ESO Technology Advisory Council

TAC-13

1st December 2023

Meeting pack

TAC-13 agenda – 1st December 2023

Item	Start	Finish	Time	Item	Presenter	Notes
1	09:00	09:05	5	**Welcome & Apologies**	Chair	
2	09:05	09:10	5	**Minutes of last meeting and matters arising**	Chair	
3	09:10	09:15	5	**Feedback from the last meeting**	Cameron Shade	
4	9:15	9:55	40	**Innovation: Horizon Scanning**	Alexi Reynolds	
5	9:55	10:35	40	**Network Control Management System**	Ian Dytham	
6	10:35	11:15	40	**Common Data Framework**	Jonathan Barcroft	
	11:15	11:35	20	**BREAK**		
7	11:35	11:50	15	**Open Balancing Platform Update & Roadmap**	Brendan Lyons	
8	11:50	11:55	5	**Subgroups update**	Chair	
9	11:55	12:15	20	**Next meeting**	Chair	Next meeting: Friday 1st March 2024
10	12:15	12:30	15	**AOB**	Chair	

Welcome and apologies

Item 1

Chair

Minutes of last meeting and matters arising

Item 2

Chair

Minutes of last meeting and matters arising

- Minutes of TAC-12 have been published on the ESO website.
- The material from the meeting are also be published.
- This section will be used to discuss any matters arising.

Feedback from the last meeting

Item 3

Cameron Shade

Feedback from the last meeting

The topics discussed at the last meeting were:

- Control room gallery tour
- Crowdflex
- Customer Centric ESO
- Open balancing platform

Feedback from the TAC:

Crowdflex

- How will real trials be dispatched?
- How will the control room gain confidence in the energy Crowdflex will provide?
- Keep closely aligned to DFS to build on its success not add a second complicated concept

Customer Centric ESO

- For this to be successful it needs a cultural shift
- Why not hire someone based on low volumes of queries?
- Fantastic evidence and data to explain the purpose and issues this will resolve

Open Balancing Platform

- Offer to put the ESO in contact with teams in Australia for discussions on limited duration assets.
- Plans to remove the fax machines were greatly received.

Innovation: Technology Horizon Scanning

Item 4

Alexi Reynolds

Topics to discuss

About the horizon scanning radar:

1. Have we missed any data and digital technology that you believe will have high or transformational impacts on the UK energy system?
2. Would you question the inclusion or placement of any of the technologies in the radar?

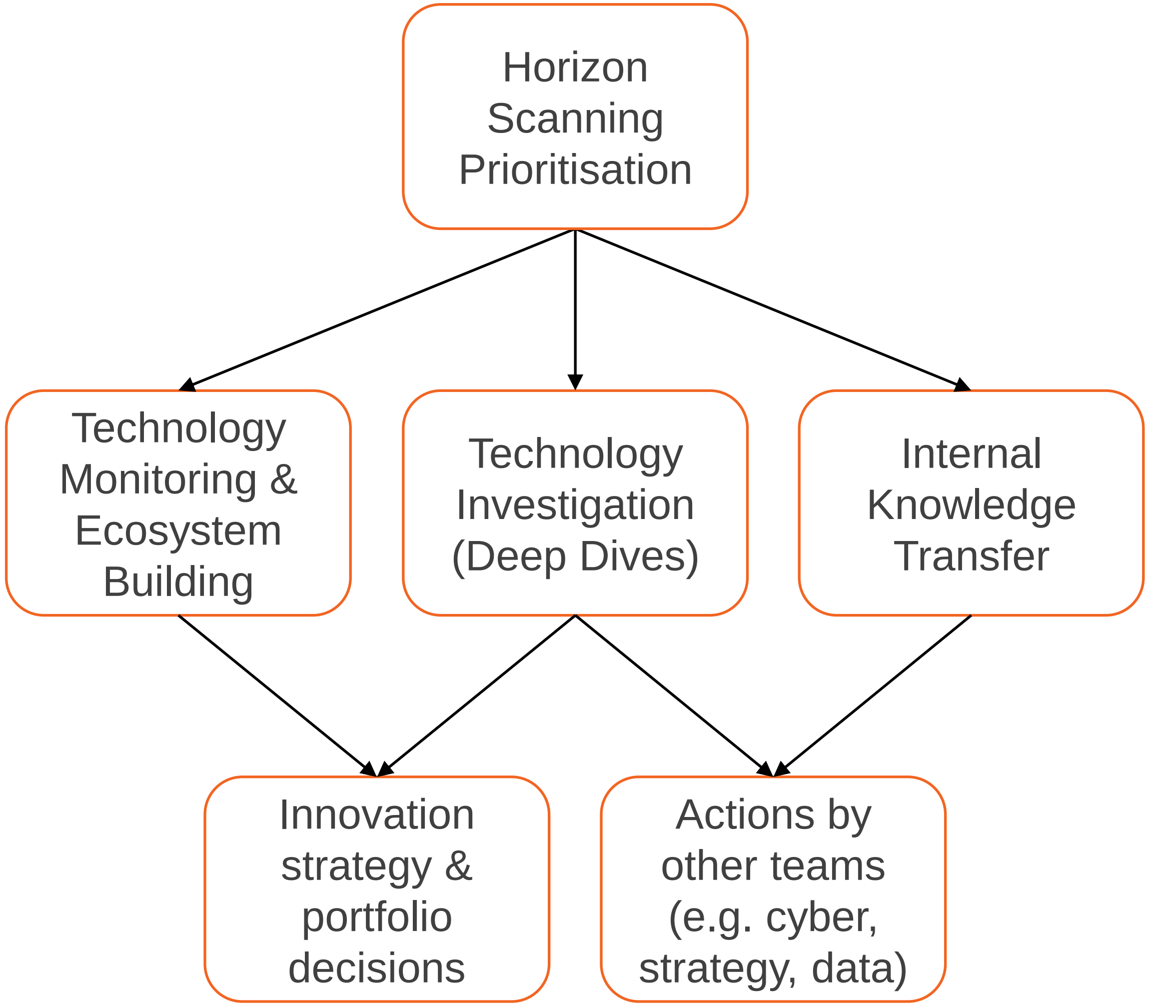
About the horizon scanning priorities:

1. Do you agree that the priorities presented are important for the ESO to monitor and investigate? Why or why not?
2. The priorities are listed in order of priority. How would you change that ordering?
3. What would you have prioritised instead?

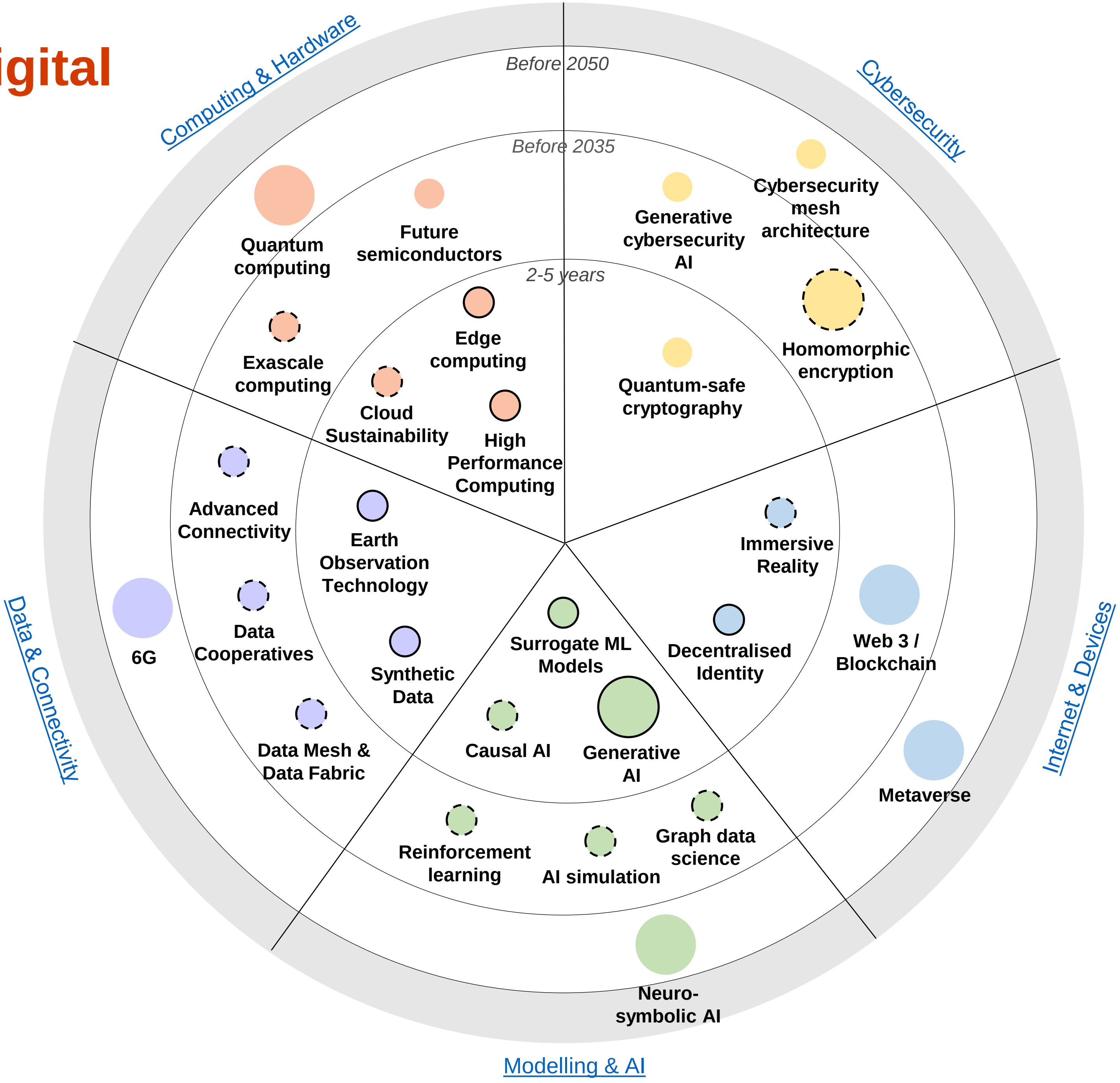
Please see Appendix A for the pre-reading material

