Virtual Energy System

Workstream 2 - Developing the underpinning frameworks

Key socio-technical factors report

March 2022

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Background

National Grid 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.

Whilst the creation of an ecosystem of connected digital twins is considered possible from a technology perspective, there are greater challenges from a people, process, and data perspective.

This combination of both social and technology (socio-technical) challenges indicates that the development and delivery of the VirtualES will need a sector-wide transformational change. The VirtualES can help deliver this change through a collaborative and principled approach, that is aligned to the National Digital Twin programme and other energy sector digitalisation strategies, with work conducted ‘in the open’.

Delivery will also require explicit and proactive engagement that builds cohesion within the energy sector and with cross-sector stakeholders.

Approach

This report identifies 14 key socio-technical factors that will form the foundation of the VirtualES – enabling the creation of this ecosystem of connected digital twins. These were derived through research, expert interviews, and industry-wide engagement.

Six of these factors were prioritised based on their potential impact on the VirtualES objectives and their relative maturity across the wider energy sector.

The social and technology factors are in line with the recommendations and findings of the recently published Energy Digitalisation Taskforce (EDiT) report, and are highlighted throughout the document where applicable. They also draw on the findings from practical experience from the development and implementation of industry-wide programmes, such as Open Banking and Open Energy though MEDA.

These 14 socio-technical factors create a clear path forward for collaboratively developing the VirtualES.

This document highlights the scope of work that will be required to design, build and operationalise a VirtualES. It also shows how this is in line with the wider digitalisation needs of the sector.

Recommendations

We recommend that:

1. The development of connected digital twins must combine both social and technical factors.
2. The ecosystem design must maximise for cohesion (common, market-wide processes) and interoperability (processes that enable low-friction transactions) across systems.
3. Cohesion and interoperability must cover a blend of factors including, but not limited to: governance, policy, legal, data rights and consent management, ontologies, skills, data standards, security protocols, dispute resolution, performance, and codes of practice.
4. There must be alignment between energy sector policy, regulation, and the plan for digitalisation. With learnings taken from the National Digital Twin programme and the CReDo demonstrator project.
5. The tangible benefits that the development of the VirtualES will bring to the energy sector should be communicated at every opportunity to build confidence and gain commitment from the sector.

Nomenclature

AI/ML Artificial Intelligence/Machine Learning
API Application Programming Interface
BEIS Department for Business, Energy and Industrial Strategy
CDBB Centre for Digital Built Britain
CIM Common Information Model
CMA Competition and Markets Authority
CPNI Centre for the Protection of National Infrastructure
CReDo Climate Resilience Demonstrator
DAFNI Data & Analytics Facility for National Infrastructure
DNOs Distribution Networks Operators
EDDB Energy Digitalisation Delivery Body
EDiT Energy Digitalisation Task Force
EDTF Energy Data Task Force
EDVP Energy Data Visibility Programme
ENA Energy Networks Association
ESC Energy Systems Catapult
ESO Electricity System Operator
EV Electric Vehicle
GC Geospatial Commission
GDPR General Data Protection Regulation
IB1 Icebreaker One
IEC International Electrotechnical Commission
IMF Information management Framework
IoT Internet of Things
ISO Independent System Operator
MEDA Modernising Energy Data Access
NDTp National Digital Twin program
NG National Grid
NCSC National Cyber Security Centre
NIS Network and Information Systems
OFGEM Office of Gas and Electricity Markets
ODI Open Data Institute
OE Open Energy
OEO Open Energy Ontology
TSO Transmission Network Operator
VirtualES Virtual Energy System

1 — Approach

Context

Framing the needs of a Virtual Energy System

The Virtual Energy System

In response to the need to achieve net-zero, and the changing landscape of generating, managing and consuming energy, National Grid ESO launched the Virtual Energy System (VirtualES) programme.

The objective of the VirtualES 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. This ecosystem of connected digital twins will enable energy data sharing across organisational and sector boundaries, facilitating scenario modelling and whole-system decision making - resulting in better outcomes for society, the economy, and the environment.

Creating the VirtualES is a socio-technical challenge that requires a collaborative and principled approach, that is aligned with the National Digital Twin programme, and other energy sector digitalisation strategies. To start development of the VirtualES, National Grid ESO have commissioned three workstreams. This report forms part of workstream 2.

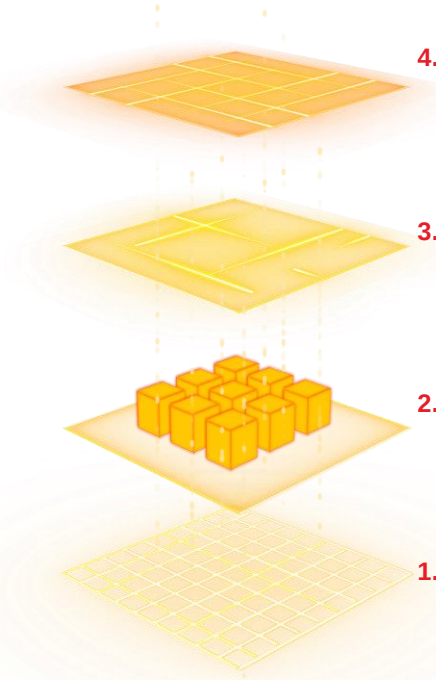
- Workstream 1 - Stakeholder engagement
- Workstream 2 - Common framework & principles
- Workstream 3 - Use cases

Workstream 2 - Common Framework & Principles

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

This framework will consider factors such as, common elements of taxonomy; metadata standards; interoperability approaches; and security and access protocol. This framework will be developed through three interconnected work packages:

1. **External benchmarking:** Understanding the cross-sector and global best practice for connecting assets, systems, and digital twins.
2. **Defining the key elements (this report):** Determining the key socio-technical factors that need to be considered for the VirtualES to succeed.
3. **Developing agreed standards with partners:** Collaboratively developing, with industry, agreed and cohesive standards and approaches for the key elements.



Virtual Energy System

Indicative components of the Virtual Energy System

Delivery team

Delivery was led by three domain experts over eight weeks

Workstream 2 (common framework & principles), is led and delivered by Arup, supported by the Energy Systems Catapult and Icebreaker One.

- **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, and actively contribute to the National Digital Twin programme.
- **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. The ESC were responsible for the Energy Data Task Force (EDTF) and are delivering the 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 three organisations assembled a delivery team to effectively collaborate and deliver the objectives of this workstream.

This key elements work package was delivered over eight weeks and followed an agile delivery methodology – with the delivery team working in four sprints, each two weeks in duration – in close collaboration with National Grid ESO throughout.

The key elements methodology and approach is detailed in the following pages.

Methodology

A double diamond process with four sprints delivered insights

Approach overview

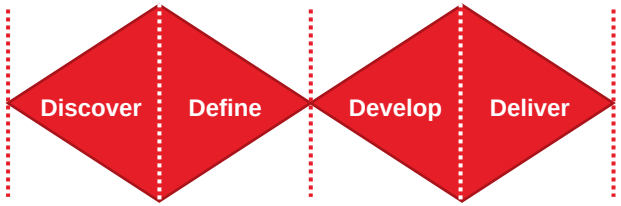
The project team adopted the British Design Council 'Double Diamond' process. Each sprint focused on one quadrant of the diamond, ensuring the key factors are designed correctly through two phases of divergent thinking and converging around recommendations.

Sprint 1: Using the benchmarking report and research a long-list of 14 socio-technical factors was produced.

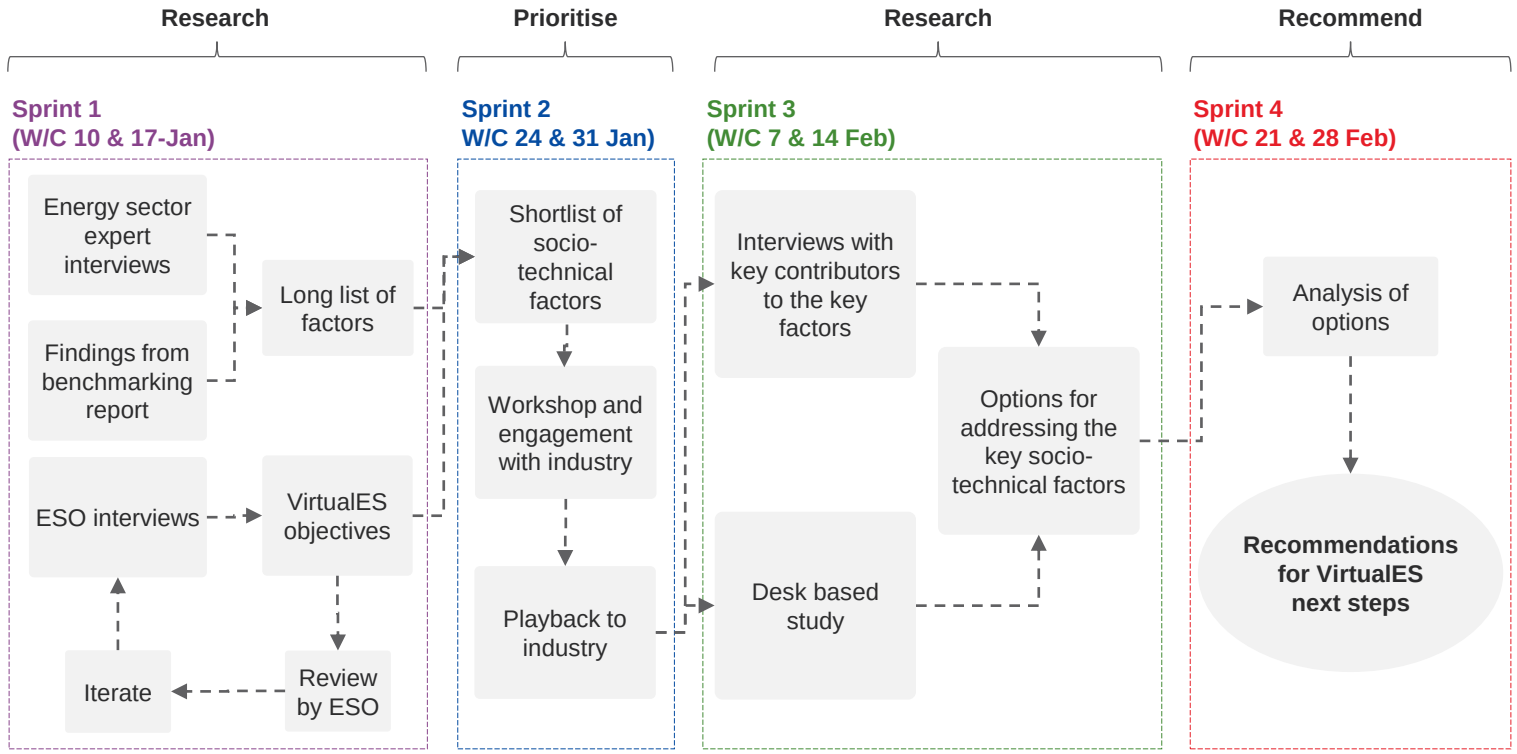
Sprint 2: The findings were synthesised, with the six priority socio-technical factors shortlisted.

Sprint 3: Further research was conducted on all the factors to understand the current industry status and recommended focus for the VirtualES.

Sprint 4: The final synthesis assessed the level of maturity and adoption of each element, providing clear recommendations for the common framework.



Double diamond process



Engagement

Engagement was key to understand the social and technical challenges

Role of engagement

Our research, expert interviews, and industry engagement has highlighted the socio-technical nature of connecting digital twins, assets, and systems at scale.

Whilst the creation of an ecosystem of connected digital twins is considered possible from a technology perspective, there are greater challenges from a people, process, and data perspective. For example, legal challenges with data sharing agreements, commercial sensitivities with models and data, interoperability difficulties through the lack of metadata standards or common ontologies and taxonomies, and the need to focus on skills, education, and change management.

Considering this, the development and delivery of the VirtualES will need sector-wide transformational change, delivered through a collaborative and principled approach with work conducted ‘in the open’.

This will require explicit and proactive engagement, within the energy sector and with cross-sector stakeholders.

Internal engagement

Internal engagement was focused on stakeholders within National Grid ESO.

Interviews were conducted with 15 key stakeholders, representing innovation, data science, power systems, operations, control room, and consumer strategy. The stakeholders were asked about their views on the purpose, objectives, enablers, and blockers of the VirtualES.

The findings of these interviews were synthesised and assisted in the development of the key socio-technical factors, and in their prioritisation.

An engagement session was held with the collective National Grid ESO stakeholders to share the findings and obtain feedback on the key factors. All feedback has was iteratively incorporated in to our reporting throughout the process.

External engagement

A show and tell was held virtually to gain feedback and comments from the wider energy sector and the leading digital twin community.

The findings and key socio-technical factors were presented to the attendees, who were asked to comment as part of an interactive exercise.

To encourage high levels of participation, the show and tell was advertised through social media channels and publicised in the weekly Gemini Call, hosted by the National Digital Twin programme and attended by over 100 digital twin expert practitioners.

The show and tell was attended by 55 stakeholders from across academia, the energy sector, and wider industry. The findings and insights gained from the show and tell are detailed in Appendix A.1.

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Socio-technical factors

Socio-technical factors overview

Research and interviews identified 14 social and technical factors

Overview

The methodology followed is detailed in Section 1.

Through research and user interviews, coupled with the findings of the benchmarking report, we identified 14 socio-technical factors which are considered necessary for the development and delivery of the VirtualES today.

It is acknowledged that the VirtualES is a multi-year programme and that the factors will evolve, and future factors become apparent, as the programme progresses.

The 14 identified factors are grouped by the categories of **People**, **Process**, **Data**, and **Technology**. The titles of the factors intentionally include verbs, making their framing actionable.

Overview descriptions of each of the factors are given on the pages 12 to 15, with their full analysis given in Section 2.2 and Section 2.3.

These 14 factors were prioritised to highlight the six factors recommended for immediate consideration. The method of prioritisation is detailed in Section 2.1.

People	Defining roles & responsibilities	Raising awareness & fostering culture	Building capabilities & skills	
Process	Aligning around industry codes & standards	Engaging stakeholders	Creating a governance framework	Determining the operating environment
Data	Aligning models & taxonomies	Establishing management & governance	Increasing visibility & enabling sharing	Managing security
Technology	Connecting physical infrastructure	Enhancing modelling and analysis	Creating an interoperable 'stack'	

People

Three socio-technical factors were identified for People, with one priority factor. See page 19 for prioritisation.

PRIORITY FACTOR

Defining roles & responsibilities

Formalise roles and responsibilities for the VirtualES, focusing on consumer benefits

Define key stakeholders' position across the VirtualES ecosystem with an indication of tasks and duties for which they are responsible.

In the context of VirtualES focus should be given to:

- Data management roles and responsibilities (e.g. data owner, steward and user), in the context of the VirtualES
- Leadership roles and responsibilities at operational and executive management levels.

