective is to enable the creation of an ecosystem of connected digital twins of the entire energy system of Great Britain, which will operate in synchronisation to the physical system.

This ecosystem of connected digital twins will facilitate the secure and resilient sharing of energy data across organisational and sector boundaries, enabling scenario modelling and whole-system decision making - resulting in better outcomes for society, the economy, and the environment.

The objective of this workstream is to develop the socio-technical framework that will form the foundation of the VirtualES.

NIA Alpha phase demonstrator

The common framework will create the common language, recommended infrastructure, and processes to connect and federate individual digital twins from across the energy sector together.

The framework considers both social (socio) and technical factors including, but not limited to: governance, policy, legal, data rights and consent management, ontologies, metadata standards, interoperability approaches, skills, data standards, security protocols, dispute resolution, performance, and codes of practice.

When implemented the common framework will be a suite of artifacts, assets, and solutions that are deployable and re-usable by actors across the sector.

Following the example set by the National Digital Twin programme and their Climate Resilience Demonstrator project (CReDo), it was observed that communicating and ultimately implementing a complex and deeply technical concept, such as the VirtualES, is best achieved through a demonstrator that appeals to a wider audience and rapidly proves that the framework theory can be implemented, that the concept is tangible, and the outcomes beneficial.

The purpose of the demonstrator is therefore to:

- Develop and demonstrate the priority key socio-technology factors which forms the framework
- Develop an initial version of selected high-value components of the suite of artifacts, assets, and solutions
- Provide the first opportunity to test the interoperability and connectivity of energy data within the context of the VirtualES objectives
- Create a foundation for the VirtualES and future common framework development

This initial use case also only considers a specific aspect of flexibility, which is the opportunity to use physical connections between grid supply points (GSPs) to move electricity between different locations to balance the system.

More information

The Key Socio-Technical Factors Report, published March 2022, provides further information on the common framework, its purpose, and its roadmap.

Appendix A.4: This page forms part of the interview guide shared with stakeholders to provide them with the background and context to the project and interview.

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Context: whole-system flexibility use case

ESO national gas

Virtual Energy System Powered by ESO

Use case context and requirement

The background to the scenario being demonstrated through the use case

Use case context

For the purposes of the demonstrator, a focus has been placed on the opportunity to use physical connections between grid supply points (GSPs) to move demand or generation between different locations. The demonstrator will consider the requirements in operational timescales from 3 weeks ahead to real time. This would be an example of achieving flexibility through a location shift.

Depending on the system configuration, GSPs can be:

- **Interconnected:** Connected as a group at GSP level e.g. 132kV or 66kV
- **Loosely coupled:** Connected at a lower voltage level e.g. 33kV or 11kV
- **Radial:** Operate as independent GSPs supplied from a single transmission connection

Radial GSPs are frequently built with connections to neighbouring GSPs (bypass circuits) which are open in normal operation (referred to as Normally Open).

These groups could have the ability to be connected at a GSP level, but typically a switch or switches in the network remain open (as considered within this use case).

For a radial configuration, in instances of planned network outages, this bypass can re-route electricity from adjacent GSPs to provide resilience to the network. This will either transfer part of the demand or generation from one GSP to the other while keeping an electrical split, or connect the two GSPs to operate as an interconnected group.

This optional bypass configuration is also used to manage thermal constraints within distribution network or to improve security of connection for demand and generation during outages. In future these connections could be used to actively optimise system capacity.

Similar considerations are required in all types of GSP connection in the operational planning process to maximise system availability and minimise system risk. This includes minimising generation restrictions through an improved understanding of demand behaviour and flexibility services within the group.

This reconfiguration typically requires weeks of planning and agreement in advance through the outage planning processes of the Grid Code and System Operator/Transmission Owner Code.

The assessment of the potential for interconnection or for any restrictions needed is dependent on visibility of the connectivity of assets involved, their capabilities and the expected behaviour of demand and generation.

As more renewable generation comes online there are potential advantages to using this connection reconfiguration more actively.

For example, in the diagram on page 5 GSP A has a significant amount of wind generated energy connected. If an outage is planned during windy weather then restrictions could be avoided by transferring generation or demand between the neighbouring GSPs, using local sources of flexibility or by running the two GSPs as an interconnected groups.

In active network managed zones, generation can be curtailed when supply exceeds demand. The proposed use case would allow excess energy produced in one part of the grid to be used elsewhere when required. This distributed generation is often from renewable sources (e.g. solar or wind).

Appendix A.4: This page forms part of the interview guide shared with stakeholders to provide them with the background and context to the project and interview.

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Use case context and requirement

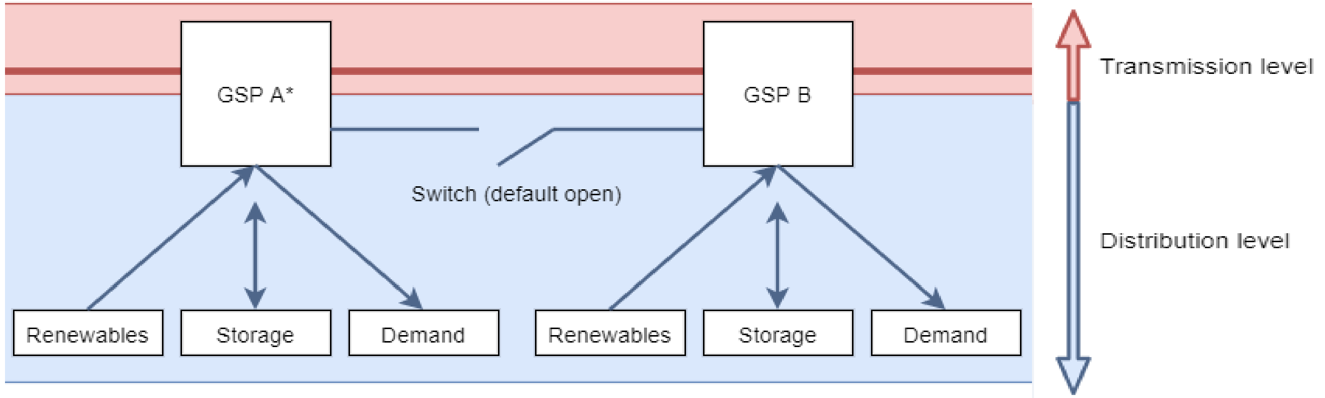
The background to the scenario being demonstrated through the use case