Purpose of discussion

- Technology horizon scanning is part of our Open Innovation strategy
- As a small team with a very large scope, we must prioritise
- We are seeking opinions and challenge from external advisors on our priorities
- This is the first time we are running this process…



Data & Digital Radar



This radar includes the data and digital technologies identified by the ESO Innovation team as being likely to have high or transformational impacts on the UK energy sector. It also captures our understanding of the maturity of these technologies and the likely timescales until they will be implemented extensively in the UK energy sector (indicated by the concentric circles). In this first iteration of the radar the positioning of the technologies within each section of the diagram is not meaningful (e.g. we are not trying to say that the timescales for High Performance Computing are shorter than for Edge Computing).

Potential impact on UK Energy Sector

- Transformational
- High

Technology Maturity

- Labs (TRL 2-4)
- Early adoption (TRL 5-6)
- Wider uptake (TRL 7-8)

Draft Data & Digital Priorities for 2024

#1 AI applications for the FSO	#2 New and emerging data sources for the FSO	#3 Enablers for data sharing across the energy sector	#4 Advanced computation impacts on the energy sector	#5 Human-machine interfaces for the FSO
• Generative AI • For enabling real-time simulation support to the Control Centre • Cybersecurity threats and opportunities	• Earth observation technologies and others providing geospatial data • Synthetic data • Sensors and IoT data	• Advanced connectivity technologies • Edge computing • Non-traditional data management and data privacy approaches	• Quantum Computing • High Performance Computing • Cloud sustainability	• Immersive reality • For aiding and advising Control Centre engineers • For training, collaboration and engagement

Network Control Management System

Item 5

Ian Dytham

Topics to discuss

- The current progress of the Network Control investment line, including GE Vernova's product launch of their new GridOS platform and our plans to adopt this new technology
- The councils experience of managing a pivot in technology during a major delivery
- The councils experience of operating core products across multiple platforms
- The best practices for assisting a supplier to achieve wider adoption of new products across their customer base

Current Progress

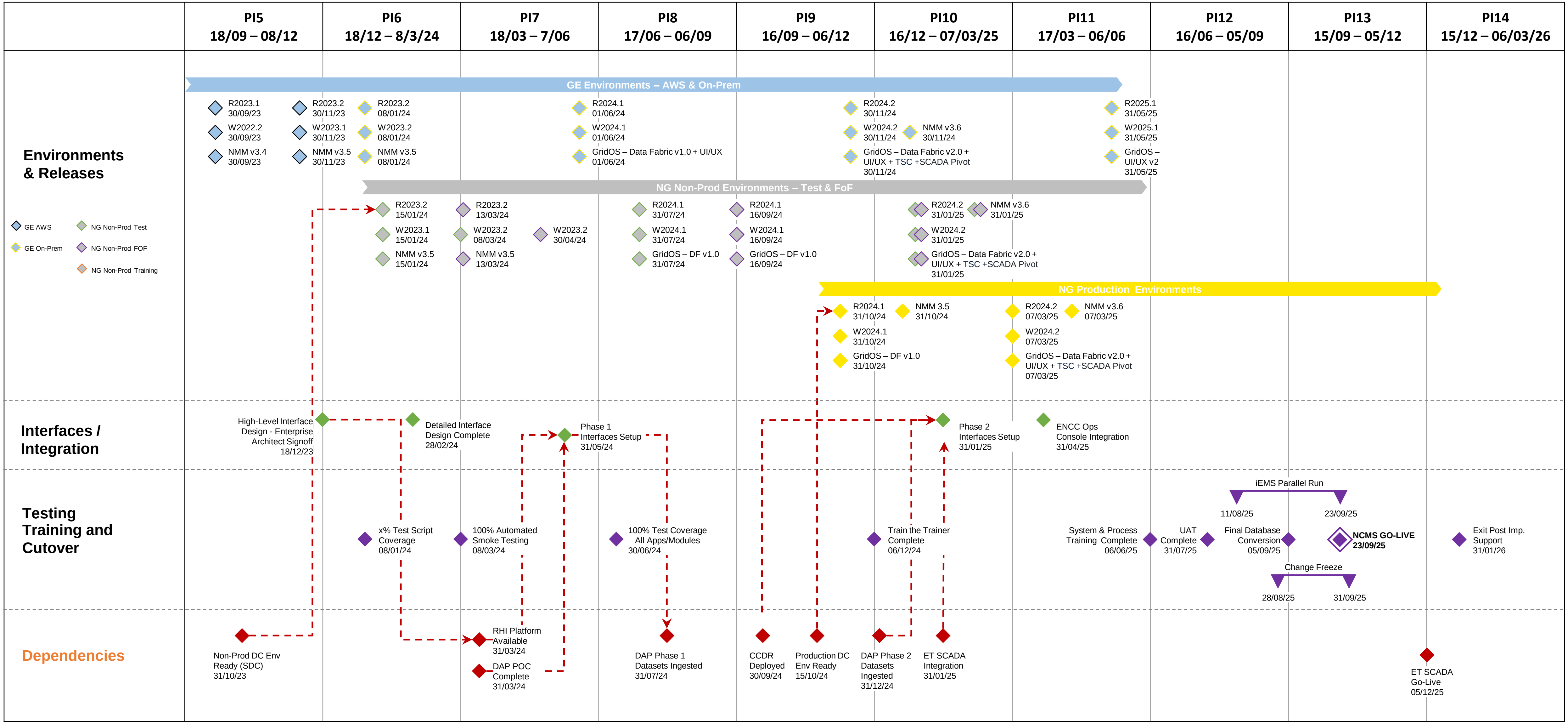
Existing product (IEMS) life extension:

- Vendor negotiations and contract award completed to Support extended life of IEMS
- Delivered priority software and hardware life extension projects
- Enhanced network modelling capabilities with online analysis of voltage power flow profiles closer to real time.

New product (NCMS):

- Validated scope and transition strategy, based on Roadmap.
- Determined core system “to be” architecture and options
- Finished core system requirements work.
- Completed proof of concept with vendors
- Completed procurement activity for core system
- Completed work with NGET on capability mapping
- Commenced build of core situational awareness system, reference environment delivered by GE using AWS cloud.

NCMS Delivery – Plan on a Page



New GE GridOS Platform Launch Timeline

The Network Control Management System (NCMS) Programme is in the process of implementing GE Digital's product, Reliance, to replace the current Integrated Electricity Management System (IEMS) that is shared with NGET. Earlier this year GE announced a change in direction to their software roadmap by introducing GridOS, which overtime will supersede the Reliance product.