Raising awareness & fostering culture

Shared vision, belief and behaviours and enabling practices to support the VirtualES objectives

Define the cornerstone beliefs and behaviours that will be needed to support the delivery of the VirtualES objectives. This will identify key values and practices that will support the VirtualES vision.

Key values could include: openness, security, customer centricity, agility, and ethics - which encourage shared prosperity

Practices could include: developing the approach for change management and building trust

Building capabilities & skills

Understanding skills & competency needs with respect to current skill levels, and develop capacity building strategies

Define the capabilities needed at all levels of an organisation to support the VirtualES ecosystem and identify the best strategies and practices to develop and establish them.

Focus should be given to:

- Understanding open data
- Interoperability
- Technology architecture/resilience
- Data analysis

Process

Four socio-technical factors were identified for Process, with two priority factors. See page 19 for prioritisation.

Aligning around industry codes & standards

Identify standardised practices in industry & align around them

Review and identify whether existing energy sector standards and codes are applicable for enabling the VirtualES, or whether amendments or additions are needed. This should prioritise strengthening existing standards over creating new standards.

Focus should be given it:

- Technical standards for modelling and operation of energy systems
- Grid Code / Distribution Code
- System Operator / Transmission Owner Codes
- Existing processes (i.e., data triage)

PRIORITY FACTOR

Engaging stakeholders

Nurture industrial, governmental, and political support

Identify the best approach to nurture strong support and active engagement from key VirtualES stakeholders.

Focus should be given to:

- Nurturing transparent and open engagement and creating trust and shared ownership across a wide range of stakeholders (e.g., industry, academia, public and private sectors)
- Locking in support and direction from governmental and regulatory actors who are able to influence the sector through policy and targets

PRIORITY FACTOR

Creating a governance framework

Set strategy and operational governance of the VirtualES

Identify the high-level governance framework to support the VirtualES ambitions.

The clarification of best-suited governance models will help VirtualES contributors by bringing clarity around how they will interact.

This should also consider effective routes for management of issues and change requests to the common framework.

Determining the operating environment

Enable the business models, cross organisational legal, policy, and contractual frameworks

Define, at a high-level, the environment needed for the VirtualES to create value and become self-sustaining.

Focus should be given to:

- Potential business models
- The legal framework needed to unlock the key challenge in relation to the sharing of data
- Policy & regulatory context

Data

Four socio-technical factors were identified for Data, with two priority factors. See page 19 for prioritisation.

PRIORITY FACTOR

Aligning models & taxonomies

Define an approach to harmonise existing data standards, taxonomies and ontologies

Harmonise the data architecture that will support the VirtualES, facilitating effective interoperability and data exchange.

Focus on setting an approach to harmonisation by:

- Building sector wide cooperation.
- Identifying how to connect/use the various existing data standards, taxonomies and ontologies

Establishing management & governance

Outline data management and governance requirements to support the VirtualES

Identify how to best enable the data requirements across the VirtualES by defining:

- Rights and accountabilities needed to ensure the appropriate behaviour in the valuation, creation, consumption, and control of data
- Practices, techniques, and tools for achieving consistent and efficient access to and delivery of data across the VirtualES
- Ways to promote and assure the quality of VirtualES data so that it is suitable for its purpose/use, and trusted

PRIORITY FACTOR

Increasing visibility & enabling sharing

Nurture effective data sharing to support interoperability

Enable actors across the VirtualES to create, exchange, and consume data in a way that ensures clear, shared expectations for the contents, context, usage and meaning of that data.
Focus should be on:

- Promoting direct access to data that is open
- Easing the consent & approval processes for data requested
- Simplify and guide data licencing
- Understanding how to best to describe and catalogue data to support search
- Allow feedback on data

Managing security

Set the core rules needed to address security, privacy and risk implications surrounding VirtualES data

Define the guiding rules to protect sensitive information assets connected to the VirtualES, in transit and at rest.
Focusing on understanding how to:

- Drive adherence to the latest practises, legislation, and regulation
- Evaluate security & privacy needs and risk of VirtualES data
- Make security and privacy a fundamental VirtualES design principle (e.g., enforce access control and clear authorisation protocols for data usage, provide data integrity and immutability, building resilience, etc.)

Technology

Three socio-technical factors were identified for Technology, with one priority factor. See page 19 for prioritisation.

PRIORITY FACTOR

Connecting physical infrastructure

Identify the physical infrastructure, devices and their connectivity required to operate the VirtualES

Determine the technical infrastructure needed to enable the VirtualES to connect physical energy infrastructure, considering connectivity, compute, and resilience requirements.

Establish a framework or guidance to evaluate the anticipated requirements, such as security, and other challenges to address. This should focus specifically where high volumes of physical devices, EVs and storage connect simultaneously to the network - supporting real-time monitoring of large processes and assets.

Enhancing modelling and analysis

Identify the modelling, simulation, and analysis software used for current and future modelling

Determine an approach to share methodologies and results of modelling and simulation within a federated VirtualES ecosystem, and co-simulation between the physical reality and energy market scenarios.

Explore the common principles and guidelines needed to support users in adopting analysis and data visualisation tools.

Understand the open source software initiatives being developed or in use to reduce costs and enable innovation.

Creating an interoperable 'stack'

Communication, cooperation & sharing across VirtualES & other in/cross sector projects

Define how the architecture of the VirtualES can actively break down barriers to integration of data, and promote wider integration and data exchange present across the energy sector and beyond.

This should look to identify best practices around:

- Data exchange & request protocols
- Integration of applications and the use of open software
- Data and metadata standards
- Distributed data management

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2.1

Socio-technical factors prioritisation

Prioritisation

Priorities include impact potential, industry maturity, and adoption

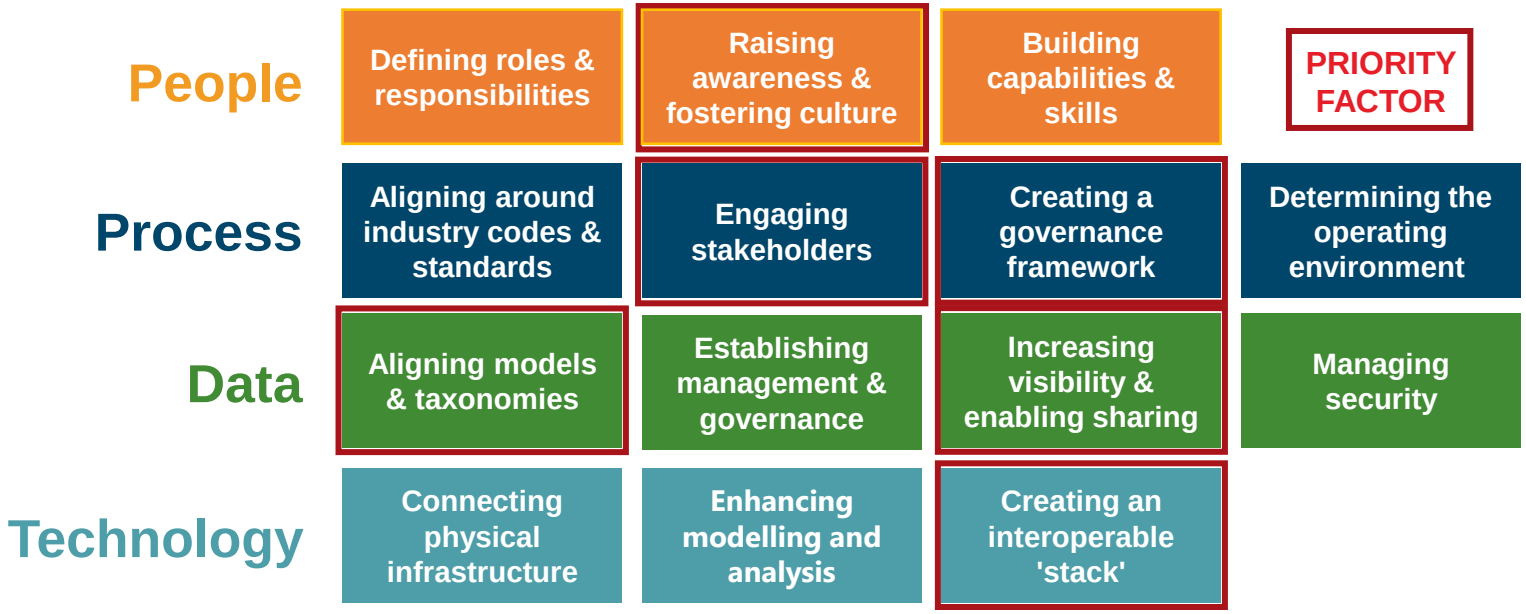
Prioritisation

Whilst all the key social-technical factors are necessary for the VirtualES, it is considered that certain factors would take precedence in setting the foundations for the next steps for further development.

Six factors were identified as an initial priority based on:

- Their potential impact on contributing to the VirtualES achieving its objectives
- The maturity of existing activities and programmes happening in their area
- The adoption of existing activities and programmes happening in their area
- There being at least one factor from each category (People, Process, Data, Technology), to facilitate a holistic approach to development.

The subsequent pages outline the methodology and process used for the prioritisation.



Alignment with the VirtualES aims and objectives

Several detailed objectives were identified that expand on the vision and overarching objectives of the programme

In order to prioritise the key socio-technical factors, it was necessary to understand how each factor will impact and contribute to the VirtualES and its objectives.

Building on the overarching objectives of the programme detailed on page 6, stakeholder interviews were conducted to understand the particular user needs and business priorities. These needs and priorities were synthesised and translated into several detailed aims and objectives. These were then tested and iterated with the stakeholders (see page 9) and used to assist in the prioritisation of the key socio-technical factors.

These derived aims and objectives are not exhaustive and are for the prioritisation of the socio-technical factors only. They therefore do not supersede or replace the vision and overarching objectives of the VirtualES programme.

High-level aims

- **Contributing to the achievement of net zero**
  Lower carbon intensity of the energy system by increasing system efficiencies through better decision making caused by increased flow of information.
- **Building a Virtual Energy System**
  Creating with industry a connected ecosystem of digital twins which replicates the energy system

Common framework (workstream 2) objectives

- **Agile**
  Delivers benefit throughout deployment through the modular system design.
- **Encouraging the industry to participate**
  Collaborating on the rules, competing on the game
- **Accessible**
  Proportionate and security-minded access, based on roles, responsibilities and requirements.
- **Upskilling of ESO**
  Developing the capabilities and skills of the business
- **Visibility of ESO to energy system stakeholders**
  ESO and their role better understood and more accessible to the sector

VirtualES objectives

- **Governance**
  Bringing people together and providing the framework that ensures all stakeholders know the role which they must fill.
- **Open data**
  Increased open data, sharing, and visibility
- **Standardisation**
  VirtualES will recommend the standards to which digital twins are produced for them to be connected
- **Interoperability**
  Demonstration of a scalable model to produce a modular, connected ecosystem of digital twins
- **Business models**
  Enable innovation, competition and support investment in digital development
- **Modelling & scenario planning**
  Allows for testing and modelling of the energy system to solve several use cases

Prioritisation summary

The background for prioritising certain socio-technical factors

People

Raising awareness and fostering culture has been prioritised given that it is critical the industry accepts and begins to push for the VirtualES having a role to play in the future energy system.

Organisations must shift their thinking beyond achieving their own organisational objectives to achieving greater system flexibility as more renewables come online.

Data and information sharing in a secure, resilient, and agile way is central to this and organisations must be brought into that culture and way of thinking. This is a key starting point. Once established organisations become invested in the VirtualES, the roles and responsibilities of the industry stakeholders are required.

Leadership roles from across the sector will be a key enabler to success, making sure there is representation from industry, the regulator, and government for mandate and incentive levers to be accessible to the VirtualES. There are clear links to governance and data management. Alongside people and organisations structuring themselves around the VirtualES, and the associated capabilities and skills that will need to be developed.

Process

Engaging stakeholders and **creating a governance framework** are the prioritised factors as they are the processes by which the core team of people that will build the VirtualES foundations will be established by.

The whole sector, and consumers, will be impacted by the VirtualES and so must have the appropriate level of input into its development. Governance must be in place to steer the programme and to help navigate through the differing opinions which will emerge.

The VirtualES must develop alongside the physical energy system, and therefore its adherence to industry codes is essential. Some of these codes might require modification to enable the VirtualES. This is typically a lengthy process and should be started as soon as possible. Changes are more likely to be efficiently executed if there is sufficient industry backing ahead of the change request.

Similarly, the operating environment is needed but cannot be put in place before the roadmap of the VirtualES is known with a clear governance structure.

Data

There are several programmes already underway in the industry for the **aligning models and taxonomies**. However, further work is needed to ensure that data standards support data sharing across organisational and sector boundaries.

There must also be **increased data visibility and sharing**, so that the gaps and opportunities can be identified.

Technology

Interoperability and the exchange of data is fundamental to the success of the VirtualES. This is enabled through **creating an interoperable 'stack'**.

The connection to the physical energy infrastructure will likely be developed on a per-use-case basis. Whilst the identification and enhancement of modelling and analysis will converge into an agreed suite once the core components of the VirtualES are in place.

