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Virtual Energy System

Workstream 2 - Common framework

Whole-system flexibility use case

August 2022

nationalgridESO

Virtual Energy System
Powered by National Grid ESO

Summary

The purpose of the document, the demonstrator, and a summary of the use case benefits

Purpose of this document

This document further defines the "*whole-system flexibility*" use case that is recommended as the initial use case to demonstrate the common framework of the Virtual Energy System (VirtualES).

Purpose of the common framework 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 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. This is an example of achieving flexibility through a location shift (page 3).

Summary of benefits

The following key benefits are considered for this initial use case:

- It will allow more renewables to be connected to the distribution level network, minimising the need for curtailment.
- It supports the transition of Distribution Network Operators (DNOs) to Distribution System Operators (DSOs) by enabling electricity to move across the same voltage level. This facilitates the distribution level network becoming more dynamic.
- It moves the electricity system towards more real-time load balancing.
- It reduces the need for reinforcement of or storage in the distribution network by unlocking in-built flexibility.
- It develops an understanding of the VirtualES common framework requirements for future iterations and use cases.

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Whole-system flexibility

Defining the use case and its benefits

Definition

As detailed in the VirtualES SIF Discovery report, 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.

For the purposes of this project, flexibility is defined as:

> *"the ability to adjust energy supply and demand and keep them balanced"*
> **Bridging the Gap 2022, National Grid ESO**

> *"the ability to shift in time or location the consumption or generation of energy"*
> **Smart System and Flexibility Plan 2021, BEIS**

The Bridging the Gap report further defines flexibility as having Three components:

- **Time shift:** using batteries and smart chargers to store excess energy for later use
- **Location shift:** using interconnections to move excess energy to locations with unmet demand
- **Vector shift:** using electrolysis to change electrical energy into chemical energy for later use or non energy-sector purposes e.g. chemical manufacturing

While whole-system modelling encompasses all energy vectors, the demonstrator project will focus specifically on flexibility within the electricity system with options for expansion to include other vectors in future stages.

Benefits of flexibility to consumers and ESO

Key benefits for end consumers include:

- Energy supply security
- Low carbon electricity supply
- Opportunities to load shift for cheaper electricity

Key benefits for the system operator include:

- Increased customer satisfaction
- Reduced overall system costs through requiring less generation and network reinforcement
- Lower carbon electricity through use integration and maximum use of more renewables

The VirtualES will support the energy system in having increasingly autonomous operation with right-time decision making.

How digital twins support whole-system flexibility

A connected ecosystem of digital twins can support flexibility in several ways:

1. Create a more resilient system through managing peaks and troughs, ensuring security of supply and resilience to climate events.
2. Enable more renewable technologies to connect to the energy system and to operate effectively, supporting net zero objectives. This is likely to be particularly effective in dispatching curtailed technologies, especially in areas of sparce grid infrastructure.
3. Enable system operation of an increasingly complex energy system, facilitating a move towards real-time load balancing.
4. Support a *flexibility-first* approach. Reducing the need for unnecessary network upgrades through a more balanced system, and supporting in understanding where upgrades would be beneficial.
5. Understand the amount of interconnection and storage required within the system.

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Use case context and requirement

The background to the scenario being demonstrated through the use case

Use case context

As demonstrated above, whole-system flexibility has a broad definition which could encapsulate multiple use cases.

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).

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Use case context and requirement

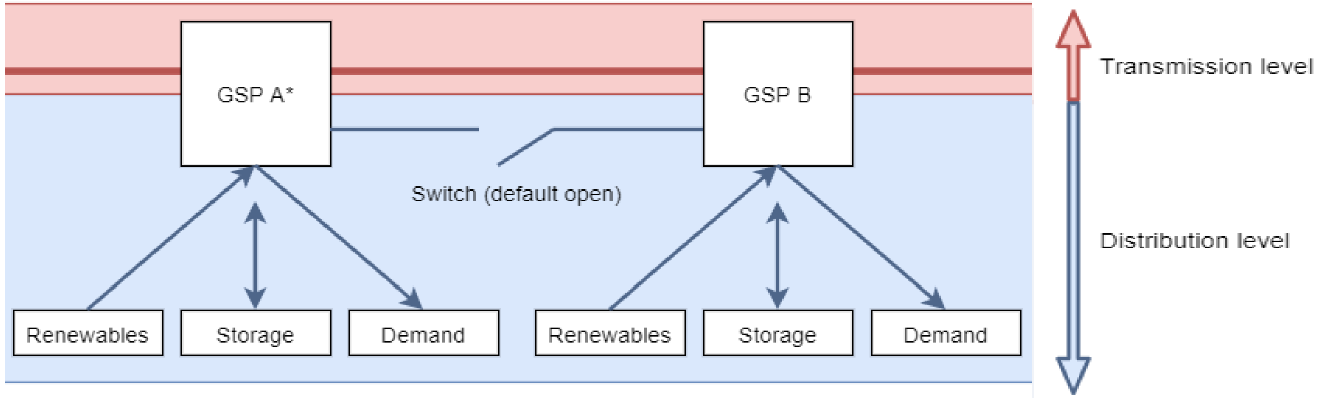
The background to the scenario being demonstrated through the use case

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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Use case scope and scalability

What the use case considers, and how it could be scaled

Scope

For this use case, the scope will consider:

- Data from one Distribution Network Operator (DNO), the Transmission Network Operator (TNO) and from Electricity System Operator (ESO) to understand the flows of information required to optimise the use of cables connecting GSPs for maximising energy system flexibility.
- Identify the specific flows of data and frequency of data exchange to optimise use the of GSP connection cables.
- Identify the roles and responsibilities involved in moving electricity across GSPs.
- Suggest any regulatory changes required to move electricity between GSPs.
- Conduct a high-level cost comparison between using bypass routes more actively compared with reinforcing transformers and transmission level grid.