Timeline of key events

June 2022

GE CONTRACT SIGNED

NG ESO award contract to GE Digital for implementation of the Network Control Management System (NCMS)

Feb 2023

GridOS LAUNCH

GE announced change in direction of software Roadmap
https://www.ge.com/news/press-releases/GE-Digital-Announces-GridOS-Software

May 2023

ORCHESTRATE 2023

GE share details for this announcement and industry wide shift (Executive Advisory Board and Customer Advisory Boards – (Attended by NG ESO)

May 2023

GE / NG ESO ROADMAP

GE / NG ESO follow up conversation and request to GE to provide ESO specific impact/opportunity assessment in the form of a Product Roadmap

June 2023

GE RECOMMENDATIONS

ESO specific change and recommendations provided during GE/ESO Executive Steering Board.

Pivot to GridOS

- Products from existing platforms (E-TERRA, Reliance) will move to a new single GridOS platform
- GridOS is more modular in design
- ESO currently use the Reliance platform
- ESO has a contract with GE to deliver a suite of Situational Awareness tools to meet over 900 User Requirements by 2025 (NCMS project)
- High level planning workshops have completed with GE on options to pivot to GridOS

Reliance vs GridOS Platform

VS

Scenario 1
Continue with Reliance

Delivery iEMS replacement with Reliance feature set, including developments to Reliance to achieve additional feature requests

Pros

- Delivers a proven end-to-end solution that satisfies the original NCMS scope and including identified enhancement
- Existing Control Room Engineers are familiar with iEMS product UI/UX and features which is closely aligned to Reliance product
- NG ESO has greater level of technical expertise/experience required for underlying Reliance infrastructure than GridOS

Cons

- Reliance product developments cease (unless exceptions) from 2025 onwards, placing a 5-7 support only constraint on the Reliance Product
- Certain GridOS modules require a different underlying infrastructure thus continued investment in Reliance infrastructure will result in more technical debt
- Existing delivery challenges and dependencies, e.g. Data Centre, GE Product Developments, Integrations, Testing have an existing impact and we will need to accelerate parts of the plan

Scenario 2
Pivot towards GridOS

Delivery iEMS replacement with a hybrid of core Reliance features *(part of a future GridOS roadmap)* and GridOS features that will be available within RIIO-2 – BP2

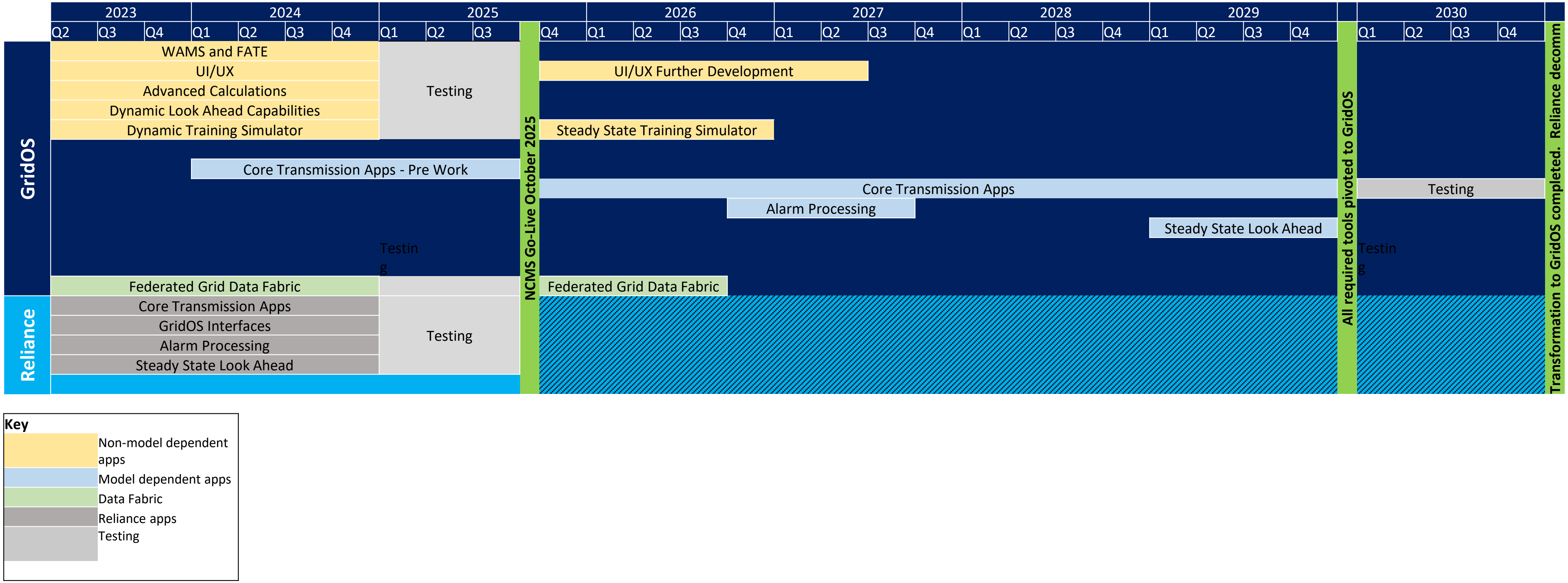
Pros

- An enhanced suite applications that evolve and modernise the grid control room for proactive and automated grid management
- An opportunity to exploit hybrid cloud architecture to deploy and scale applications where they are needed – on-site or in a hybrid environment
- Reduced footprint of legacy product (Reliance) to transition away from in subsequent RIIO periods
- Increased test automation reducing test cycle times and deployment to production *(new modules/features are developed with 80-90% test automation)*

Cons

- GE GridOS product roadmap delivers initial GridOS opportunities during 2024/5 which would defer the current Go-Live from April 2025 to October 2025
- GridOS features within the 2024/5 roadmap are still under development and may exceed our delivery timescales
- NG ESO would be early adopters of GridOS features which are not proven in a production setting to date.
- There will be an increased need to familiarise NG ESO of GridOS features thus potentially resulting in increased training.

Pivot Plan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2024
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GridOS
WAMS and FATE
UI/UX
Advanced Calculations
Dynamic Look Ahead Capabilities
Dynamic Training Simulator
Testing
UI/UX Further Development
Steady State Training Simulator
Core Transmission Apps - Pre Work
Core Transmission Apps
Testing
Alarm Processing
Steady State Look Ahead
Testin
g
Federated Grid Data Fabric
Federated Grid Data Fabric
Testin
g
Reliance
Core Transmission Apps
GridOS Interfaces
Alarm Processing
Steady State Look Ahead
Testing
NCMS Go-Live October 2025
All required tools pivoted to GridOS
Transformation to GridOS completed. Reliance decomm
Key
Non-model dependent apps
Model dependent apps
Data Fabric
Reliance apps
Testing