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Maturity and adoption

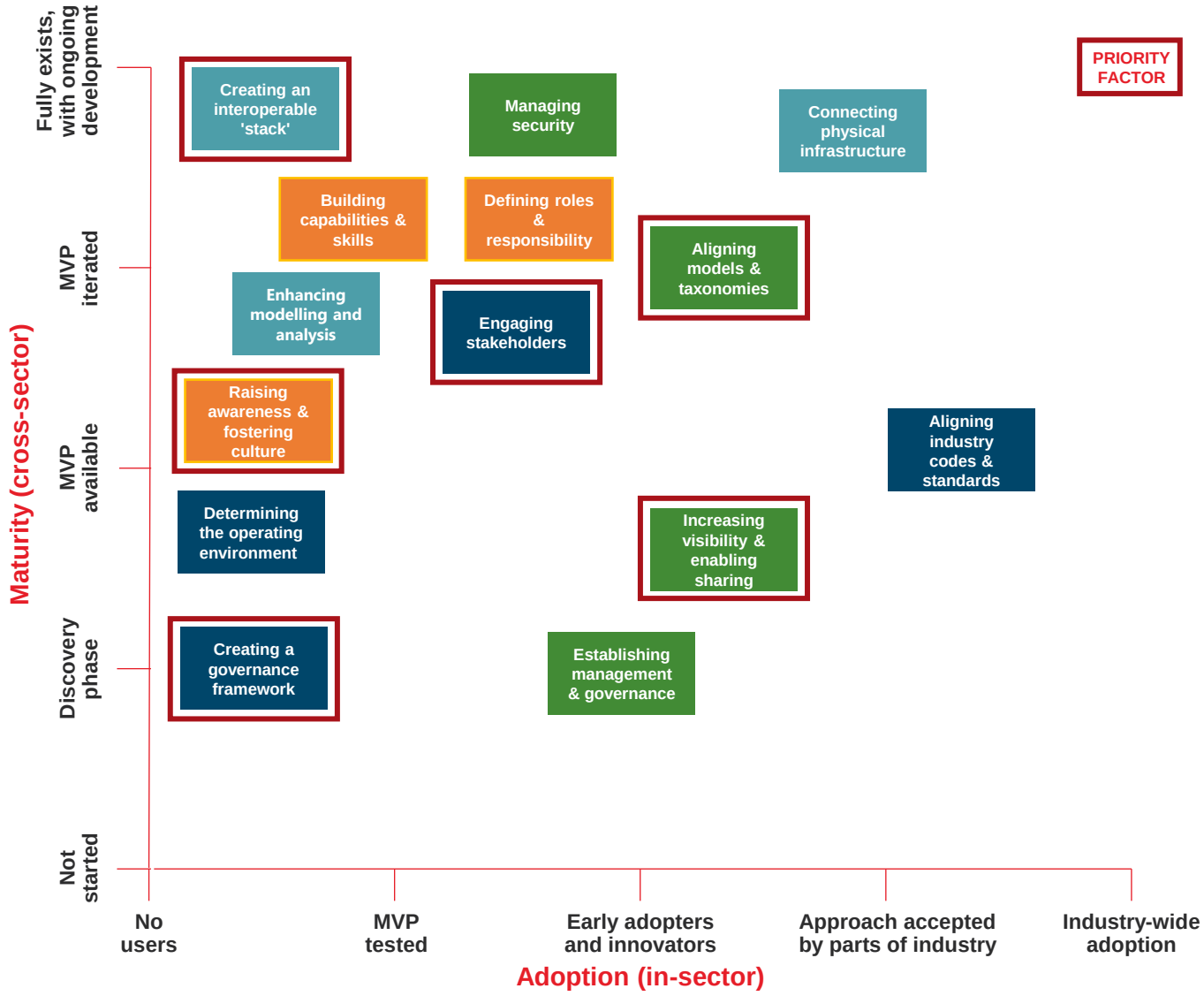
Comparing maturity (cross-sector) and adoption (in-sector)

The research, user interviews, and benchmarking outcomes provided a high-level assessment of the current maturity cross-sector and adoption in-sector for each socio-technical factor.

This acknowledges that in the domain of connecting assets and systems together into an ecosystem there are areas of significant progress and development across wider industry, and that the VirtualES aims to learn from this collective experience.

The factors were indicatively plotted to understand their relative position to each other, and the position of the prioritised factors.

This acknowledges that each factor has a number of component parts. Given this complexity, the position on the diagram is purely high-level and intended for outline comparative purposes only.



Categories

People | Process | Data | Technology

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2.2

Priority socio-technical factors

Raising awareness & fostering culture

People

Current status

It is acknowledged that the VirtualES is a new industry initiative, and so naturally the communications to date have provided the high-level vision, but the specific aspects of the VirtualES are yet to be fully detailed and defined. Through continuing the planned input and collaboration within the sector this will become clearer.

In a period of significant change to the structure, organisations and roles across the energy sector, for example with changing roles for the ESO and DNOs, it is understandable that many organisations are focussed more on their own IT / data developments and business outcomes rather than the sector wide initiatives.

Therefore, there is a risk of activities and developments within organisations potentially evolving in different directions. There is now an opportunity for the VirtualES initiative to provide a guiding framework for these organisational level activities to align with.

There are several other initiatives within the sector such as the Energy Digitalisation Taskforce (EDiT) who in their recent report stated: *"A digitalisation culture needs to be embedded throughout the energy sector by promoting digital leadership, valuing digital assets, and focusing on whole system user experience."*

EDiT recommend that key challenges are associated with integrating digitalisation into an engineering culture centred around the long lifetime assets with long-term investments.

EDiT also note that regulatory valuations are dominated by the high upfront capital costs of physical assets which does not "*create the right environment for investment in digitalisation*".

Sector-wide understanding of the VirtualES will be improved if it is clear how it fits into the other initiatives such as the EDiT recommendations, which are being considered by industry. This context should be communicated widely, as well as the interfaces with other initiatives across the energy sector, as outlined in the EDiT Appendix '*Moving to Action: Digitalizing our Net Zero Energy Future*'.

It is also critical that the VirtualES initiative coordinates with the National Digital Twin programme, as energy is a key 'thin slice' of the national infrastructure, and it is important that this work is understood outside of the sector.

Examples

The Energy Charter - Australia
An example of a 'whole system user experience' as suggested by EDiT can be seen with the Australian Energy Charter. This Charter is not specifically about digitalisation, but does have a cross energy sector commitment '#bettertogether' and a commitment to work collectively with a customer-centred culture.

The Energy Charters core objectives are to:

- Drive #BetterTogether collaboration across the supply chain to deliver better customer outcomes.
- Provide an authentic disclosure process that focuses on trust and transparency.
- Ensure a credible Independent Accountability Panel that encourages continuous improvement in customer outcomes.
- More awareness, engagement and support for the Energy Charter across the energy sector.

Raising awareness & fostering culture

People

Where the VirtualES needs to get to

In the EDiT report, recommendation #6 – embedding a digitalisation culture there is a vision described as follows:

"The energy system we will create is an energy system that is designed for customers, shaped and controlled by their actions and needs, anticipating and adapting to their changing preferences, served by frictionless retailers all rewarded for outcomes, not inputs. Customers have a whole system carbon account revealing their carbon consumption."

In order to achieve this network operators will need to manage their networks to respond to this changing need and will require more information about demand profiles to be responsive and dynamic through anticipatory analytics driving investment and operational decisions. It is felt by EDiT that companies will see rising valuations by improving digitalisation of the energy system, which will attract more investment and shareholder returns.

The VirtualES therefore needs to play its role in this vision by providing a framework and roadmap for the changes necessary to the sector's digitalisation and sharing of data to enable the vision.

It is also clear that if all the various actors and initiatives converge on a clear vision and goal, there will be less duplication of effort and improved solutions which the energy system and consumers will benefit from.

This is where the Energy Digitalisation Delivery Body (EDDB) proposed by the EDiT report could have a role. As well as coordinating the orchestration of the digitalisation effort, it will have a communication and advocacy function to make key actors aware of the approach being adopted and its benefits.

The right messaging is a key aspect of raising the awareness, in order to ensure that the various actors realise they have a role to play in the overall energy system digitalisation, and that they will directly benefit. Therefore, it has to evolve from being a high-level ambition, to a greater level of detail - identifying each tier of the energy system what they can do to contribute. By doing so individual organisations or industry groups can quantify, and plan, their digitalisation activities and investments to deliver their part of overall change.

Key values, such as openness, security, customer centricity, agility, and ethics, should be identified that support the VirtualES vision and encourage shared prosperity.

How we get there

The main steps the VirtualES needs to take to help strengthen the digitalisation culture across the energy sector are as follows:

- Raising awareness through articulating the tangible benefits of the VirtualES to the sector through tangible use cases.
- Providing a framework and roadmap for the necessary changes to the sector's digitalisation and data sharing to enable its vision.
- Engage with digitalisation leadership and encourage active involvement.
- Promoting user-centred design through end-to-end whole-system thinking.
- Identify the key values and practices that will support the VirtualES vision.

In addition to these steps above, the advocacy and promotion of a coherent industry wide approach to digitalisation could be a key VirtualES deliverable.

The VirtualES can help align existing and planned initiatives and encourage investment in digitalisation where required.

Engaging stakeholders

Process

Current status

Engagement with sector stakeholders is critical to inform the industry about the development of digital assets and how they will work together.

There are a broad number of existing initiatives across the energy sector to bring focus groups together to drive progress in data and digital innovation. These include, for example, the following organisations and initiatives:

- Energy Digitalisation Taskforce (EDiT)
- ENA- Data and Digitalisation Steering Group
- Energy Systems Catapult (ESC) - Modernising Energy Data
- Geospatial Commission – National Map of Storage
- Global Power System Transformation Consortium
- Ice Breaker One - Open Energy
- National Digital Twin Programme - DT Hub
- Open Data Institute (ODI)
- Ofgem Data and Digital Service Providers forum
- UK Distribution Network Operators

All of these are engaged with a spectrum of stakeholders and interested parties including cross-sector industrial organisations, academic institutions, and the public.

There are many initiatives covering energy, data and digitalisation working groups, and they are delivering knowledge hubs, issuing progress and update reports, sharing webinars, discussing future digitalisation opportunities and raising early awareness of developments and risks. There are also various routes and mechanisms of stakeholder engagement. However, there is little evidence of these initiatives or stakeholder engagement activities working collaboratively together, or even being visible to each other.

It is recognised that each of the energy sector organisations involved in the broader landscape may be focused on delivering a good experience for their stakeholders, however if this is done in isolation, the ultimate outcome for customers or innovators is poor. This reduces engagement and slows innovation.

The recent EDiT report provides the observation that in the development of public interest digital assets:

"*At present, there is a patchwork approach where different organisations are independently leading on distinct assets with lock-in. This means they are not as well coordinated or integrated as they could be, and the rate of progress will vary wildly. In addition, sector stakeholders are not well informed about the development of the assets or do not understand how they will work together*.",

Therefore sector-wide and coordinated stakeholder engagement and collaboration is key to develop effectively and efficiently.

Through the engagement activities conducted in this work package, the key findings are:

- Internally within the ESO there is limited awareness of the VirtualES, and only a very high-level understanding of its objective and purpose.
- There is uncertainty regarding roles and integration between teams/organisations/initiatives and the VirtualES program. Uncertainty can lead to uncollaborative behaviours, and so clear and repeated encouragement of engagement is key.
- There is a high-level awareness externally, with evidence of misinterpretation of the intention of the program and proposed role of the ESO.

Engaging stakeholders

Process

Examples

National Digital Twin programme
The National Digital Twin programme (NDTp) was established by the 2017 'Data for Public Good' report, which also established its governance and advisory group - the Digital Framework Task Group (DFTG). The DFTG is made up of senior leaders within industry, academia and government, and reports to government through the CDBB's Strategic Advisory Board.

Stakeholder engagement is at the core of the NDTp, and a number of activities are run to encompass a broad range in inputs to progress streams of the initiative.

- ***Digital Twin Hub*** - This is a collaborative and supportive web-enabled community for those who own, or who are developing digital twins within the built environment.
- ***Gemini Programme*** - This programme aims to develop resources for the DTHub community and expand the outreach of the Information Management Framework (IMF) and of the NDTp itself. The Gemini programme brings together people and organisations willing to volunteer by contributing time and resources to the NDTp to develop materials for use by the DT Hub community.
- ***The Gemini Call*** - weekly engagement providing a summary of current activity in the NDTp, an update on current Gemini projects and provides the opportunity to suggest new projects, ideas and raise questions directly with the NDTp team.

All online presentations are shared via YouTube with over 50,000 views since the launch in 2018.

Open Energy
IceBreakerOne have built on the experience from the Open Banking Initiative in the stakeholder engagement for Open Energy. The stakeholder engagement spanning across industry, academia, government, and technology. They are working with four Advisory Groups: User, Market, Societal Needs; Policy, Regulation, Legal; Operational Requirements and Technical.

The Advisory Groups have over 60 experts from across the energy sector. These are each supported by a research team, and the terms of reference are published openly to provide a common understanding of the purpose and direction. There is an Open Energy Steering Group who provide the overall governance and coordination across the Advisory Groups and Proof of Concepts.

Participants are expected to act as representatives of their organisation, actively contributing their expertise and experience, advising on and contributing to the approach and development of Open Energy.

The objectives for the Advisory Group are to provide a forum for discussion and review of the progress made by the research team allocated to each Advisory Group; provide feedback and recommendations to the OE team; guide the development of the OE Standard; and endorse the final documented deliverables for the AG.

Engagement with stakeholders takes the form of interviews; workshops; Show and Tell sessions; and IB1 run a series of webinars which are recorded and made available through their events pages.

Both the NDTp and Open Energy demonstrate a clear structure, open forum to engage widely and regular and consistent engagement to remain visible and maintain confidence in progress and a community.

Active shaping from stakeholders across the industries is key. As such, effective processes to gain input and drive consensus are essential, particularly if the enabling context is not already in place (e.g., legal frameworks).

Engaging stakeholders

Process

Where the VirtualES needs to get to

There needs to be strong, consistent support and active engagement from key VirtualES actors in the form of transparent and open engagement, with trust and shared ownership across a wide range of stakeholders such as industry, academia, public and private sectors. This needs to be underpinned by consistent support and direction from governmental and regulatory actors able to influence the energy sector through policy and targets.

There are three focus areas of stakeholders, who are key to ensuring support from energy industry:

- Government and regulators
- Relevant interconnecting industries such as transport; academia; public sector
- The private sector.

Representation is needed from key organisations, inside and outside the sector, to maximise knowledge sharing and incorporate both public and private sectors.

Equally as important are governmental and regulatory actors to lead and influence the energy sector through clear direction as well as leveraging policy and targets mechanisms.

This group of stakeholders needs to provide direction, but also respond swiftly to the needs of the market.

The groups need to be equally integrated to enable dynamic progress and an agile evolution of policy and legislation.

External engagement activities should continue to seek to join up with existing initiatives, as listed above.
The benefits of this are three-fold:

a) Benefit from what has already been achieved

b) Access established networks of interested parties

c) Demonstrate engagement with relevant initiatives to provide assurance to stakeholders.

The programme needs to run with an on-going commitment to develop and nurture strong industrial, governmental and political support. The approach with key VirtualES actors needs to be flexible and open to incorporate new stakeholders as they become apparent.

From these actors will come the drivers and instruments of change. Therefore transparent and open engagement are critical to creating trust, and essentially, a sense of shared ownership across the stakeholders.

The key themes to be achieved across the industry are as follows. These are reflected throughout the recommendations of the socio-technical factors.

- **Buy-in to vision** – engaging and collaborating with sector stakeholders is critical to achieving buy-in to the vision.
- **Articulating the benefits -** particularly how the VirtualES can make the energy transition more seamless for organisations and consumers.
- **Stakeholder panels & Governance** - Stakeholders should include all those interested in the current and future needs of the energy sector. Independent stakeholders are also a key aspect of the Governance set up (see Governance Factor). The benefits of stakeholder panels in the Governance landscape is that this is the mechanism to test, set, and validate the direction through assimilating and hearing expert advice, engaging in research and informing adaption to progress.
- **Clarity on roles (terms of reference)** – enabling an understanding of responsibilities and providing opportunity for new parties to engage.

Engaging stakeholders

Process

How we get there

The Stakeholder Engagement workstream (workstream 1) has a dedicated focus on this aspect and has set out a robust Stakeholder Engagement plan, which is in the process of being implemented.