The scope will explicitly not consider any alternative arrangements for DNO networks, or any regulatory of network/system changes.

Scalability and extensibility

The first iteration of the demonstrator will focus on the scope provided above.

In future there are several elements of flexibility which have been discussed throughout this document that the use case could be expanded to include, such as:

- Sharing data between multiple DNOs who share a single GSP
- Optimising network investment decisions, assessing the potential benefit of:
  - Adding demand close to generation
  - Reinforcing the network
- Active management of the distribution network in near real time.
- Enabling shift of electricity between GSPs at connections between lower voltage systems
- Making real-time decisions within the gas network and then using a whole-system approach for multiple energy vectors together. This would connect with other sector programmes (i.e. NGGT ‘data twin’ and SGN’s SIF Alpha)

In this use case, there is a clear need for data exchange between the system operator, transmission network operators, and distribution network operators to enable use of GSP connectors to manage flexibility.

As the DNOs transition towards being Distribution System operators (DSOs), this use case will support them in understanding the data they need from other parties to more effectively manage and control their networks.

The ambition of the demonstrator is to develop the VirtualES common framework through this flexibility use case. This will then provide the building blocks for the scaling of the use case to consider of each of these factors.

Appendix A.1 provides an initial overview of the data sharing requirements currently considered to underpin this work. This will be refined further as the demonstrator progresses.

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Addressing the priority socio-technical factors

How each of the six priority socio-technical factors will be demonstrated and developed through this use case

Priority socio-technical key factor	How it will be demonstrated through this use case
Raising awareness and fostering culture	Improved system flexibility is a key aspect of achieving a net zero energy system,-through increased use of renewable sources. By highlighting this use case it raises the profile of the need for a VirtualES to achieve net zero. This use case will raise awareness of opportunities and challenges associated with using bypass connections for flexibility. The demonstrator has the potential to advocate more active use of bypass links to enable more renewable generation in the future. Successful demonstration of this use case highlights some of the benefit that can be unlocked through increased data sharing. The demonstrator will be developed in the open where possible in order to demonstrate the desired culture required for a successful VirtualES. Awareness will also be created by working closely with DNOs and TNOs and by presenting key ideas to advisory groups.
Aligning models and taxonomies	Data sharing is a critical aspect of modelling for flexibility of the energy system, and therefore data models and their alignment is critical to achieve inside and outside the electricity sector. This use case is the first step in alignment of models between distribution and transmission level and we will work with each party to agree standards.
Increasing visibility and enabling sharing	“Data portals” will form a central role in the sharing of data to different actors in the sector, so they can use datasets from other parts for their own modelling. This will be enabled through portals such as Open Energy which will be demonstrated within the flexibility use case. This use case will enable an understanding of the data sharing required to maximise the use of bypass connections.
Creating interoperable tech-stack	The delivery of this use case will require a technology stack of a certain level of maturity that inherently supports interoperability by allowing supply and demand to be balanced across separate GSPs.
Engaging stakeholders	System flexibility requires all parts of the sector to contribute as it will be from distribution through to transmission, generation. It will also include gas networks (e.g. NGGT as a potential project partner) and those external to the energy sector. Demonstrating this use case will therefore explicitly require input from a number of stakeholders.
Creating a governance framework	For the above factors to be achieved data governance is critical, e.g. so that the appropriate data is made available in the appropriate platforms and security is considered etc. This requires good data governance to be demonstrated. This use case will be used to create an outline governance framework to allow DNOs to share data with TNOs and, in follow-on work, between different DNOs to enable the use of bypass systems.

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Example data requirements

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Example data requirements

The flows of data that may be required to support the demonstrator

Electricity System Operator (ESO)

ESO will need visibility of:

Example	From
TO network configuration & capability	TO
Configuration of protection, inter trips and active network management	TO
TO connected generation configuration & capability	Generators
DNO network configuration & capability (132kV and below to lowest voltage level of any interconnection between GSPs)	DNO
Configuration of protection, inter trips and active network management	DNO
DER connections location & capability (132kV and below aggregated to limit of network visibility)	DNO
Demand connections location & capability (132kV and below aggregated to limit of network visibility)	DNO

Distribution Network Operator (DNO)

The DNO will need visibility of:

Example	From
TO network ‘standard’ configuration and capability	TO
proposed TO configuration	ESO
proposed operational plans e.g. voltage strategies, outages, faults	ESO

Transmission Operator (TO)

The TO will need visibility of:

Example	From
Any DNO changes in configuration	DNO
DNO network configuration & capability (132kV and below to lowest voltage level of any interconnection between GSPs)	DNO
proposed TO configuration	ESO
proposed operational plans e.g. voltage strategies, outages, faults	ESO

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