Common Data Framework

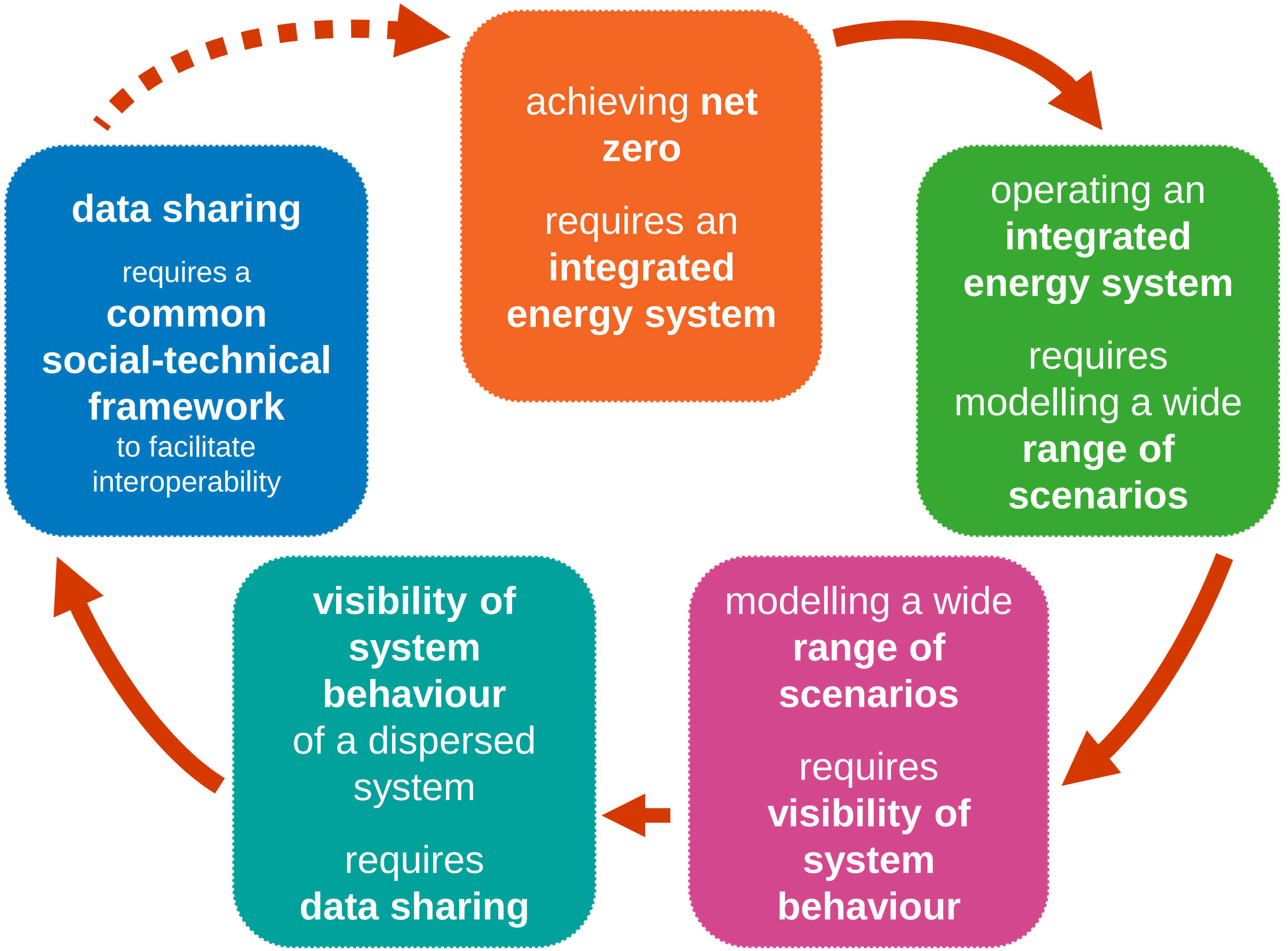
Item 6

Jonathan Barcroft

Topics to discuss

- What is your experience of maturity of these capabilities and are there other risks to adoption?
- Where do you see the applicability of existing programmes and industry codes?
- Are there any aspects of interoperability that cause particular concerns?
- Do you have any feedback from experience of developing an MVP e.g. feature prioritisation, scope constraints?

The challenge: the energy system is changing



The solution: Virtual Energy System

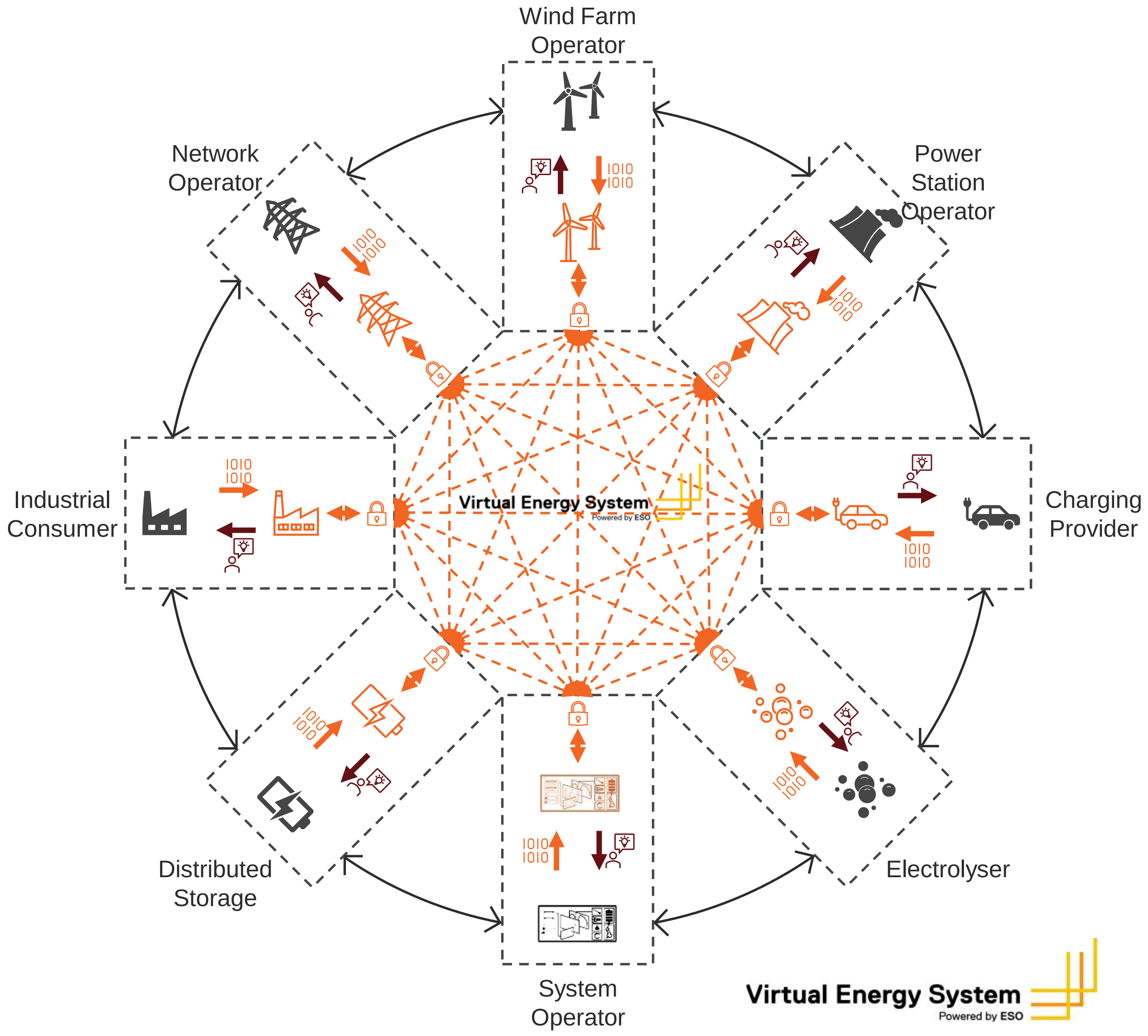
Ambitious objective:

Creating the common
data sharing infrastructure

to enable an ecosystem of
connected digital twins

that will facilitate the transition
to net zero.

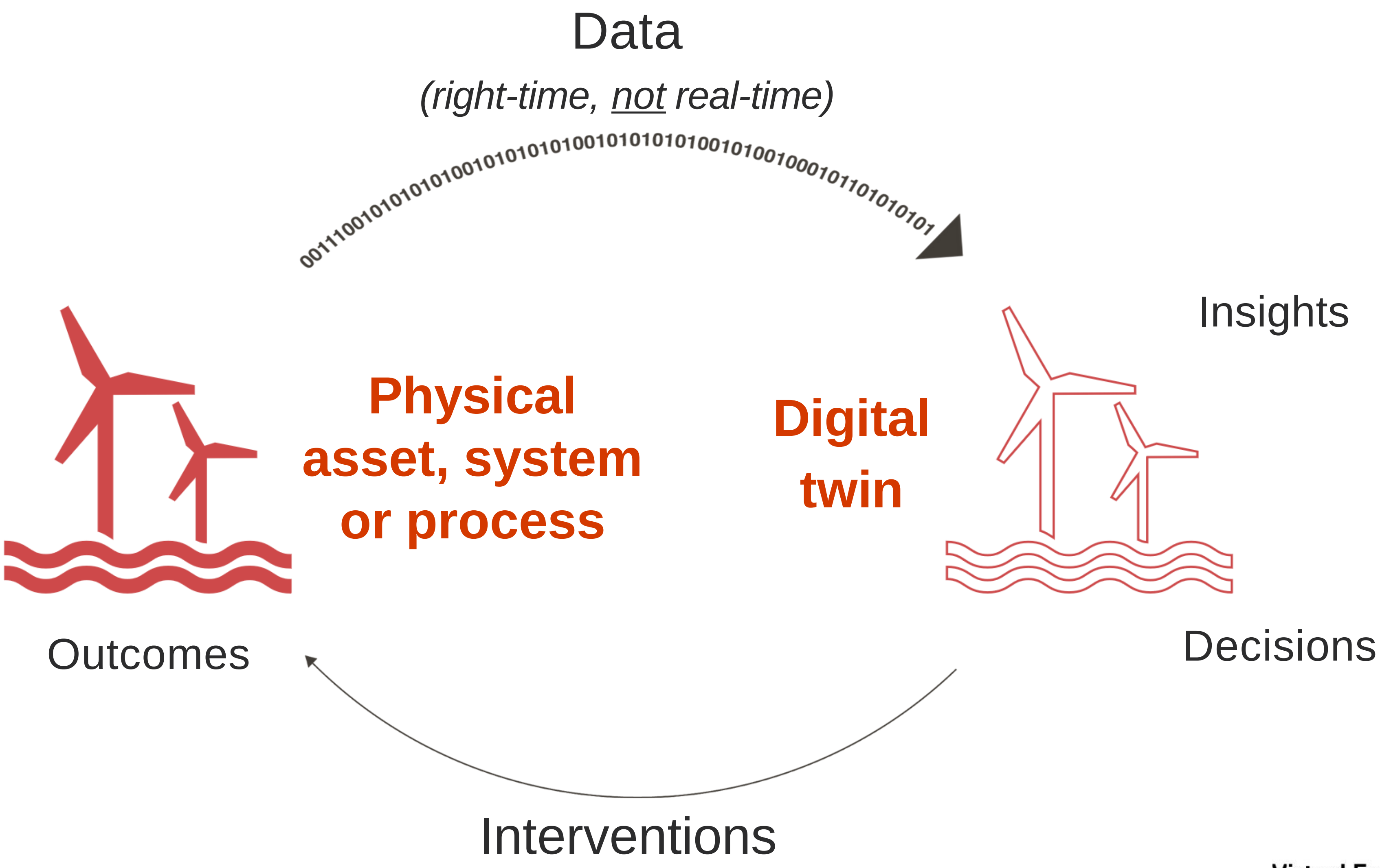
(e.g. energy optimisation, carbon reporting, investment planning, …net zero energy transition)