This includes dedicated web pages providing information about the VirtualES, the approach to creating Advisory Groups, a Advisory Committee; and a schedule of engagements to be led by industry experts to provide opportunities for dialogue between National Grid ESO and the industry as the programme develops.

The recommended next steps for this factor are presented prior to the outcomes of the Stakeholder Engagement workstream and their planned next steps.

In the meantime, the following recommendations have been drawn from the research of this Work Package.

- A critical next step is to increase awareness across the teams in the ESO to enhance engagement within the organisation, which in turn will enhance messaging externally. For this report a series of interviews were undertaken across ESO and industry, which provides a map of interested parties to engage with further.
- The awareness of the VES will be improved if it is clearer how it fits into the other initiatives such as the EDiT recommendations, the NDTp, and other initiatives at different levels within the Energy sector as outlined in the EDiT Appendix ‘Moving to Action: Digitalizing our Net Zero Energy Future’. This interaction should be communicated widely.
- The feedback from the Show and Tell (provided in Appendix A.1) provides insights to the key areas of interest and feedback from the attendees. Responding to these queries and perspectives, should help inform on-going messaging to mitigate misconceptions, and make best use of enthusiasm for engagement.
- Sharing the outcomes of the parallel workstreams - use cases and stakeholder Engagement - with clearly identifiable interfaces and knowledge sharing will help provide a consistent message.
- Lock-in support and direction from governmental and regulatory actors who are able to influence the energy sector through policy development and targets.
- Human factors are a major challenge in any technology transition. Providing a plausible solution and a plan where everyone has an important role to play will set the conditions for collaboration centred around the VirtualES. This approach, together with a regular cadence of engagement, assists in managing expectations.
- Mapping the entire landscape of relevant initiatives and ensuring contact with them all at the baseline level. The next step should be to engage with the most active groups, including but not limited to the organisations and initiatives sited above. Prioritisation should be given to engaging with the NDTp. Within the Digital Twin Hub is a Networks Directory which provides connections point to featured networks, i.e., specific topics within the digital twin sphere. This Networks Directory page could be used as a connection point to the VirtualES network to demonstrate connections between the programmes.
- The recommendations of this factor mirror those from other factors and should be developed with close attention to the recommendations from Awareness & Culture.
- It is important to ensure that there are dedicated roles for interfacing with these groups, whose names can become familiar in the landscape.

Creating a governance framework

Process

Current status

The UK energy sector and market are guided by a governance arrangement established ~30 years ago with the privatisation of electricity and gas.

According to the I-Gov study, run by Exeter Energy Policy Group from 2012 to 2019, which looked at the level, type and speed of system change within GB energy systems which is needed to support decarbonisation, the current governance framework is not appropriate in its current form.

"The GB system is inadequate in the face of rapid innovation in energy systems, and the need to decarbonise".

This is mainly due to the lack of processes for managing change, across government departments and agencies, and across different industrial sectors. This vacuum, they found, leads to:

- Confused signals for market participants
- Arrangements that favour established players that can influence policies and regulatory processes due to knowledge and resources
- Lack of co-ordination across:
  - the energy system itself, driven by lack of links between electricity and heat and the electricity lifecycle (generation, distribution, supply, retail, and consumption).
  - the energy sector and those other sectors with strong interdependencies, such as transport.
- Lack of arrangements for protecting low-income households.

The journey toward net zero brings closer the reality and need for a highly digitalised energy sector.

Digitalisation creates another layer of complexity as its benefit and trade-offs are not yet comprehensively understood across the sector.

The impacts of change brought by progressively more digitalised energy services on current actors, processes, and operations will need to be managed.

The EDiT, which was set up by BEIS, Ofgem and Innovate UK to help deliver the digitalised energy system needed to reach net zero, has reviewed the current governance arrangements of the energy sector and identified a number of gaps.

One of their recommendations is to introduce a Digitalisation Governance framework across the sector to ensure:

- the necessary fundamental enablers for change are in place, and
- the capabilities needed to support a digitalised energy future are well-architected to take stakeholders' needs into account.

Creating a governance framework

Process

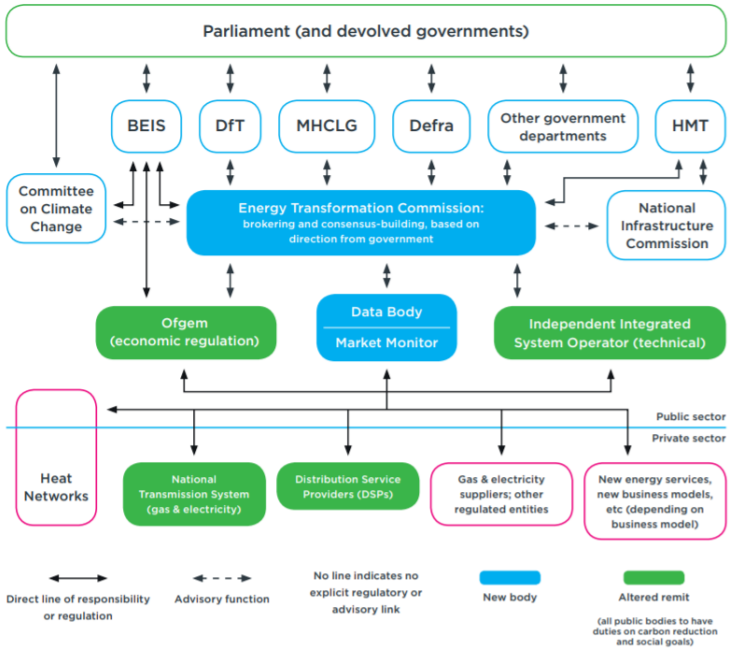
Example: I-Gov New Energy Governance Model

The I-Gov initiative, a project of the University of Exeter's Energy Policy Group, recommended a governance model for the energy system that focuses on incentivizing outcomes, driven by three core principles:

1. Legitimate and transparent governance with clear outcomes and transparent decision-making processes
2. People at the centre with those providing services such as demand reduction, flexibility, and demand response are rewarded, and those unable to partake looked after
3. Adaptive regulation - where regulation is output-based and responsive to local needs

This model would be centred on a series of reforms aimed at giving the GB energy system a clear direction to innovation and net-zero carbon emissions. These include:

- An Energy Transformation Commission (ETC), to implement objectives set by UK government through co-ordinating all the institutions involved and providing a hub for consultation and engagement.
- An Integrated Independent System Operator (ISO) which would integrate gas, electricity and aspects of transport.
- Ofgem's remit would focus on regulation of transmission, distribution and supply of energy and energy services and have an explicit duty to regulate for carbon reduction in line with statutory targets.
- Devolution of energy governance to local levels with local authorities with a new statutory duty to set carbon budgets with flexibilities and funding provided from national government.
- Reform of Distribution Network Operators to provide local markets for energy services as Distribution Service Providers (DSPs). They would add to DNO functions with co-ordination and balancing services, for electricity, demand response, flexibility, and ancillary services.
- A cross-economy Data Regulator a data body to oversee and link to energy system information.
- A market monitor to follow market exchanges and identify improper trading or profiteering.



Source: I-Gov New Energy Governance Model

Creating a governance framework

Process

Example: Energy Digitalisation Taskforce Digitalisation Governance

The EDiT report included a series of recommendations for a digitalised Net Zero energy system. One of these calls for digital governance to bring confidence, transparency and safeguarding to the digitalisation of the energy sector.

The proposed governance model for the energy sector aims to promote legitimacy, accountability, and assurance with effectiveness and speed of the federated entrepreneurship and innovation. It aims at being pragmatic, agile and adaptable, anticipatory, and able to mitigate negative trends.

In their recommendation, the new framework would help to ensure that Public Interest Digital Assets are managed effectively, promoting competition and innovation while the energy regulator would still play a key role monitoring new business models, algorithms, and companies to prevent risks to the system and customers.

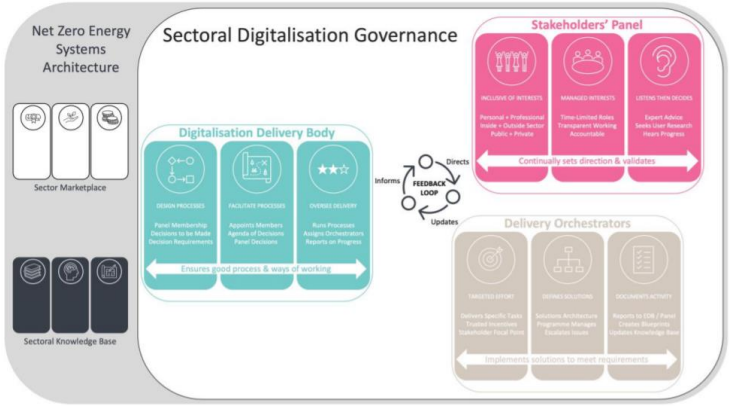
The introduction of cross-sectoral regulation is also proposed as a potential mechanism to manage transparency and accountability of dependencies between sectors.

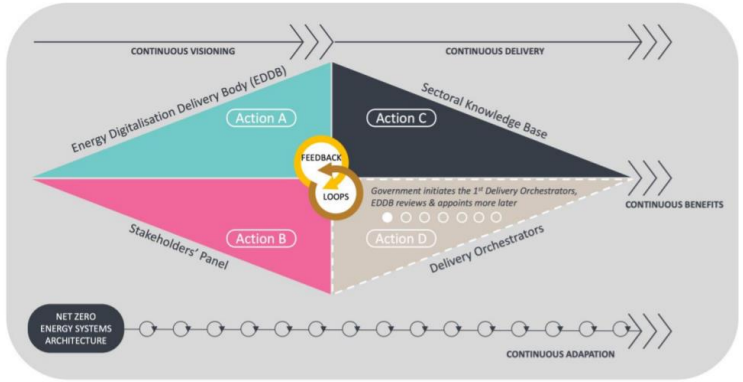
The proposed framework features three components:

1. Stakeholders' Panel: a place where all stakeholders' views, interests and needs are heard and a mechanism for using these as principles and constraints to direct the digitalisation of the sector.
2. Energy Digitalisation Delivery Body (EDDB): an independent body which coordinates the digitalization of the energy sector and supports confidence in financing, fairness, evidence and quality of work.
3. Delivery Orchestrators: implementing bodies orchestrating 'ground-level' delivery on behalf of the EDDB, providing practical information on progress and opportunities to participate.

The report's independent analysis of governance solutions also evaluates the ecosystem of initiatives currently present in the sector and sees:

"..an opportunity for VirtualES to develop into an orchestrating role, such as on methods for describing assets (i.e., metadata and an ontology) or for sharing data models as well as managing how models are to interface with the physical energy system"





Source: EDiT - Delivering a Digitalised Energy System

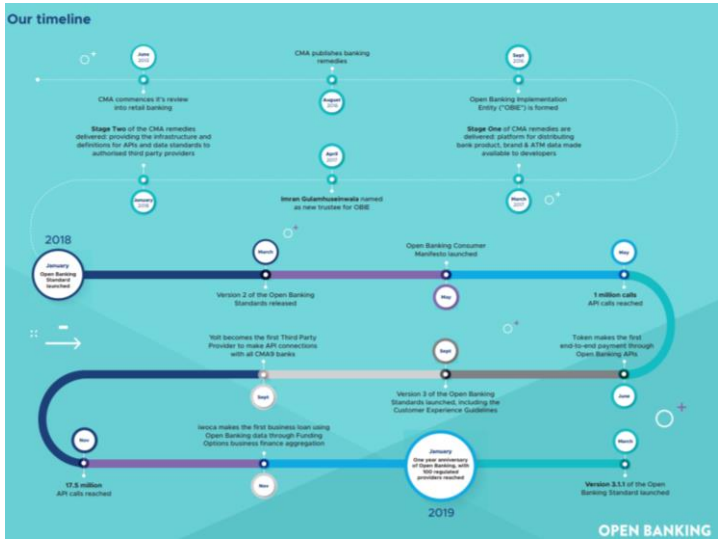
Creating a governance framework

Process

Example: Open Banking

The Open Banking initiative provides multiple relevant lessons pertaining to the governance requirements to support sector-wide transformation. These insights include :

1. Governance needs to adapt as an initiative evolves through different stages.
   - When the Open Banking initiative launched, an independent body, the Open Banking Working Group (OBWG), was tasked to coordinate the definition of the Open Banking Framework through active involvement of industry stakeholders, with the regulator as an observer.
   - Once the Open Banking Framework was adopted in 2016 by the United Kingdom Competition and Markets Authority (CMA), the Open Banking Implementation Entity (OBIE), a private body overseen by CMA, came into existence to deliver the APIs, data structures and security architectures to make it easy and safe for individuals and SMEs to share the financial information held by their banks with third parties. At the same time, nine UK major banks became core executors and financial sponsors.
   - Since implementation in 2019, the framework underpinning the future governance of the OBIE has been reviewed and developed to ensure the initiative remains independently-led and accountable, adequately resourced, dedicated to serving the interests of consumers and SMEs, and sustainable and adaptable to future needs of the ecosystem.
   - The implementation - set to finish in 2022 - will see the CMA take on the ongoing maintenance of Open Banking and monitoring and compliance.
2. Active shaping from stakeholders across the industries is key. As such, effective processes to gain input and drive consensus are essential, particularly if an enabling context is not already in place (e.g. legal frameworks).
   - The OBWG used six thematic sub-groups and a system of chair and co-chairs with the ability to mandate work to be done and enforce decisions. This model proved successful for the definition of the Open Banking framework.
3. The regulator must be involved throughout the initiative to ensure participation and to mandate change.
   - Initially, the Treasury acted as instigator, using its regulatory power to encourage participation. Later, the CMA adoption of the framework and its mandate to Banks made change inevitable.



Source: Open Banking Implementation Entity

Creating a governance framework

Process

Where VirtualES needs to get to

It is critical that the VirtualES operates effectively and cohesively with the wider governance framework present in the energy sector, i.e. those policies, institutions, rules and incentives related to the energy system, and the underlying decision-making process.

Specifically, VirtualES must align to and/or promote the institution of a sector wide decision rights and accountability framework that promotes the appropriate behaviours in the creation, sharing, use and control of Digital Assets across the energy sector.

While this does not yet exist, the EDiT report provides an independent analysis of governance solutions and makes a recommendation for the institution of a Digitalisation Governance. This will be essential if the VirtualES seeks to govern Digital Assets at an appropriate level to support critical use cases and the move to net zero.

The findings of this work recommend that the VirtualES aligns to the governance ecosystem proposed by the EDiT to position itself in an Orchestrator role, i.e. an implementing initiative orchestrating 'ground-level' delivery on behalf of the EDDB and providing practical information on progress and opportunities to participate.

In addition VirtualES should provide hands on coordination across the use of Energy Digital Assets by other sectors, and act as a cross-sector integrator.