This would increase the potential renewable energy capacity of the grid, supporting the overall energy system decarbonisation.

Curtailment could also be reduced if additional demand (or storage) is added close to the point of generation or where the network is already strengthened.

The demonstrator could be expanded to support these longer-term investment decisions.

Initially, supply shifting could be planned a few days ahead using renewable forecasting and, as knowledge increases and the use case demonstrated the connection could facilitate real-time flows of electricity between parts of the distribution level.



Example GSP configuration (GSPs can be owned by the TNO or the DNO)

Considerations

Currently, connections between GSPs are largely used for planned power outages or to provide backup for groups that are sufficiently large under Engineering Recommendation P2: Security of Supply.

Ownership of assets and their controlling party can vary across the system, the demonstrator will expand visibility of assets within areas of interest of neighbouring networks.

The demonstrator will consider the operational limits and processes set out in the SQSS, Grid Code and System Operator Transmission Owner code and other requirements currently in place. These will include security of supply (including risk identification and mitigation), voltage limits (both steady state and step change), thermal ratings, system stability, fault levels and the ongoing work of ENA Open Networks.

Reconfiguring the network could lead to other constraints of embedded generators and this should be monitored by the demonstrator. The demonstrator will also need to consider the fault level of each of the connections so as not to overload the system and ensure the correct reinforcements are in place before GSPs are reconfigured.

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Research interviews

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Appendix A.4: This page forms part of the interview guide shared with stakeholders to provide them with the background and context to the project and interview.

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Research interview

The interview approach and the desired outcomes

Interview approach

This use case was developed through a user-tested hypothesis that the lack of network-wide end-to-end visibility of generator's assets, connectors and network capacity and constraints created an obstacle in accurately modelling, assessing, and controlling the whole-system flexibility.

Our research interviews will be structured around understanding the **data needs** and **technology needs** from three perspectives:

1. Network modelling
2. Operational planning
3. Real-time operations

An indication of the personas to interview and the types of question areas to explore are given on page 8.

Data needs

The aim is to establish which key data sets are required to be sharable across the industry with the appropriate detail, frequency, and granularity for it to be used to fulfil the needs of the use case.

Desired outcomes include:

- Understanding and identifying the data sets that are available and those that are currently missing.
- Understanding the current frequency and granularity of those data sets and determine if it fits with current data needs.
- Understanding if data manipulation or generalisation would be necessary and instances when it cannot be open or shared in its current state.
- Understanding which organisation(s) maintains the identified data.
- Understanding the data licencing status. If data is open / available. Where it is not, assess the feasibility of obtaining the required access, frequency and granularity.

Technology needs

The aim is to determine whether it is possible to make energy data visible and accessible to actors across the industry through a secure and scalable solution to store shared data and modelling.

Desired outcomes include:

- Understanding and identifying the current technologies used for data sharing between partners, including barriers and gaps,
- Understanding the applicability of current processes/systems/technologies in facilitating data sharing for the demonstrator use case.
- Understanding the functional/non-functional/security requirements for data sharing technology.
- Understanding suitable options for data sharing technologies/architectures and the associated tech stack.

Appendix A.4: This page forms part of the interview guide shared with stakeholders to provide them with the background and context to the project and interview.

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Personas to interview and indicative research questions

Indication of the personas to interview and the types of question areas to be explored

Network modelling

Future Network Development

Modelling & Forecasting Team

Framing

- What models are relevant to our use case?
- How is modelling currently used for system flexibility?
- How are externalities (TNO, DNO, Generators) modelled?

Data:

- What is the data quality and consistency like?
- What key data standards and specifications do you use?
- How is asset data currently captured / used in modelling or implementing system grid flexibility?

Technology:

- What is the current modelling toolset
- How is the data stored and modelled?
- Are there any integrations into other systems or software (within your organisation, and cross-organisation)?

Operational planning

Network Planning

Operational Planning

Framing

- How are planning decisions currently modelled and made in your organisation?
- How far in advance can a re-route of power be planned?
- What decisions need to be made to implement system flexibility?

Data:

- What data sets would you need for addressing the proposed flexibility use case?
- What would be the data/information flow for the proposed flexibility use case?

Technology:

- What technology/software is used for planning decisions?
- How is the data stored, modelled and shared?
- What type of analysis is conducted on the data?

Real time operations

Operational Control Team

Framing

- What inputs do you require to implement system flexibility?
- What real-time events and decisions are made to implement system flexibility?

Data:

- What data sets would you need for addressing the proposed flexibility use case?
- What would be the data/information flow for the proposed flexibility use case?

Technology:

- What technology/software is used for planning decisions?
- How is the data stored, modelled and shared?
- What type of analysis is conducted on the data?

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