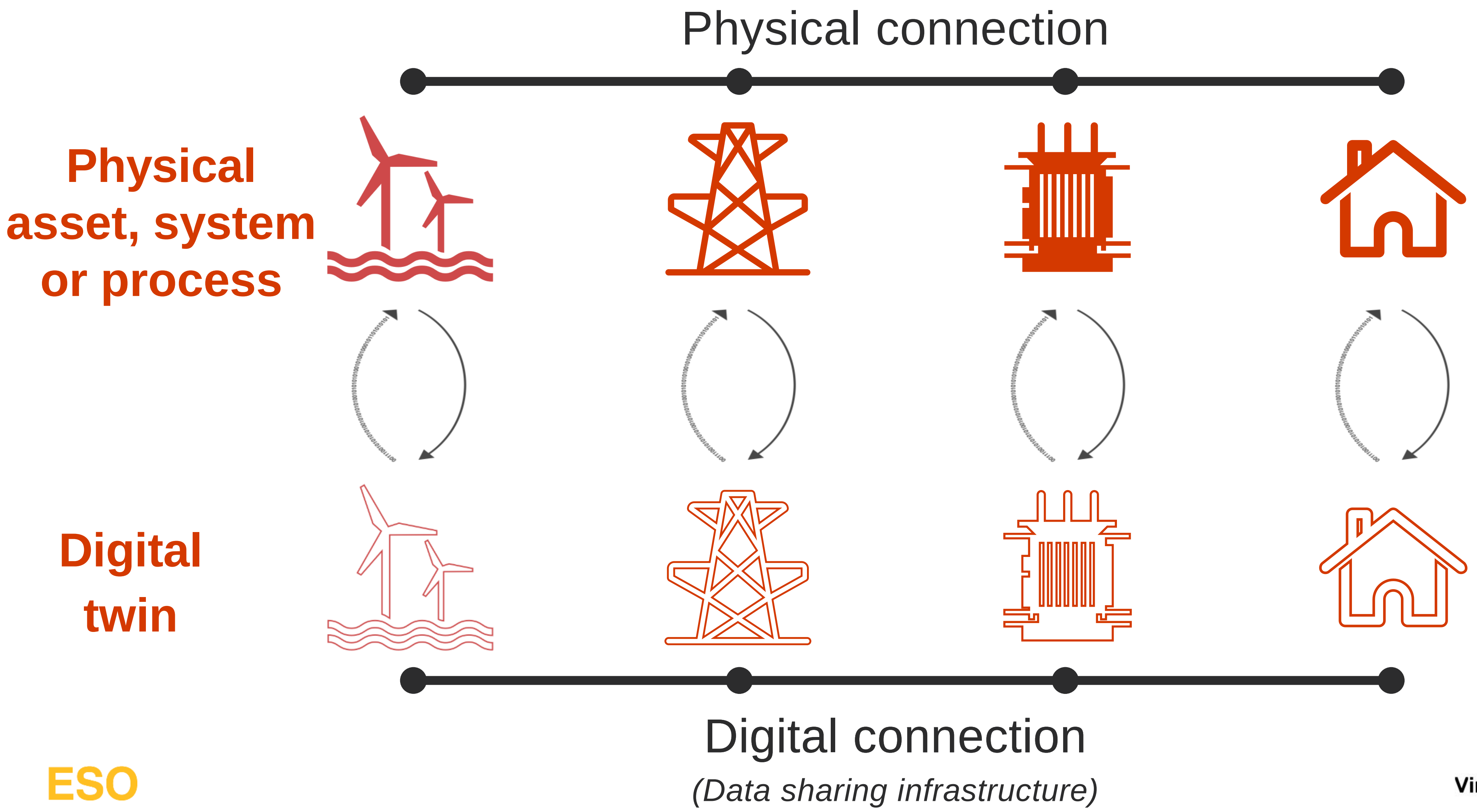
ESO

Virtual Energy System
Powered by ESO

An ecosystem of connected digital twins



An ecosystem of connected digital twins



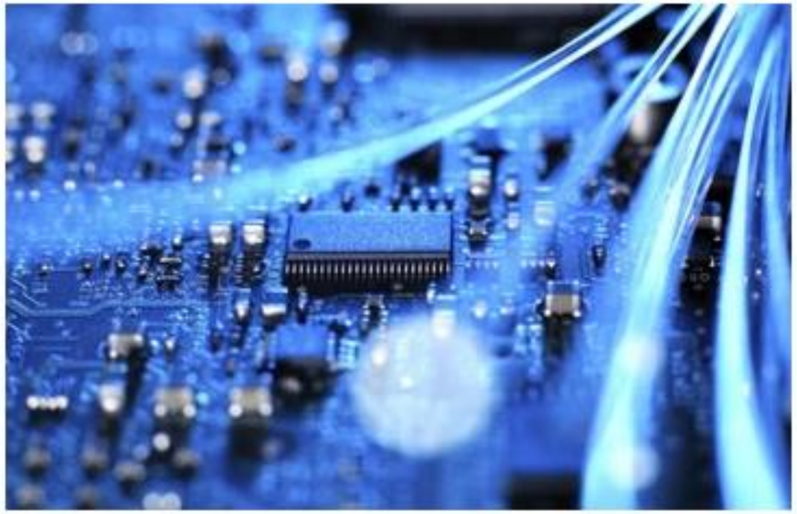
What needs to happen: a common framework

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 'tech-stack'	

Advisory groups

People & Process
(Governance and Regulation)

Responsible for:
Governance; legal frameworks; ethics & data privacy; regulation & policy recommendations; skills;



Data & Technology

Responsible for:
Data models, system specifications; cyber security; interoperability; data sharing and visibility

Use Cases

Responsible for:
Business and funding models; assessing benefits & costs; potential use case mapping; definition and prioritisation tools;

Aligning models & taxonomies

Metadata

Description of the data including sources, dates, usage restrictions

Well described data is more immediately valuable than perfectly structured standardised data – VirtualES Advisory Group Feedback

Ofgem has set out Dublin Core as requirement in Data Best Practice

Dublin Core

Energy

Description of objects and their relationships in an energy context

Ofgem has set out ‘GB CIM’ for the future of Long Term Development Statement’s from DNOs

Further work required for a gas equivalent

GB CIM (CGMES)

National

Description of objects and their relationships, including how they change over time in a cross sector context

National Digital Twin Programme has set out ‘IES4’ (Information Exchange Standard) as a cross sector standard

IES4

Increasing visibility & enabling sharing

Data spectrum

Private
Not shared, strict controls

Shared
Mix of controlled use and access

Open
Open Government Licence
Creative Commons Attribution

Trust Framework

Establishes user's confidence, right and legality, where required, to share data between parties