Taking guidance from EDiT recommendations, and the Open Banking experience, it is recommended that there is an Implementation Entity that oversees and coordinates VirtualES delivery and integration.

This must be an independent body, initially provided through government funding. It should be overseen by the future Energy Digitalisation Delivery Body (EDDB), or by the energy regulator if there is no EDDB.

The governance framework will need to be adaptable to change as the energy transition unfolds. In Ofgem's 2021 policy, they set the motion for the ESO to become the Independent System Operator (ISO) for the energy system, broadening the ESO's remit.

This transition must be anticipated through the assessment of options, i.e. for the ISO to provide the role of the VirtualES Implementation Entity, or if that role must be delivered by a different body.

The delivery of the VirtualES will need to respond to the needs of stakeholders, including consumers, so VirtualES governance must provide a robust process for engagement and accountability to the sector's need. The recommendations for this are covered in the Stakeholder support & engagement socio-technical factor.

Key recommendations to incorporate in to the VirtualES governance framework from review of relevant initiatives are:

- Be legitimate and transparent with clear outcomes and decision-making processes.
- Follow user-centred principles.
- Integrate with existing sector governance.
- Regulator engagement to ensure participation and to mandate change.
- Promote agile and adaptive regulation.
- Provide an orchestrating role in data and model integration.

ARUP

Creating a governance framework

Process

Energy Regulator

- Responsible for alignment with regulatory environment and strategic agendas (e.g., net Zero)
- Mandate adoption of VirtualES Standards and best practices

Energy Digitalisation Delivery Body

- Sets system-wide priorities and monitors delivery of digitalisation strategy.
- Responsibilities for system-wide digitalisation policies setting, decisions, issues resolution
- Promote adoption of VirtualES Standards and best practices

VirtualES Implementation Entity/ Orchestrator Body

- Define outcome of VirtualES, set priorities and gain buy in
- Drive on the ground delivery of VirtualES outcome through industry engagement and consensus building (including the common framework)
- Supervise connection of energy Twins and Digital Assets
- Manage interdependencies across the energy system (generation, transmission, distribution, retail, consumption, flexibility/balancing, storage) as well as across energy and other sector (e.g. transport).

Stakeholder groups

- Provide view of needs and set principles and constraints to direct VirtualES delivery
- Used by VirtualESOB to deliver outcomes that respond to the need of the sector

Twin / Digital Asset Owners

- Adopt VirtualES framework, standards and procedures

Potential elements that the VirtualES could be Orchestrator of:

- Delivering a catalogue of energy data
- Defining how to describe Digital Assets
- Delivering element Digital spine for energy system
- Defining how to connect and integrate Digital Asset and twins across different level of the energy system and across other sectors
- Providing guidance on how to manage the interface between models and the physical energy system

These elements will need to be ratified across the industry to minimise roles and ensure simplicity.

How to get there

The scope and outcome of the VirtualES needs to be clarified and aligned with other digitalisation initiatives across the sector so that VirtualES can benefit from existing experience and provide leadership for identified needs.

ESO should also build consensus and agreement on the scope of the VirtualES across the energy sector. Ensure this is officially supported by Ofgem and industry.

These form the foundations for governance of the VirtualES. As the needs of the energy transition change and existing actors evolve and new ones join, the governance will need to be agile and adaptable whilst maintaining the confidence of stakeholders

The next steps will further build on the definition of the VirtualES implementation Entity / Orchestration Body such as:

- Decision making power and responsibilities
- Reporting lines
- Funding and independence of VirtualES
- Stakeholder engagement
- Delivery assurance processes

Aligning models & taxonomies

Data

Current status

There is no tailored ontology for the energy systems that would accurately describe all the relevant data and the characteristics and elements of the modelling approaches.

The existing Open Energy Ontology (OEO) is a collection of all the terms and the relationship between these terms. It enables a robust transition to a sustainable energy system by consolidating distributed data inventories across disciplines and domains and hence creating and maintaining interactions within global interdisciplinary energy systems.

The Common Information Model (CIM) has been developed over many years and is widely in use in the UK and EU as a common vocabulary and basic ontology to describe what data is being exchanged among a utilities business systems. It has been officially adopted by the International Electrotechnical Commission (IEC).

Western Power Distribution describe CIM as follows: *"The Common Information Models (CIM) provide a complete and consolidated view of electricity network assets and their connectivity. The models bring together a huge range of datasets from different types of energy network infrastructure equipment, sensors and assets, including transformers, circuit breakers, wires and cables."*

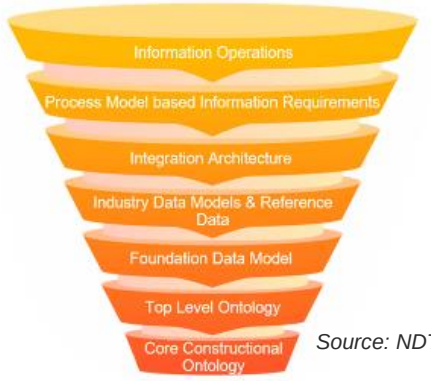
The broad range of terminologies needed for the energy domain are not covered in full by any of the existing approaches. These approaches are also lacking a suitable structure for the system requirements.

Hence, there are difficult challenges which entail management, data interpretation, modelling approaches, and data exchange and sharing. This will pose challenges to organisations and programs that require and use energy data.

Examples

National Digital Twin Programme, Information Management Framework: This initiative is proposing an Information Management Framework (IMF) comprising of a Foundation Data model (an ontological model describing general concepts independent of the domain), a Reference Data Library (the specifics of particular controlled vocabularies – taxonomies, and how common words are used), and an Integration Architecture. Collectively this will enable the National Digital Twin through data integration of different sector digital twin nodes.

The energy models will, in part, need to align to this IMF to be integrated and shared with other sectors. The NDTp Climate Resilience Demonstrator (CReDo) project has incorporated the IMF in its design and has demonstrated how this can be implemented across sectors (including energy).



Source: NDTp - IMF

Aligning models & taxonomies

Data

Examples (continued from previous page)

EnArgus Ontology: This is a German developed ontology to support decision making in the energy sector.

Although, this ontology contains a wide range of terms and definitions, these are not accessible by the public which limits the openness and benefits of this ontology for the energy systems.

openmod: The Open Energy Modelling Initiative is an energy modelling domain which contains a glossary of 323 terms about modelling photovoltaic panels.

It was used as the basis for OEO and has enabled matching synonyms and acronyms for each of the 323 terms. This glossary is no longer maintained and refers users to the OEO on GitHub.

Open Energy Ontology (OEO) and **Common Information Model (CIM)** are predominant energy sector examples, that are described in the 'current status' section.

Where the VirtualES needs to get to

As machine learning and artificial intelligence are becoming core to data driven methods and applications, it is important to ensure that the energy domain data is machine interpretable.

The use of the existing OEO or CIM ontology will support an increased amount of machine-readable public data in the energy systems. And hence, further development of the OEO and/or CIM will be based on broad participation within the energy sector.

An ontology will have been built using existing resources and implementations in addition to well-defined and known ontologies that make up many components of the whole picture to synthesis the energy vocabulary covering national and international standards.

The requirement for a digital equivalent of a Grid Code will enforce use of a model data standard which will improve take up.

How to get there

To achieve a successful, interoperable, standardised VirtualES, ontologies need to be defined and specified. The main actions that are needed to align ontologies are:

1. Provide common vocabulary by further developing and populating the data catalogue. Facilitating standardised data sharing and avoiding ambiguities in the energy domain.
2. Provide a well-formed structure of definitions and relationships to enable users to better navigate through the domain complexity.
3. Build on and use already existing developed vocabularies, ontologies, and domain knowledge such as OEO.
4. Promote wider and consistent adoption of CIM by all DNOs and its further development.
5. Ensure the energy domain model can be shared outside of the sector as a 'thin slice' aligned with shared reference data and top-level ontologies outlined by the IMF.
6. Develop a digital equivalent of a grid code which stipulates the use of a standard data model.

Increasing data visibility and enabling sharing

Data

Current status

There are several issues which must be resolved if energy data is to be used to its maximum potential.

Currently data is not widely shared, neither is the extent to which organisations maintain complete data sets. This results in anyone wanting to access data sets firstly needing to search for and contact people within organisations to determine if a data set exists. Requestors must then go through lengthy processes, sometimes requiring industry code changes, in order to secure access to that data set. This can sometimes take years and the resulting data sets are often of disappointing quality and or quantity. Missing data sets are also a recognised industry wide problem.

Open Energy's 'Energy Data Search' seeks to overcome many of these problems, however the initiative is in its infancy and therefore widespread adoption has not yet been achieved.

Examples

Significant amounts of work have already been completed in this area, following the recommendations of the EDTF and will be continued through the recommendations of the EDiT.

The taskforces were commissioned by UK government (BEIS), the energy regulator (Ofgem) and the UK's innovation agency (InnovateUK).

Four out of five recommendations of the EDTF relate to data and as reported by the EDTF, in the two years since their publication good progress has been made against the recommendations, perhaps with the exception of deploying an Energy Asset Register prototype.

EDTF Recommendation		RAG
1	Digitalisation of the Energy System	
2	Maximising the Value of Data	
3	Visibility of Data	
4	Coordination of Asset Registration	
5	Visibility of Infrastructure & Assets	

Source: Energy Data Taskforce: Two Years On

Open Energy
In response to recommendation 3 of the EDTF the Open Energy project was initiated with its vision to make it *'easier to discover, share, access and use energy and related datasets, supporting the sector's drive towards decarbonisation and its related social and economic benefits.'*

A core capability of Open Energy is search, which enables dataset search and discovery. Open Energy search empowers users to find out what datasets exist and who owns/controls them. Search results also outline the sensitivity class, access rules, and capability grants associated with a certain dataset, meaning that access and licensing details are transparent. Open Energy search is currently free and available to all. Datasets are sourced via Open Energy members (Data Providers) and open sources (e.g. web-scraped Open Data). Open Energy addresses consent-based, secure access to shared data.

Open Data Triage
"Presumed Open" is a principle recommended by the EDTF whereby organisations make their data as open as possible. When data cannot be made open a justification should be provided.

Open Data Triage is then the process by which issues can be interrogated which would prevent a data set from being made open. Then mitigations can be put in place in order for them to be made open.

Increasing data visibility and enabling sharing

Data

Energy Data Visibility Project (EDVP)
In response to recommendation 3 of the EDTF, EDVP was initiated to develop agreed metadata standards and glossaries for the sector. This was validated through user research and a data standards and glossary advisory group.

National Grid ESO data portal
ESO are currently developing a portal for publishing their own data, which will initially address issues around the accessibility, understanding and consumption of ESO data. The portal will create a centralised repository for all published ESO data, accessed via a clear and intuitive user interface for searching and querying data.

Where the industry needs to get to

Providing greater visibility and sharing of energy data is considered a key enabler of the digitalised energy system. This is repeatedly recommended and highlighted in the EDTF and EDiT reports, and in Open Energy.

Data must be open where appropriate. Definition is required in order to determine what is appropriate to be made open, creating an explicit link to security, leadership, and governance.

Organisations must take responsibility for their own data, and whether open or closed it is critical that data is visible and searchable. It is considered that metadata should be openly published to agreed and industry accepted standards, such as that produced by EDVP.

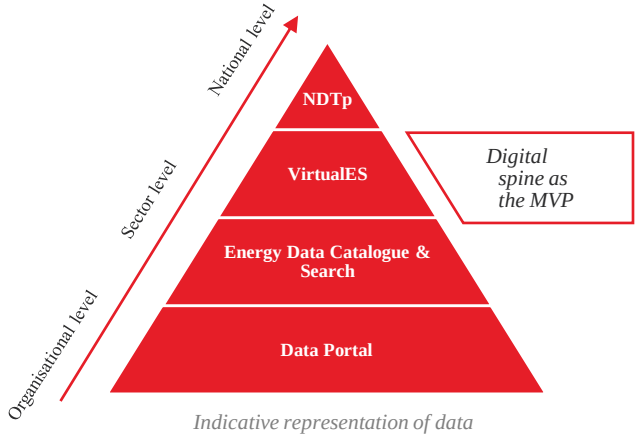
There must also be mechanisms by which data can be requested and feedback can be provided, allow energy data to iteratively improve. New business opportunities may arise through the identification of missing data sets and the need for the gaps to be filled.

How we get there

As shown in the above examples, there are several developments and projects that are seeking to address this factor.

The recommendations are therefore for the VirtualES to:

- Publish machine-readable, open metadata in a manner that can be included in Open Energy, including both Open and Shared data.
- Engage with the future delivery orchestrator for the Energy Asset Register.
- Review standards for publishing data and metadata, with the VirtualES being the vehicle driving adoption of standards across the sector. For instance, consider whether the outputs of EDVP could act as a foundation for further development in the context of the VirtualES.
- Review currently ongoing ESO projects, in light of the EDiT recommendations, wider industry initiatives and the future VirtualES aspiration.



Indicative representation of data sharing and visibility initiatives

Creating an interoperable stack

Technology

Current status

Interoperability is the ability of a product or system to cooperate with other products or systems to share resources. It is widely understood as being essential to creating more flexible transmission, distribution and consumer services.

However, there is no “interoperability” industry-standard definition across the energy sector. When it comes to the energy system, interoperability needs to be considered broadly. Understanding the wider implications of interoperability is considered to be essential if the energy system and consumers of energy are to benefit from the potential of digitisation.

Due to the lack of an effective way to systematically analyse these complex considerations, ESC led a study in 2018 to develop a framework for understanding the full implications of interoperability across the energy sector.

This framework includes 19 types of interoperability, which have been grouped into 6 areas:

- **Consumer interoperability**: provisions exist for consumers to switch between different commercial offers and technology choices
- **Commercial interoperability**: incentives are aligned across the energy system so that value can flow where it needs to, driven by market forces
- **Data interoperability**: easing the sharing and portability of data between different systems
- **Device interoperability**: devices are swappable, replaceable and exchangeable as needs change and technologies develop, so consumers can make informed choices between open and closed ecosystems
- **Physical interoperability**: end-to-end systems function as changes happen to parts of the system
- **Vector interoperability**: energy provision across gas, electricity, heat and transport fuels are compatible with one another, and coordination occurs in a timely fashion.

The study highlighted the need to consider multiple forms of interoperability simultaneously to achieve the flexibility required to adapt to consumer, technology and systemic changes.

The advantages that would be brought by interoperability include:

1. Consumers get a better deal by being able to use their products and services in many ways.
2. Grid flexibility services can be made to work if interoperable systems can communicate with each other.
3. System costs might be reduced by using existing infrastructure in smarter ways.

At present, however, such a sector wide approach to interoperability is not clearly present nor well-coordinated, with different organisations independently leading on distinct aspects with lock-in.

Creating an interoperable stack

Technology

Example: Energy Digitalisation Taskforce – delivering a digitalised energy system

The energy system is becoming increasingly decentralised with more actors and assets involved than ever before. As solutions are deployed to achieve net zero, this is only set to continue to increase.

EDiT published a series of recommendations to help deliver the digitalised energy system needed to reach Net Zero, one of which is interoperability which sets to address this issue. Interoperability will be key to maintain safety, security, and efficiency.

There is value in breaking down the existing silos within and between organisations, and value in harnessing the emerging interactions of different assets and actions.

Realising this value will be significantly easier with the suitable digital tools and platforms in place, driven by open-source software and open standards.

Customers and innovators alike will benefit from interoperability as it increases innovation and competition, maximises resilience in a distributed system, and makes the spending of customer money more efficient.

In their recommendations, EDiT highlight six key enablers of interoperability, two of which go hand-in-hand; delivering a data sharing fabric and a digital spine for the system:

Deliver data sharing fabric
Data sharing fabric is the governance, administrative and technological solution for the management of access to shared data across organisations.

Once established and adopted organisations, across the energy sector can safely and securely share data with minimal friction. It will form part of the network Digital Spine covering the entire energy system.

Open Energy are currently running a pilot, funded through the Modernising Energy Data Access funding competition, and delivered by Icebreaker One, to deliver this.

Create / deliver a digital spine for the system
The digital spine would create a virtual nervous system that would help those responsible for operating the energy system at various levels to take actions to ensure the system is stable and resilient.

It enables a minimal layer of operation critical data to be ingested, standardised and shared in near real time.

It is made up of a network of connected nodes which ingest data about the energy system, deployed by organisations across the energy sector. It standardises this key information and would offer a basic overview of the status of the system.

"The Digital Spine could form the data foundation of a whole energy system digital twin." - ***EDiT***

The report highlights that the digital spine must be developed as an independent project with no commercial interests to achieve decentralised ownership. This will ensure it is built in the interest of customers and stakeholders across the system.

There is a need for government to define the scope and governance of public interest digital assets as the current approach is not very well coordinated, with different organisations independently leading on distinct assets with lock-in.

Creating an interoperable stack

Technology

Where the VirtualES needs to get to

The Virtual Energy System should aim to promote Data Interoperability by:

1. allowing key Energy Digital Assets to connect with one another, integrate with physical assets and other digital assets across other sectors
2. underpinning/facilitating the exchange of data across the energy systems

Core to this is the building of a technology stack which is interoperable, i.e., the different solutions within this have the capability to communicate with one another freely and easily.

VirtualES must promote interoperability with one primary goal: eliminating data silos across what is and will likely grow to be an even more distributed technology ecosystem. The UK energy sector is in fact a system where a vast number of stakeholders have ownership of data and physical assets in accordance with the regulatory division of the energy market.

Consequently, the VirtualES will have a distributed technology stack which must be able to communicate seamlessly if it is to bring the advantages foreseen by the digitalisation of the sector.

As identified by the EDiT taskforce, delivering a data sharing fabric and a digital spine for the energy system are essential components to underpin the digital interoperability of the sector and consequently of the VirtualES. As such the findings recommend VirtualES becomes the orchestrator for:

- **the delivery of the Digital Spine:** a technology stack that creates a network of connected nodes which ingest, standardise and bring together a minimal layer of operational critical data.
- **the adoption of a data sharing fabric**: a sharing and cataloguing and data management technology stack to facilitate and manage the search, sharing and accessing of data across organisations. This should look at leveraging existing work done by the Open Energy initiative.

By advancing data interoperability the VirtualES will be able to facilitate the wider interoperability of the sector by supporting interoperability across the consumer, commercial, device, physical and vector components.

How to get there

To ensure interoperability is a key factor in the digitalisation of the energy sector, the VirtualES should immediately look to:

1. Define, with stakeholder involvement, a high-level architecture for the Energy Sector Digital Spine to encourage interoperability.
2. Ensure the data sharing fabric brings visibility of data across the entire spectrum of energy data through a sharing and cataloguing stack that is accessible to all stakeholders, as appropriate, and which built on existing work.
3. Identify set of best practices when it comes to building a technology stack that promotes wider integration and data exchange. This could include guidance on data exchange methods and protocols, use of open software, system integration, access control and more.
4. Understand how to address distributed data management across the VirtualES and what the tools are that would support this process.
5. Plan the coordination of the digital spine delivery in accordance with best practices.

2.3 — Other socio-technical factors

Defining roles & responsibilities

People

Current state

Leadership:

BEIS, Ofgem and National Grid ESO have significant roles to play in the long-term success of the VirtualES. There needs to be alignment of policy, regulation, and execution of the plan to move towards a digitalised energy sector.

It is the responsibility on these organisations, and their executives, to align under the advice and direction of, for example, the EDiT recommended approach.

Organisations:

Within energy sector organisations there will be data management roles and users responsible for the dissemination, manipulation, and analysis of energy datasets.

These roles are currently mostly focused on internal organisational datasets. Additional tasks will be required, such as the conversion, dissemination, and creation of new datasets for wider energy sector sharing – in line with the agreed standards. These additional responsibilities could be absorbed into existing roles.

Where the VirtualES needs to get to

Alignment amongst the energy sector lead organisations will naturally bring closer alignment across the sector's policy, regulation and activities. Organisations will be further incentivised to progress with digitalisation activities, building on the requirements from RIIO2, and value will start to be assigned to digital assets.

Organisations will have put in place the necessary roles and responsibilities within their data management teams for the manipulation and delivery of agreed datasets in the agreed formats, with its metadata shared on central discovery portals such as Open Energy. Using feedback gained through these portals, organisations can respond to data requests from individuals or organisations with approved access to the data.

Analysts and data scientists, within the wider energy sector and beyond, will be able to take advantage of the rich source of energy data now available to them, creating additional value through the insights derived, and a platform for innovation. This will inform decision makers within their organisation through an evidence base of analysis, using the analytical, modelling, and simulation platforms now established.

How to get there

The recommended next steps will be dependent on the outcomes of raising awareness & fostering culture, as it will require buy-in and commitments from key organisations to the VirtualES and an aligned approach.

If there is positive commitment and support, the likely next steps for BEIS, Ofgem and ESO would be to:

- Build on existing recommendations (i.e. EDiT, EDTF), and agree the best ways to align policy, regulation, and the approach to encourage digitalisation and sharing of energy data.
- Involved the sector and key actors in task and finish working groups to encourage engagement and alignment.
- Work with organisations to understand what changes would be expected for typical data management roles as a result of having the VirtualES, and how this varies for different actors (e.g. DNO, energy generator, TSO etc). This would allow organisations to compare existing roles, and whether any changes would be required, or additional staff training or recruitment would be needed.

Building capabilities & skills

People

Current state

There is a recognised, and crucial, skills gap relative to those required for the digitalisation of the UK energy sector. This is recognised by energy companies, regulators and policymakers.

Digital skills are also part of, and recommended in, most major industry programmes, such as the EDiT and the National Digital Twin programme.

Most organisations have started to identify the skillsets required to implement their digitalisation aspiration. There is also a significant lack of employees with combined domain and digital experience has also been identified. This means that organisational structures across the energy sector will need to change to facilitate the hiring and deployment of these incoming skillsets.

Where the VirtualES needs to get to

One of the key enablers of the VirtualES is the connection and interoperability of energy data. Many of the critical skillsets and competencies for the VirtualES therefore relate to data. These should include:

- Widespread capabilities and understanding of how to consistently apply common standards and approaches, and to transform data to align with standards to facilitate interoperability.
- Developed understanding of what open data is, and what it involves, and how it can be applied successfully across the energy sector.
- Understanding of data sharing requirements and licensing models.
- Security and resilience capabilities .

In addition to these, there are a broad array of skillsets and competencies needed that reflect those currently in high demand in the market, such as analytics and system architecture competencies.

How to get there

In order to most effectively address the skills and capabilities needs, the VirtualES should:

- Clearly articulate their scope and remit.
- Define a clear operation model for the VirtualES and its supporting ecosystems.

Once this is established, the VirtualES will be able to:

1. Define the capabilities it needs.
2. Assess the capability present and identify gaps.
3. Develop capacity building strategies to support the upskilling across its ecosystem.

Aligning around industry codes & standards

Process

Current state

The UK energy market is regulated through a series on industry codes and standards.

Industry Codes – These underpin the electricity and gas wholesale and retail markets with licensee compliance being a condition of their licences.

Code	Type	Code Administrator
Balancing and Settlement Code (BSC)	Electricity	Elexon
Connection Use of System Code (CUSC)	Electricity	National Grid ESO
Distribution Use of System Agreement (DCUSA)	Electricity	Electralink
Grid Code	Electricity	National Grid ESO
Distribution Code	Electricity	Energy Networks Association
System Operator - Transmission Operator Code (STC)	Electricity	National Grid ESO
Uniform Network Code (UNC)	Gas	Joint Office of Gas Transporters
Independent Gas Transporter UNC (iGT UNC)	Gas	Gemserv
Smart Energy Code (SEC)	Gas and Electricity	SECAS
Retail Energy Code (REC)	Gas and Electricity	REC

Distribution Network Operators are also required to provide a Data Transfer Service (DTS) to facilitate the electronic transfer of certain industry data.

Industry Standards - Licensees are required to comply with a number of technical codes and standards relating to their transmission and distribution operations. These include:

- **Technical standards** – Such as the Grid Code, the System Operator Transmission Owner Code, the Distribution Code, the GB Security and Quality of Supply Standard and the Distribution System Planning Standard.
- **Derogations from standards** – direction from the Gas and Electricity Markets Authority, which relieves a licensee from its obligation to comply with a technical standard or code.
- **Quality of Service Guaranteed Standards** - Guaranteed standards of service levels that must be met by each distribution company and that have been set to guarantee a level of service that is reasonable to expect companies to deliver in all cases.
- **Security and Quality of Supply Standard (SQSS) -** Sets out criteria and methodologies for planning and operating the GB Transmission System.

Where the VirtualES needs to get to

To create a “digital spine” for the energy system, drive energy data interoperability, and help connect the multiple digitalisation initiatives across the sector, the VirtualES must be actively supported and promoted by the industry standards and codes currently use to regulate the sector.

The codification of the VirtualES, therefore providing its mandate, will ensure its adoption is sector-wide and embedded in how the sector is regulated and operated.

How to get there

Once the scope of the VirtualES is ratified by the industry, it will be necessary to:

- Understand the impacts the VirtualES could have on the way the sector currently operates. This evaluation exercise should be use case driven and iterative to ensure the VirtualES adapts to future needs.
- Identify the existing standards and codes that need to change to allow for, or promote, adoption.
- A review and update of those codes and standards through the existing code’s governance structures.

Determining the operating environment

Process

Current state

The UK energy sector is formed by private and public entities that collectively deliver a single solution of energy services to consumers. This includes administrative bodies, government departments, transmission and distribution operators, electricity generators and suppliers and more. None of these organisations alone has the capacity to provide governing oversight for the whole system.

The EDiT recommendations highlight how: *"For the energy system to be digitalised, […] the sector needs a common understanding of and to agree on shared objectives. Today, agreement is not in place nor is there a mechanism for achieving it.".* The report argues that central planners (government, non-profit, or private) should come together to define which services are needed and how they be must delivered and coordinated.

Nevertheless, the UK energy sector has a set of processes and mechanism, such as policy making, that help to ensure change and new ways of operating can be adopted. For example, in the last few years the UK sector has gone through the definition of a new Target Operating Model for market-wide Half Hourly Settlement Reform.

Where the VirtualES needs to get to

To deliver meaningful change, the VirtualES will need a policy and legislative environment that will enable it to serve the entirety of the energy sector. It will also need to be structured to effectively operate in the existing organisational construct of the energy sector, and be accepted in its potential role as the "Delivery Orchestrator" for some of the core objectives of the energy digitalisation agenda as proposed in EDiT.

In practice this means the VirtualES needs an operating environment that:

- Creates the legal framework it needs to be successful. For example, unlocking the key challenges in relation to the sharing of data.
- Design and implement policies to implement new operating models. For example, mandate the interoperability requirement for energy data and data sharing protocols.
- Provides a governance framework for assessing and working through risk and security implications.
- Incentivise and enable collaboration between different actors in the sector, whilst addressing commercial sensitivities and conflicts of interest.
- Enable the VirtualES to iteratively evolve its model over time to adapt to the sector digitalisation journey.
- Evaluate and measure the value the VirtualES will create.

This operating environment will result from the interplay of several entities across the energy sector.

The implementers of the VirtualES will need to steer the change it needs, potentially through the Digitalisation Governance proposed within the EDiT report.

How to get there

Once the scope of the VirtualES is ratified by industry, the VirtualES will need to:

- Identify the core operational enablers of its work and assess whether there are critical gaps.
- Engage other digitalisation effort for alignment.
- Engage with relevant entities to ask, scope, and potentially drive the change needed in the operating environment.

Establishing data management & governance

Data

Current state

In 2021, Ofgem has published the Energy Data Best Practice Guidance, developed with the Energy Systems Catapult and government. It is now part of Ofgem's standards for data and digitalisation, to be followed by relevant Licensees and by Ofgem itself.

It is a principles-based approach which provides guidance on the quality, accuracy, and accessibility of data. It sets out eleven principles of data management best practice for the energy industry:

1. *Identify the roles of stakeholders of Data Assets.*
2. *Use common terms within Data Assets, Metadata and supporting information.*
3. *Describe data accurately using industry standard Metadata.*
4. *Enable potential Data Users to understand Data Assets by providing supporting information.*
5. *Make Data Assets discoverable for potential Data Users.*
6. *Learn and deliver to the needs of current and prospective Data Users.*
7. *Ensure data quality maintenance and improvement is prioritised by Data User needs.*
8. *Ensure Data Assets are interoperable with Data Assets from other data and digital services.*
9. *Protect Data Assets and systems in accordance with Security, Privacy and Resilience best practice.*
10. *Store, archive and provide access to Data Assets in ways that ensure sustained benefits.*
11. *Treat all Data Assets, their associated Metadata and Software Scripts used to process Data Assets as Presumed Open*

Internationally, the GO FAIR principles (Findability, Accessibility, Interoperability and Reuse) provide guidance for data management which emphases machine-to-machine actionability (i.e. the capacity of systems to find, access, interoperate, and reuse data with none or minimal human intervention).

Where the VirtualES needs to get to

Given the VirtualES objective to facilitate an ecosystem of connected digital twins for the energy sector, its data governance and management approach must be sector-wide.

The VirtualES should both align with current industry guidance and programmes (such as the National Digital Twin programme), and be active in developing new guidance.

VirtualES data management capabilities should aim to:

- Make data visible, discoverable, accessible, and sharable to those that need it, and provide a mechanism to facilitate trust in the data.
- Facilitate data being integrated and brought together to generate insights.
- Drive the behaviours and accountabilities needed.