It will reduce friction to finding, accessing data

Compliance and assurance

Requirements of relevant legislation e.g. Utilities Act, GDPR and industry codes

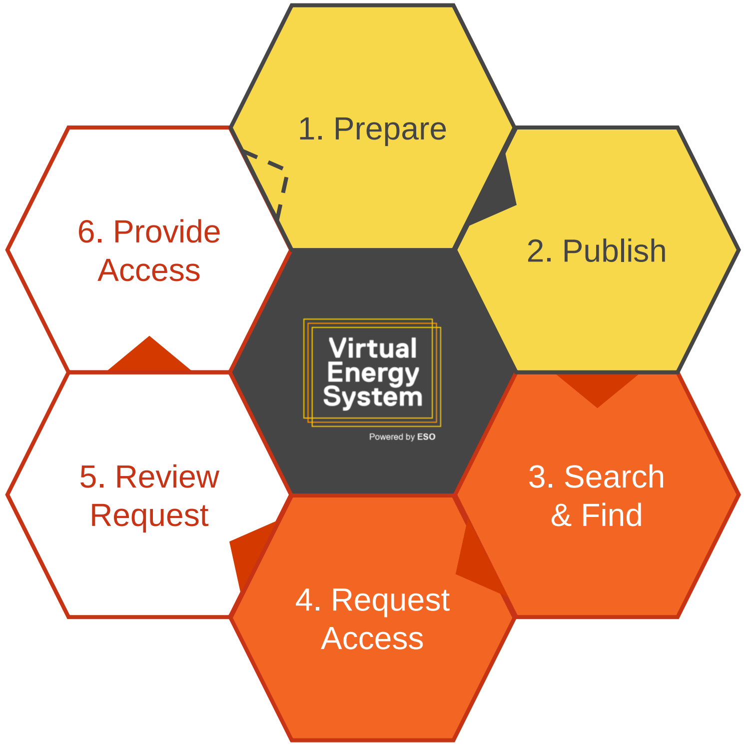
Industry agreed processes for triage and access control

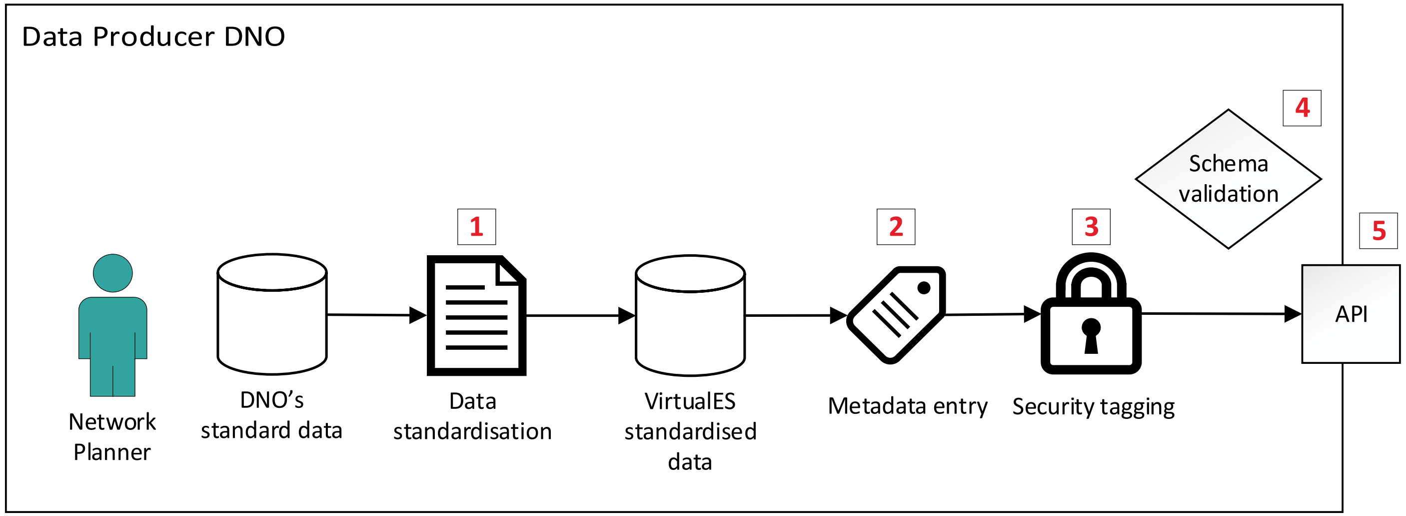
Introduce machine based system monitoring, validation and assurance

Creating an interoperable technology stack: User journey

1 – Prepare & 2 – Publish

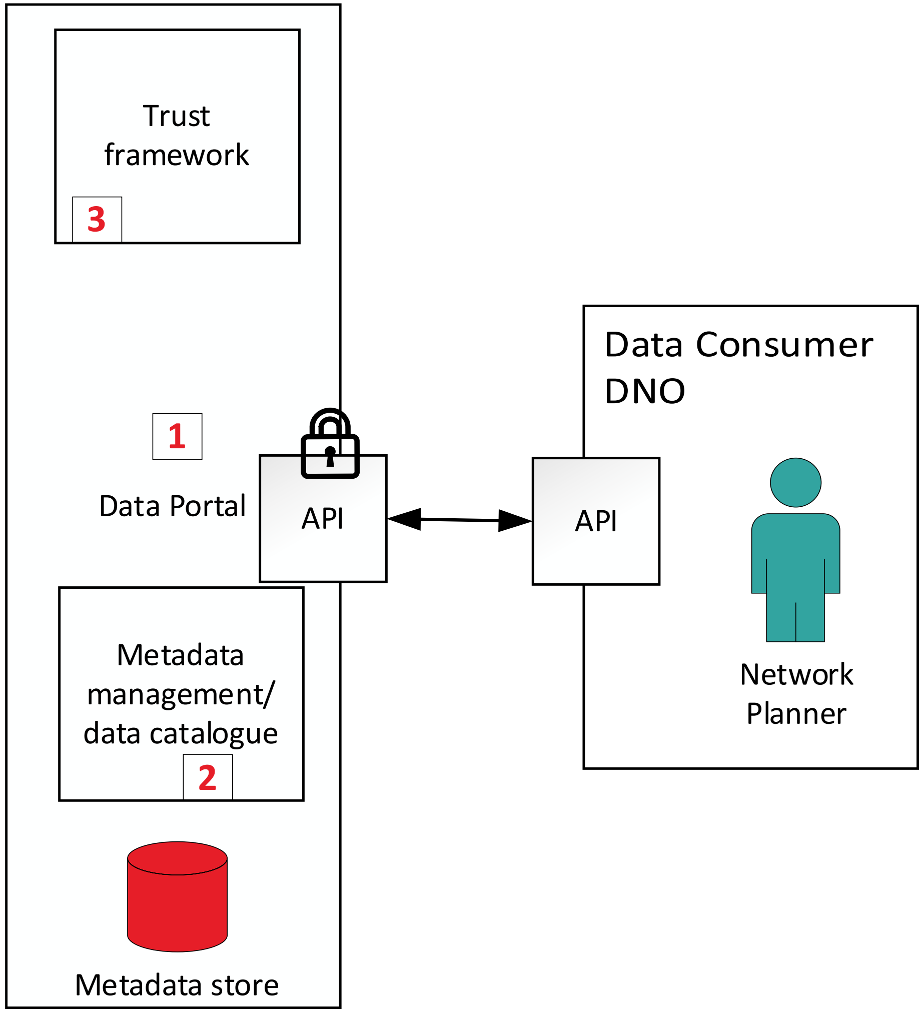
Task Lead: Data Provider





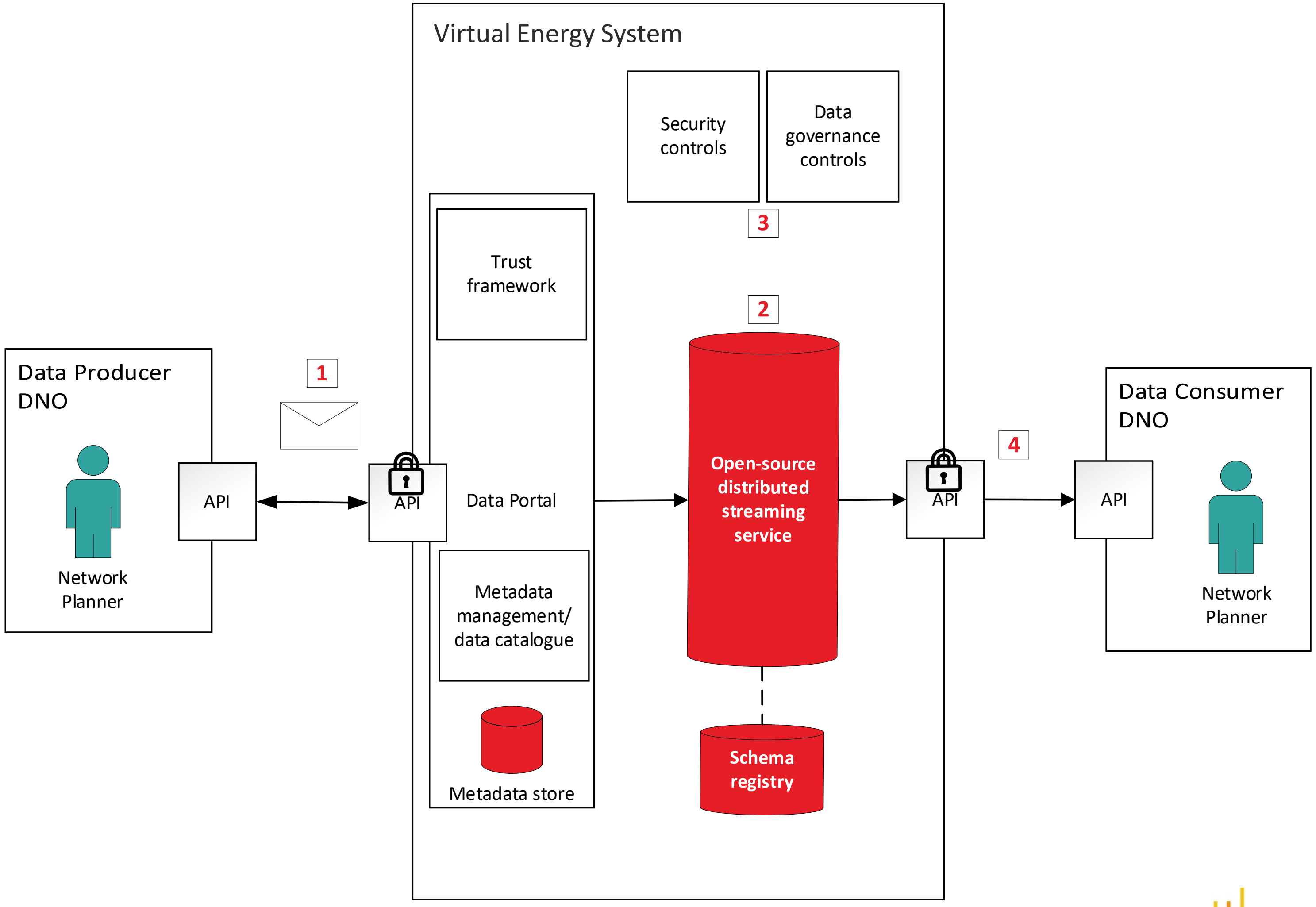
3 – Search & 4 – Request access

Task Lead: Data Consumer

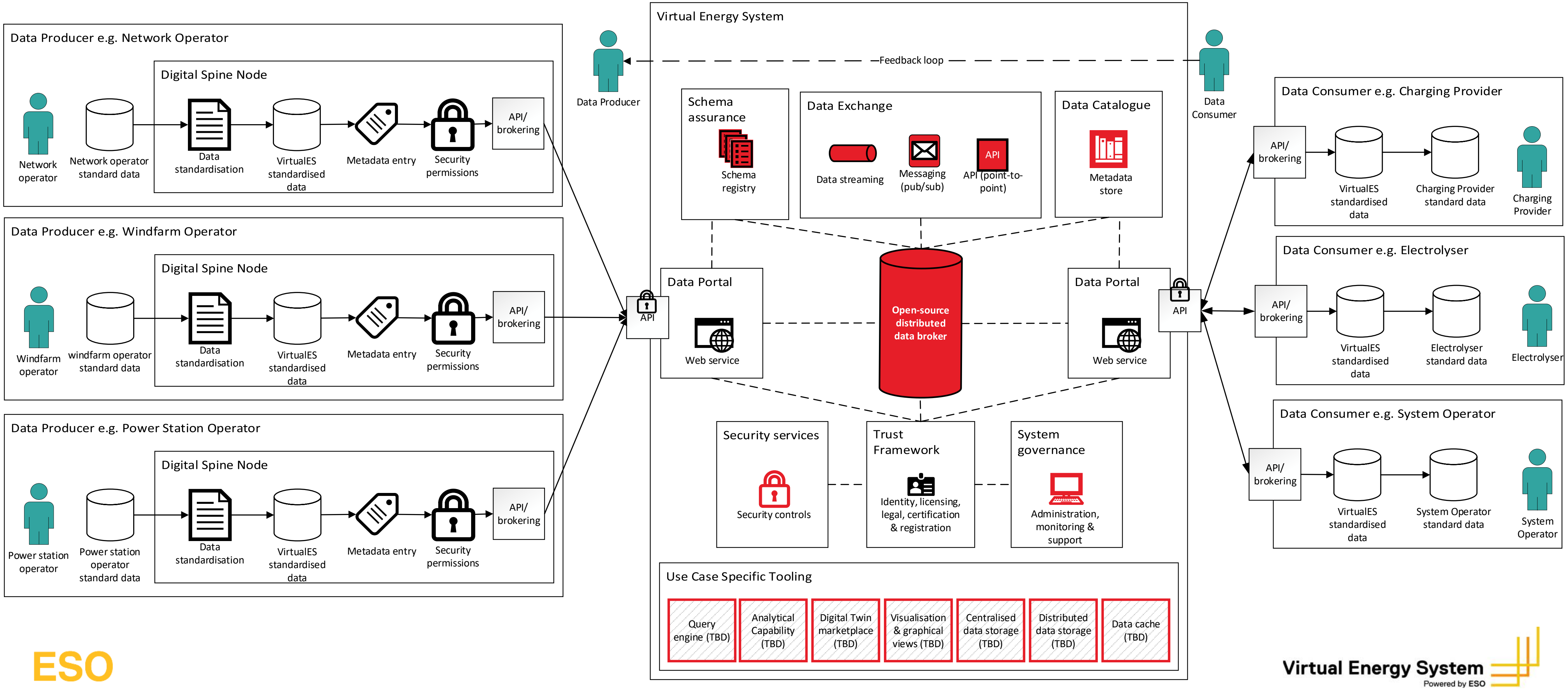


5 – Review request & 6 – Provide access

Task Lead: Data Provider



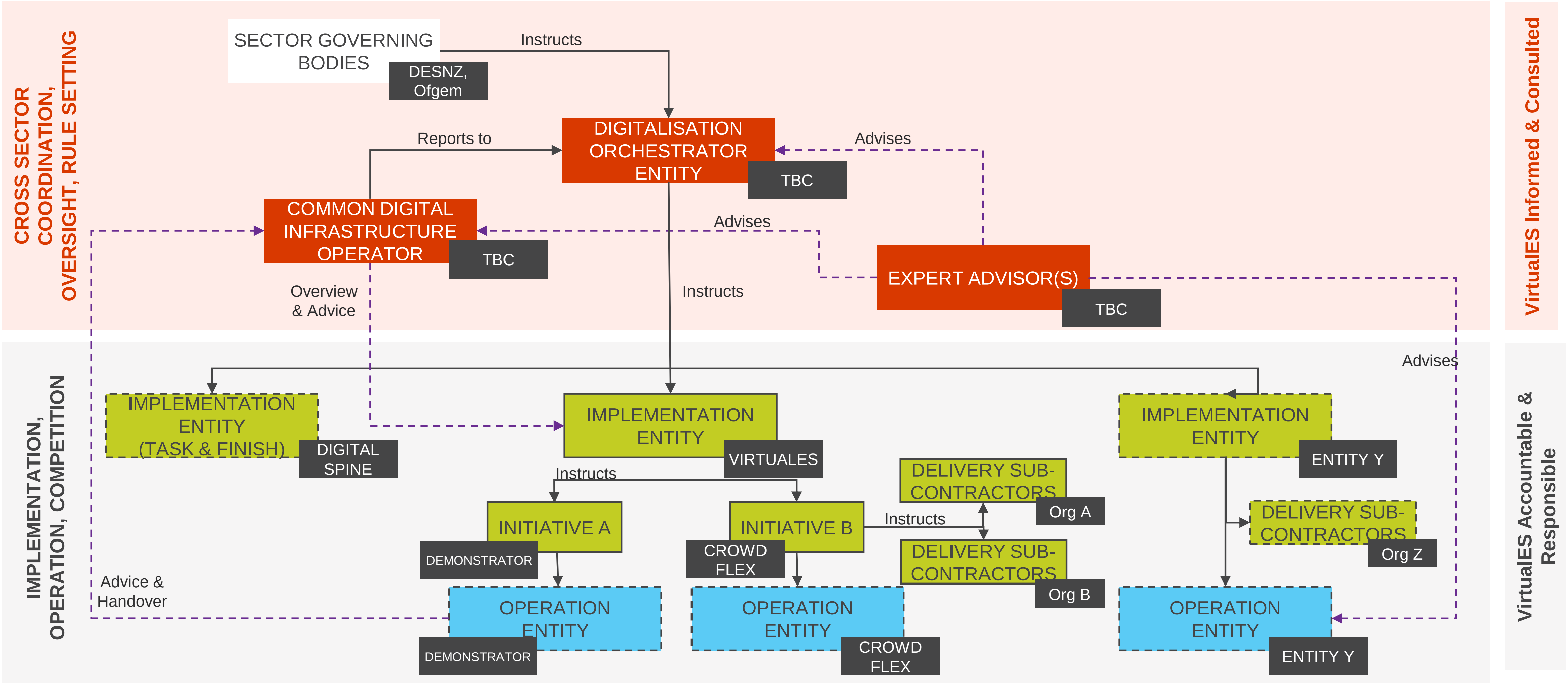
High level design



Creating a governance framework

Why we need a governance model?	Governance design principles
• Enable participation & decision making • Unclear and Overlapping governance mechanisms • Invite discussion and drive conversations with key stakeholders across the sector • Build a sense of shared endeavour	1. Transparent competition 2. Accountability 3. Stakeholder engagement 4. Responsiveness 5. Participation 6. Empowerment 7. Legitimacy

Creating a governance framework



Break

11:15 – 11:35

Open Balancing Platform Update & Roadmap

Item 7

Brendan Lyons

Programme Vision 2023 - 2025

1. Manage increased **number of market participants**

2. Quickly **adapt** to new requirements, innovation and services

3. Enable **level playing field** for new flexibility services

4. Optimise **balancing cost**

Some key areas of focus for the Balancing Programme to 2025

We will deliver a **2nd Data Centre providing enhanced resilience** to the Open Balancing Platform (OBP)

Transition of **Electronic Data Transfer /Electronic Dispatch Logging** to the OBP Strategic platform. De-risk BM failure & enabling further changes to support storage management.

Build out **cross programme integration** – e.g., Integrated Energy Management System, Single Markets Platform and Data & Analytics Platform.

Enablers to support **Non-BM in the Open Balancing Platform (OBP)** enabling Ancillary Services Dispatch Platform (ASDP) Decommission in 2025.

Enhanced storage management with **Fast Dispatch** & new **Balancing Mechanism (BM) Quick Reserve service.**

Delivery of **MW Dispatch Service** (NGED & UKPN); to allow earlier connections of assets and to manage constraints.

New **Platform for Energy Forecasting** enable ESO to update forecasting models with ever evolving energy landscape and data

Enabling delivery of **accurate and easily accessible forecasting data** to market participants through BMRA & ESO Data Portal

Decommissioning of EBS through the transition of functionality into BM

Roadmap for BP3 - 2025 and beyond elaborated, underpinned and interlocked with other programmes

Open Balancing Platform Release Plan timeline

Winter 2023

Capabilities:
1. Bulk Dispatch of Battery Zone & Small BMU Zone
2. New IT platform in one Data Centre