How to get there

Once the scope of the VirtualES is ratified by the industry, it will be necessary to:

- Review the VirtualES data requirements and ensure these align as much as possible to the existing data management directives.
- Where gaps exists, the VirtualES should work with the regulator and industry to evolve the guidance for the VirtualES and the wider sector benefit.
- The VirtualES should look to build and maintain the practices and tools it needs to enable consistent and efficient access to and delivery of data.

Managing security

Data

Current state

Across the energy sector there is wide-spread recognition that digitalisation of the sector brings in new risks for the security and resilience of the overall system.

In the "*Transitioning to a net zero energy system - Smart Systems and Flexibility Plan 2021*" Ofgem and BEIS highlight that as more smart devices are installed in homes and businesses, and more organisations access them for flexibility and other services, there will be new risks related to cyber security.

Being security-minded and embedding digital security principles is recognised as essential to enabling safe digitalisation at scale. The EDiT report also recommends:

- Implement modern password policies
- Implement merit order of patching based on risk profile
- Map cascade effects of system security zones
- Increase frequency of regular penetration testing
- Adopt a zero trust and least privilege approach requiring through sector wide policies.
- Enable disclosure of risks and discovered vulnerabilities before they become incidents
- Run drills and threat assessment exercises. This is supported by a 'Red Team' within regulatory entities that is monitoring and designing drills and cross-sector cascade stress testing
- Leverage cross-sector collaboration to common cyber security challenges

While security is a visible and discussed topic across the sector, there is not yet a sector wide approach to security. Thankfully, there are developed, advanced and internationally recognised standards for security which the energy sector can adopted as it moves further into its digitalisation.

Where the VirtualES needs to get to

Being security minded must be a fundamental requirement of the VirtualES. There must be continuous alignment to international security standards and best practices as well as any sector specific protocols that might emerge over time.

Specifically, it will be key to:

- Implement key security standards. Such as:
  - Cyber security in accordance with NSCS guidelines, NIS directive and ISO 27001.
  - Data privacy principles standards for IoT implementation and other in accordance with the UK CPNI.
- Enforcing clear trust protocols (such as around authorisation) for data usage and integrity.
- Align with the developing principles of the National Digital Twin programme.

How to get there

Once the scope of the VirtualES is ratified by the industry, it will be necessary to:

- Collaboratively identify the security best practices and protocols to be adhered to, aligned to CPNI.
- Carry out an assessment of the potential security risks created, and identify core security requirements.
- Test possible resolution and mitigation assumptions.

Connecting physical infrastructure

Technology

Current state

Whilst extracting data from physical infrastructure, for example by deploying IoT sensors, is common practice the UK energy sector does not have a complete view of what happens across the system - as there is no minimal common layer to facilitate critical data being ingested, standardised, and shared in near real time.

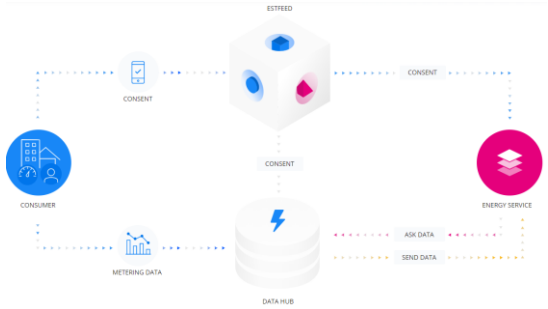
The EDiT has identified the need of a digital system monitoring solution, a "Digital Spine", as high priority:

"to enable energy sector actors to ingest data that is critical to system operation, process this into a standardised format, present the data in a common way and enable data to be securely shared with other actors in near real time".

The Digital Spine is conceived as a cloud-based distributed solution, using open-source solutions, where each energy sector actor deploys a node (or multiple nodes) that ingest, process, and present system critical data to be shared with other nodes. Every node has a data ingestion, processing and presentation layer conforming to standardised data formats and security requirements. EDiT envisages this being an open-source community development with a central coordinator for aspects such as verification and coordination.

Looking at other country's digital energy systems, Estonia has taken the opposite approach. The Estonian transmission and Distribution Operator, Elering, has built a Data Hub (Estfeed) for the entirety of the energy system, with a centralised database and common data standard. Since 2016 it has enabled suppliers to provide customers with advanced services, such as access to their hourly energy consumption data, and apps.

The data feeds have also helped DSOs reduce losses through improved fault detection. The data sharing platform has a highly secure architecture with consent management built on top of the data exchange platform. This enables the data owners to give permission to different energy service providers to use their data.



Source: Estonia's data hub Estfeed provides a secure system with consent to metered data for energy services.

Where VirtualES needs to get to

The VirtualES could be the Orchestrator of the delivery of the Digital Spine for the UK energy system, which the EDiT proposed as necessary for the creation of a set of connected digital twins across the energy sector.

The VirtualES will likely need to adopt and manage a distributed architecture, whilst ensuring it provides a safe environment for energy data. It is considered that it will need a higher degree of centralised capabilities, on top of what is envisioned by EDiT, to help enforce interoperability of data and connections. The VirtualES will also need to identify and set connectivity best practices and potentially provide the connectivity infrastructure to connect to physical energy assets.

How to get there

Once the scope of the VirtualES is ratified within the industry, it will be necessary to:

- Set a framework to evaluate industry requirements.
- Define and agree the VirtualES technical architecture.
- Set a high-level delivery framework, prioritising key technical challenges to be addressed with industry participation (e.g. connectivity from high volumes of physical devices).

Enhancing modelling and analysis

Technology

Current state

Modelling and simulation software for energy systems and networks is core to decision making within the different tiers of the sector. This is critical for the effective load balancing of electricity and managing the networks to ensure the lights stay on.

Specialist modelling software currently in use is unlikely to change due to the high costs involved, and often these are bespoke developments. However, analysis and analytical software will most likely only account for internal datasets.

Numerous analytical tools exist which are being used or developed within analytical platforms. Organisations are investing heavily in these platforms and the teams of data scientists / analysts required to maximise the value of their data for improved operations and investments.

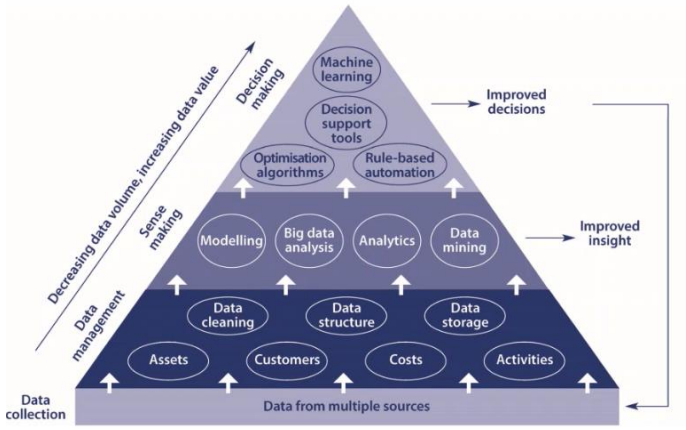
These systems can be configured to accept different data services when they become available. This provides an opportunity with increased amounts of shared data to produce greater insights.

An example of this outcome is the CReDo digital twin demonstrator, which took advantage of the DAFNI platform and innovative analysis software to illustrate how cross-sector data and assets can be connected.

Where the VirtualES needs to get to?

There is a big opportunity to expand the modelling and simulation of energy systems and markets through the VirtualES by increasing available data from across the sector and its documentation / interoperable formats.

Based on this it is anticipated there will be greater analytical capacity of energy generation, consumption and distribution as a result. Through use of decision support tools, operators within the market will be better able to serve customers with improved reliability, pricing and response times to incidents



Source: The Information Value Chain, based on the diagram presented in the Gemini Principles by CDBB

How to get there

The recommended next steps would be:

1. Determine what platforms or modelling and analysis software is planned, in development, or operational that could benefit from connected data.
2. Learn key lessons from the CReDo project and apply them to the energy sector as a ‘thin slice’ of the national infrastructure, and connected to the National Digital Twin.
3. Understand the insights which can be improved as a result of additional analysis of the proposed available datasets shared within the sector and the benefits resulting.
4. Gather the use cases for software, which have been defined by different organisations within the energy sector and other national infrastructure bodies relying on energy data. Determine common benefits and possibility for sharing analysis approaches.
5. Investigate the development and use of DAFNI, and determine the potential to be a software platform resource for the energy sector.

3.0 — Recommendations

Recommendations

Overall recommendations that are applicable to all socio-technical factors

Pages 21 to 49 detail the specific recommendations for National Grid ESO to consider in planning and developing the next steps of the VirtualES.

The recommendations for the priority socio-technical factors have been consolidated and summarised on pages 52 and 53 for convenience.

In addition to the specific recommendations, the following 12 overall recommendations are given.

1. The development of connected digital twins must combine both social and technical factors.
2. The ecosystem design must maximise for cohesion (common, market-wide processes) and interoperability (processes that enable low-friction transactions) across systems.
3. Continue to develop the common framework, with particular focus on the priority socio-technical factors. These are summarised in the next 2 pages. For the full recommendations see pages 22 to 49.
4. The scope and outcome of the VirtualES needs to be clarified and aligned with other digitalisation initiatives across the sector, so that the VirtualES becomes an additive and critical Orchestrator.
5. Articulate the benefits of having the VirtualES first and foremost, so that it is clear why and how it adds value to the sector and its consumers.
6. Review the VirtualES workstreams and develop a coordinated plan going forward so that work is led by the use cases.
7. Identify assumptions that need to be tested during the next phases.
8. Consensus and agreement on the VirtualES scope needs to be built and reached across the sector, and officially supported and endorsed by the energy regulator and industry.
9. Embark on active, frequent, and consistent communication and engagement with existing initiatives to ensure alignment and provide the confidence across the sector that the VirtualES is coordinated and collaborative.
10. Identify clear roles and responsibilities in terms of the VirtualES, and how actors across the energy system can participate.
11. Plan and deliver with flexibility in the approach to governance and roles, staying adaptable as the energy transition progresses in parallel with the development of the VirtualES
12. It is critical that any design considerations such as data taxonomies, are aligned at the national level to the National Digital Twin programme’s Information Management Framework. This ensures that the VirtualES can be the ‘thin slice’ digital twin of the energy sector.

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Summary recommendations

Summary of the recommendations and next steps for each priority socio-technical factor

PRIORITY FACTOR

Raising awareness & fostering culture

Shared vision, belief and behaviours and enabling practices to support the VirtualES objectives

To ensure the VirtualES is a **key driver for strengthening a digitalisation culture** across the energy sector, the recommended initial steps include:

- Raising awareness through articulating the tangible benefits of the VirtualES through realistic use cases.
- Providing a framework and roadmap for the necessary changes to the sector's digitalisation and sharing of data to enable its vision.
- Engaging with digitalisation leadership and encourage active involvement.
- Promoting user-centred design through end-to-end whole-system thinking.

PRIORITY FACTOR

Engaging stakeholders

Nurture industrial, governmental, and political support

To **harness industry support and enable the VirtualES as a connector and integrator**, the recommended initial steps include:

- Clarifying and communicate how VirtualES fits into the current landscape of digital initiatives across the sector.
- Identifying roles and responsibilities for stakeholders and set a mechanism for collaboration.
- Establishing regular cadence of engagement and lock in their support (e.g. governmental actors).
- Engaging and leveraging existing forums.

PRIORITY FACTOR

Creating a governance framework

Set strategy and operational governance of the VirtualES

To build **an independent, pragmatic, and adaptive governance** to enable the evolving operating model for the VirtualES, the recommended initial steps include:

- Defining and agreeing the VirtualES role in the wider energy ecosystem, in terms of decision making power and responsibilities.
- Establishing clear reporting lines across the system.
- Providing transparency on independence and funding of the VirtualES.
- Ratifying core ways of operating, such as stakeholder engagement and delivery assurance processes.

ARUP

Summary recommendations

Summary of the recommendations and next steps for each priority socio-technical factor

PRIORITY FACTOR

Aligning models & taxonomies

Define an approach to harmonise existing data standards, taxonomies and ontologies

To ensure the VirtualES **interoperability by aligning sector ontologies**, the recommended initial steps include:

- Adopt and adapt what already exists, for example align data standards with the NDTp Information Management Framework (IMF) where possible.
- Extract the lessons learned from the CReDo project in the use of the IMF for the energy sector's adoption.
- Create ontologies that are missing and not yet covered by the existing approaches.
- Follow the main phases of ontology development.

PRIORITY FACTOR

Increasing visibility & enabling sharing

Nurture effective data sharing to support interoperability

To align the **VirtualES and make it a driver of existing work** across the sector, the recommended initial steps include:

- Publishing machine-readable, open metadata in a manner that can be included in Open Energy, including both open and shared data.
- Reviewing current data sharing initiatives to bring in key advances in development in how data will be accessed across the industry in future.
- Actively engaging in programmes addressing standards for publishing data and metadata; be a leader in the adoption of standards across the sector.
- Engaging with the future delivery orchestrator for the Energy Asset Register.

PRIORITY FACTOR

Creating an interoperable 'stack'

Communication, cooperation & sharing across VirtualES & other in/cross sector projects

To ensure **interoperability is a core principle and characteristic of the VirtualES**, the recommended initial steps include:

- Defining a high-level interoperable architecture for the Digital Spine.
- Contributing to the leadership in the coordination and delivery of the Digital Spine
- Providing data visibility to users of VirtualES.
- Identifying a set of best practices that promotes wider integration and data exchange (e.g. data exchange protocols, open software, system integration, access control and distributed data management).

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A.1
Summary of show & tell feedback

	Factor	Factor Description	Headline feedback	Summary of responses	Why do you agree/disagree?	Are you aware of, or working on, existing initiatives that are considering this factor?	What level of involvement would you like in the development of this factor?
People	**Defining roles & responsibilities**	Formalise Roles and Responsibilities for VES with the intentions of consumer benefits	* Need to get the balance right of formalising roles but allowing agility and innovation without too much rigour	Yes: 20% Maybe: 80% No: -	*Need to get the balance right of formalising roles but allowing agility and innovation without too much rigour *(Maybe)Yes to the extent that this is less of a priority to ensure minimal overlap of the Roles & Responsibilites pertinent to the individualy digital twins that will integrate under the VES, however, will likely need the R&R to ensure awareness is meaningful	*Yes - we're looking at the Energy Transition and what an Energy Data Marketplace might look like	*High *informed only
	Raising awareness & fostering culture (Priority)	Share vision, belief and behaviours and enabling practices to support VES objectives	* General consensus that this platform will be engaged with / of interest to an very broad spectrum of people * Sharing a clear vision will be key to enabling behaviours for success. * Recommendations to include the broader context as to how electrification will affect commercial operations and public life. * Recommendation that raising awareness can help indicate the skills and capabilites that are needed in industry now and in the future.	Yes: 100% Maybe: - No: -	* Hugely important to get the vision clear and outline very succinctly the WHY behind doing this * Sharing requirements for enabling practices is a key priority, but ambiguous/undefined behaviours may hinder a meaningful undertstanding & therefore sufficient action * VES should be a common platform where different parties can share vision and information. *As much as it is important to raise public awareness, it is important to invest on next generation of innovators, i.e. engineers, researchers, etc. to ensure sustainability *A wider understanding of how the electrification of many industries and parts of life helps raise awareness and gaining public support.		
	Building capabilities & skills	Understand skills & competency needs with respect to current skill levels and develop capacity building strategies	* A close contender for a priority factor (although recognising that they are all 'priorities') *A notion that there's a 'chicken & egg' situation with the cultural shift and enabling that with the right skills and capabilities for delivery.	Yes: 43% Maybe: 43% No: 14%	* I am working on the Data Analytics Platform which exposed me to a new set of skills needed to engage the new technology with our existing processes * (NO) Not sure cultural shift is likely to be successful without the capabilities & skills required to adopt practices that facilitate the VES objectives. Do appreciate that not everything can be a priority! * (Maybe)VES can have very different building blocks, which need different skills and capabilities. Thus, when setting out the vision, to me, it is better to think about whether such vision can be realised. If not, what is the gap? Can such gap be addressed with local resources or should be borrowed internationally. *(Maybe)To some extent I feel this will build out as progress is made and best approach is defined		

	Factor	Factor Description	Headline feedback	Summary of responses	Why do you agree/disagree?	Are you aware of, or working on, existing initiatives that are considering this factor?	What level of involvement would you like in the development of this factor?
Process	**Aligning around industry codes & standards**	Look at whether standardised practices in the industry require amendment to support the VES	* Calls for government and regulator support for this factor. * Suggestion for targeted engagement with Code Managers and Administrators - Retail Energy Code * Recommendation to engage with Ofgem's next iteration of Code Consolidation, and/or ESO's * Whole System Technical Code (WSTC) and Future System Operator (FSO) if not too far off)? * Reference / suggestion to align to the EDiT work and the Digital Spine	Yes: 50% Maybe: 50% No: -	*(Maybe)Again appreciate not everything can be a priority, but Gov. support really should include alignment in order to achieve standardisation, or at the very least highlight that alignment will be necessary at a given point in time. Code Managers/Administrators should certainly be made aware that standardisation is a future requirement e.g. REC *(Maybe) I think we should conduct an extensive review and decide what is the best way to move from current practice to VES. This might reduce risk, uncertainties and investment.	Could be swept up in Ofgem's next iteration of Code Consolidation, and/or ESO's WSTC	Consulted (industry level), especially where expected to develop integration at a future point (e.g. Digital Spine expectations for non-regulated parties, digital & data monopolies review etcetera)
	Engaging Stakeholders (Priority)	Nurture industrial, governmental and political support	* The responses to this actor echo that of Raising awareness and Fostering culture (P) * Suggestion to engage with the Utilities Regulator Duties Review 2022 for support for DTs? * Call for Policy intervention, and consultation at industry level to support that.	Yes: 100% Maybe: - No: -	*In the future market where digital transactions across distributed assets effectively run the system, it is likely that any change/initiative will require extensive modelling, not least to identify any unintended consequences so DT initiatives should be supported from the off to set clear expectations across current & future energy vectors * It is essential that VES has the support from different organisations, so that parties can have incentives/obligations to develop DT. Without clarifying the shared vision, different parties can go to different way, which could waste resources and also impact the value of VES.	Utilities Regulator Duties Review 2022 may provide further detail as to integration of regulators, if that is the case support for DTs could be included there?	Consulted (industry level) to the extent that this support requires policy intervention
	Creating a governance framework (Priority)	Set strategy and operational governance of the VES	* Calls for alignment with CDBB, EDiT, GeoSpatial Commission 'National Map of Storage' and ENAs 'National Map of Assets'. * Additional consultation called for at industry level; '…this governance impacts market participant obligations and or financing arrangements'	Yes: 75% Maybe: - No: 25%	*As above, clear expectations are essential prior to many upcoming initiatives being developed *(NO) Considering its the broad vision which cannot be realised by one-off effort, strategic planning is needed at the beginning. I am personally impressed by the work of CDBB. Possibly, VES can borrow some good experience from it.	Initiatives under the digitalisation strategy and subsequent initiatives to deliver ESC EDiT recommendations should all be in tandem, as should Geospatial Commissions' national map of storage, and ENA's national map of assets etcetera	Consulted (industry level) to the extent that this governance impacts market participant obligations and or financing arrangements
	Determining the operating environment	VES to operate through business models, cross organisational legal and contractual framework and policies	* Suggestion to connect with the work by ESC looking at 'Single Carbon Regulator', and cross-organisational framework / policy. * Again a call for (ongoing) industry level consultation also in the context of the EDiT work and the Digital Spine.	Yes: 75% Maybe: 25% No: -	*Open Source Initiative does not appear to be big in the UK currently and there is no existing legislation for Open Source data/software (so far as I know), so until that materialises a legal framework for the integration of open source DTs cannot be a priority *(Maybe) Once the vision and strategics are clear, the operation environment can be developed. To me, this should come after those top propriety business. *The legal aspects and policies might have a limiting factor on everything else that is done across these four groups (e.g., policies about data sharing), so although it might not be the highest priority, something needs to be done about them to make sure other priorities will be actually addressed. *Business models are needed for this to have legs	Proposals for single carbon regulator atm (ESC) so may need to be considered wtihin 'cross-organisational framework/policy'	Consulted (industry level) to the extent that this governance impacts market participant obligations and or financing arrangements, and where expected to develop integration at a future point (e.g. Digital Spine expectations for non-regulated parties, digital & data monopolies review etcetera)

	Factor	Factor Description	Headline feedback	Summary of responses	Why do you agree/disagree?	Are you aware of, or working on, existing initiatives that are considering this factor?	What level of involvement would you like in the development of this factor?
Data	**Aligning models & taxonomies (Priority)**	Define an approach to harmonise existing data standards, taxonomies and ontologies.	* Emphatic comments that data is one of the most important areas * Again, a call for further industry consultation and providing context of interface / integration with the Digital Spine	Yes: 100% Maybe: - No: -	*Different parties are using different models for different processes to insure secure and commercial operration of the GB network at all levels. *[intentional repetition] In the future market where digital transactions across distributed assets effectively run the system, it is likely that any change/initiative will require extensive modelling, not least to identify any unintended consequences so DT initiatives should be supported from the off to set clear expectations across current & future energy vectors *Totally agree. Data is the basis for VES and this should be one of the top priorities. *Currently there are lots of inconsistencies between open data, e.g., it is not possible to reconcile records of which generators produced what with records of what generators exist. In other words, there is still lots of ambiguities in the data already available, so it will be important to have a common, shared understanding about the data that is being shared. *An up-to-date source of information with a common information model (even globally) is key to facilitating the growth of the VES and industry.	*Yes *None beyond current policy proposals/recommendations e.g. nothing active However, Ofgem are ensuring the DNOs move to CIM standard and that market participants communicate via JSON	*High *Consulted (industry level) to the extent that this governance impacts market participant obligations and where expected to develop integration at a future point (e.g. Digital Spine expectations for non-regulated parties, digital & data monopolies review etcetera)
	Establishing management & governance	Outline data management and governance needed to support VES	* A comment that this should be a first priority "to ensure that data sets are already at a stage where they are interoperable, especially where it is expected that DTs of emerging areas (offshore wind, hydrogen etc) will be integrated" * Again, a call for further industry consultation and providing context of interface / integration with the Digital Spine	Yes: 40% Maybe: 40% No: 20%	*Investigate the data security and level of access provided by the data owner is essential *(NO) I believe the data management and governance to be a higher priority to ensure that data sets are already at a stage where they are interoperable, espcially where it is expected that DTs of emerging areas (offshore wind, hydrogen etc) will be integrated.	None beyond current policy proposals/recommendations e.g. nothing active	*Moderate *Consulted (industry level) to the extent that this governance impacts market participant obligations and where expected to develop integration at a future point (e.g. Digital Spine expectations for non-regulated parties, digital & data monopolies review etcetera)
	Increasing visibility & enabling sharing (Priority)	Identify ways to nurture effective data sharing to support VES interoperability.	* mixed response to the prioritisation of this factor as Interoperability will be achieved via Standards & governance rather than data sharing, it is also more important to have these enabling factors in place prior to the sharing proposals if not done in tandem. * Again, a call for further industry consultation and providing context of interface / integration with the Digital Spine	Yes: 71% Maybe: 14% No: 14%	*Within the need to know baisis considering the security and commercial sensitivity of the data *(NO) Interoperability will be achieved via Standards & governance rather than data sharing, it is also more important to have these enabling factors in place prior to the sharing proposals if not done in tandem. It is possible to impose data sharing requirements easily & cost-effectively where the data sets are already interoperable, it is not easy or cost-effective to impose data sharing where data sets have been developed under different formats/standards *Totally agree. I think it is also important to outline the levels/complexities of VES, what data is needed for each purpose. This can be linked to applications or business models of VES.	None beyond current policy proposals/recommendations e.g. nothing active	*High *Consulted (industry level) to the extent that this governance impacts market participant obligations and where expected to develop integration at a future point (e.g. Digital Spine expectations for non-regulated parties, digital & data monopolies review etcetera)
	Managing security	Set the core rules needed to address security, privacy and risk implications surrounding VES data	* Feedback indicates that the purpose and extent of the prioritisation needs careful communication that all these factors will be progressed, but that prioritisation is simply establishing the ‘starting blocks’. * A suggestion to publish samples of information as open data to encourage innovation, and contribute to interoperability. * Again, a call for further industry consultation and providing context of interface / integration with the EDiT proposals for a Digital Spine.	Yes: 60% Maybe: 20% No: 20%	*A system with this magnitude will be targeted aggressively by foul players who will try to benefit from the data or of the sake of inflicting damage to the system *(NO) Still appreciating that not everything can be a priority, I think it highly unlikely that integration/data sharing will occur where robust security & privacy 'rules' are not already in place *(Maybe)Once all needed data is identified, this will become important. I think this should also be linked to data acquisition to minimise the investment in some cases. Integrating data collection with security/privacy in some cases might be a better solution. *One key requirement here will be the need to publish samples of information as open data to encourage innovation. This will help develop solutions that directly contribute to interoperability, otherwise it will be still in-silo solution developed on a case-specific application, and with limited interoperability.	None beyond current policy proposals/recommendations e.g. nothing active	*Moderate *Consulted (industry level) to the extent that this governance impacts market participant obligations and where expected to develop integration at a future point (e.g. Digital Spine expectations for non-regulated parties, digital & data monopolies review etcetera)

	Factor	Factor Description	Headline feedback	Summary of responses	Why do you agree/disagree?	Are you aware of, or working on, existing initiatives that are considering this factor?	What level of involvement would you like in the development of this factor?
Technology	Connecting physical infrastructure	Identify what physical IT infrastructure and devices and their connectivity are required to operate the VES	Seen as an area for long-term ongoing focus	Yes: 33% Maybe: 67% No: -	*Expect this will grow over time depending upon integration anyway *(Maybe) The extent to which this is required beyond existing knowledge of requirements depends on the use case - e.g., closer to real-time vs. planning. But, current efforts of smart data metering will need continual support.		
	Analysis of Software	Identify the likely modelling / simulation and analysis software which will be used to enable current and future modelling of the VES.	* Support for bringing forward the prioritisation of this factor. * Suggested alignment with existing initiatives in the Energy Data landscape.	Yes: 40% Maybe: 60% No: -	*(Maybe) If it is plausible to bring this forward I would; I imagine the modelling/simulation to be a key use-case, especially for funding parties to realise benefits *Effective modeling is likely the key value item of the VES. There will be heavy computational requirements to model the many use cases. To fully capture the effects of distributed energy resources must the entire power system down to the household level is needed. The sooner this is being considered the better.	*My interest is in modelling the cyber-security of the energy network control systems. The value of doing so is that cyber-attacks can be simulated and the effectiveness of the security analysed in more detail than can be done through documents and spreadsheets. There is much work in this space; examples are https://energy-shield.eu/ and https://www.ofgem.gov.uk/publications/analysing-cyber-security-industrial-control-systems. *Consulted (industry level) to the extent that this governance impacts market participant obligations and where expected to develop integration at a future point (e.g. Digital Spine expectations for non-regulated parties, digital & data monopolies review etcetera) *Yes. Working on modeling the full top to bottom analysis of the power system.	*I would like to be involved in the development of this aspect. *High
	Creating open interfaces (Priority)	Software and hardware will differ by usage, but the exchange mechanism is critical for the import or export of shared data and metadata.	* Agreement with the prioritisation of this factor	Yes: 100% Maybe: - No: -	*Expect the exchange mechanism to be part and parcel of the governance frameworks in reality *Totally agree *Access to credible, quality data provides the foundation from which to gain meaningful results from a VES.	Again nothing active, but this is in-keeping with other ESC initiatives e.g. Digital Spine, Data Catalogue	

	Factor	Factor Description	Headline feedback	Summary of responses	Why do you agree/disagree?	Are you aware of, or working on, existing initiatives that are considering this factor?	What level of involvement would you like in the development of this factor?
Part 2 - Anything that we're missing?							
Category	**Key Factor Name**	**Description**		**Suggested Factor to consider** **Reason for this factor being included / considered**		**Are you aware of, or working on, existing initiatives that are considering this factor?**	**What level of involvement would you like in the development of this factor?**
DATA	*Emerging markets	see responses above relating to emerging markets		Depending upon the length of time this initiative will be in development, consideration should be given to emerging markets and how they're developing the tools necessary to ensure that can develop & integrate their own digital twin e.g. hydrogen, CCUS, possibly fusion etc.			I would like to be involved in data fusion and knowlege extraction
TECHNOLOGY	Cyber-security	*Modelling energy network cyber security *As the energy network grows in complexity, protecting the control signals that maintain grid stability from cyber-attack becomes increasing important yet more difficult.		Digital models are powerful tools for simulating attacks and understanding how best to defend against them.		*My interest is in modelling the cyber-security of the energy network control systems. The value of doing so is that cyber-attacks can be simulated and the effectiveness of the security analysed in more detail than can be done through documents and spreadsheets. There is much work in this space; examples are https://energy-shield.eu/ and https://www.ofgem.gov.uk/publications/analysing-cyber-security-industrial-control-systems. *I am working on the Data Analytics Platform (DAP) from network operability, working on different network analysis models needed for the simulation softwares.	* I am working on the Data Analytics Platform (DAP) from network operability, working on different network analysis models needed for the simulation softwares * I would like to be involved in builidng VES/DT for operation and maket applications.
PROCESS	-	-		-	-	-	-
PEOPLE	-	-		-	-	-	-

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