3. Interface to/from existing BM system

Spring 2024

Capabilities:
1. Fast Dispatch
2. Balancing Reserve
3. Interface from SCADA

Summer 2024

Capabilities:
1. BM Quick Reserve
2. Bulk Dispatch Wind BMUs
3. Interface from Single Market Platform

Autumn 2024

Capabilities:
1. Constraint Management
2. Interface to Data Analytics Platform

Winter 2024

Capabilities:
1. Interface to Ancillary Settlements
2. New storage parameters
3. OBP Strategic – second Data Centre
4. EDT/EDL mastered from OBP

Spring 2025

Capabilities:
1. NBM Instruction Types
2. NBM APIs

Summer 2025

Capabilities:
1. NBM Quick Reserve
2. BM Slow Reserve
3. NBM Slow Reserve

Autumn 2025

Capabilities:
1. Move DC/DM/DR and MW Dispatch to OBP
2. All services off ASDP

Subgroups update

Item 8

Cameron Shade

Subgroups update

- Digital and Data Strategy held 13th October
  - The Digitalisation strategy.
    - Great discussion, fantastic offers of use cases for ESO to learn from.
  - Next meeting 12th January 24.

- Control Room of the Future held 25th October
  - Deep dive on Wind BMU's
    - Discussion very helpful particularly on energy dispatch algorithms
  - Next meeting TBC

Next meeting

Item 9

Chair

Next meeting and calendar

Meetings are every quarter for a half-day on the first Friday morning of the month, 9am-12.30pm

- 1st March 2024

AOB

Item 10

Chair

Appendix A: Data & Digital Horizon Scanning Priorities for 2024

Pre-reading materials for the ESO Technology Advisory Council

Contents

Pre-reading Request

We request that the Technology Advisory Council members read the Overview section of this appendix prior to the council meeting on 1-Dec-23. The other section of this appendix is provided for your reference only – there is no expectation that council members will read this appendix in full.

Overview

Background

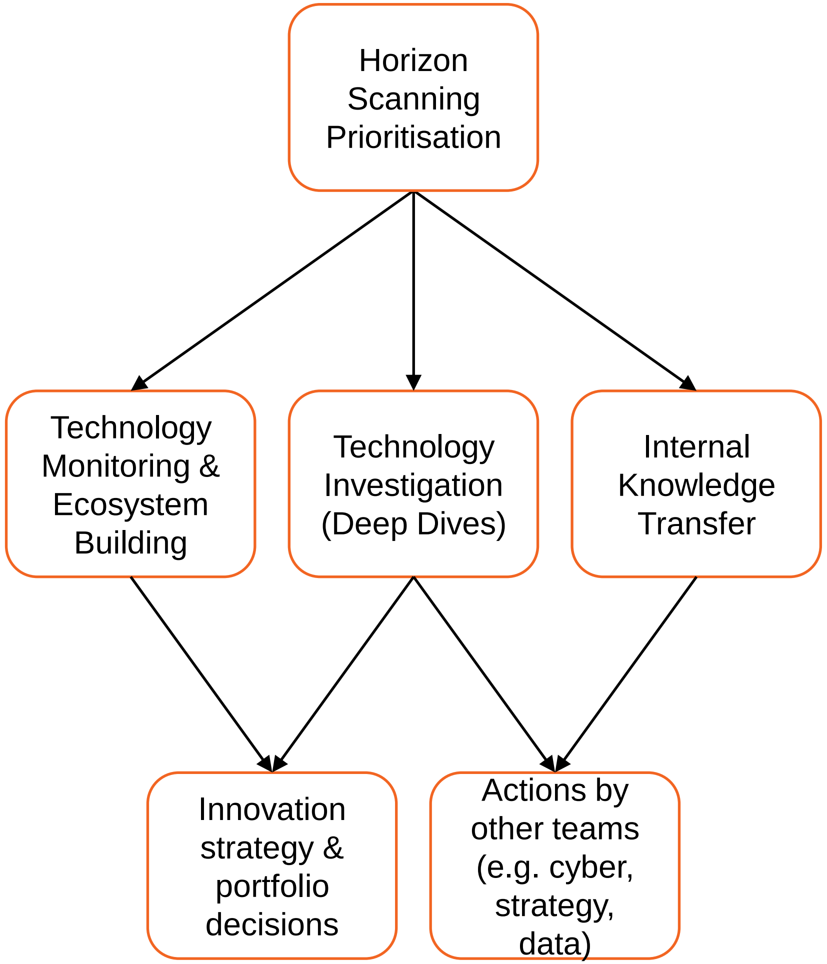
The ESO Innovation team undertakes technology horizon scanning as part of our Open Innovation strategy. Through the exchange of knowledge and ideas with external experts we identify new problems and de-risk emerging solutions. The scope of our horizon scanning extends to all technology ecosystems that could enable the UK's net zero goals, but we focus on immature and emerging technologies that are not likely to be implemented extensively within the next 3 years.

As a small team with a very large scope, we must make decisions about where to focus our horizon scanning efforts. We will run a prioritisation process each year to determine the priority technology areas where further research by our team will create the most value. Our priorities will influence our choices for:

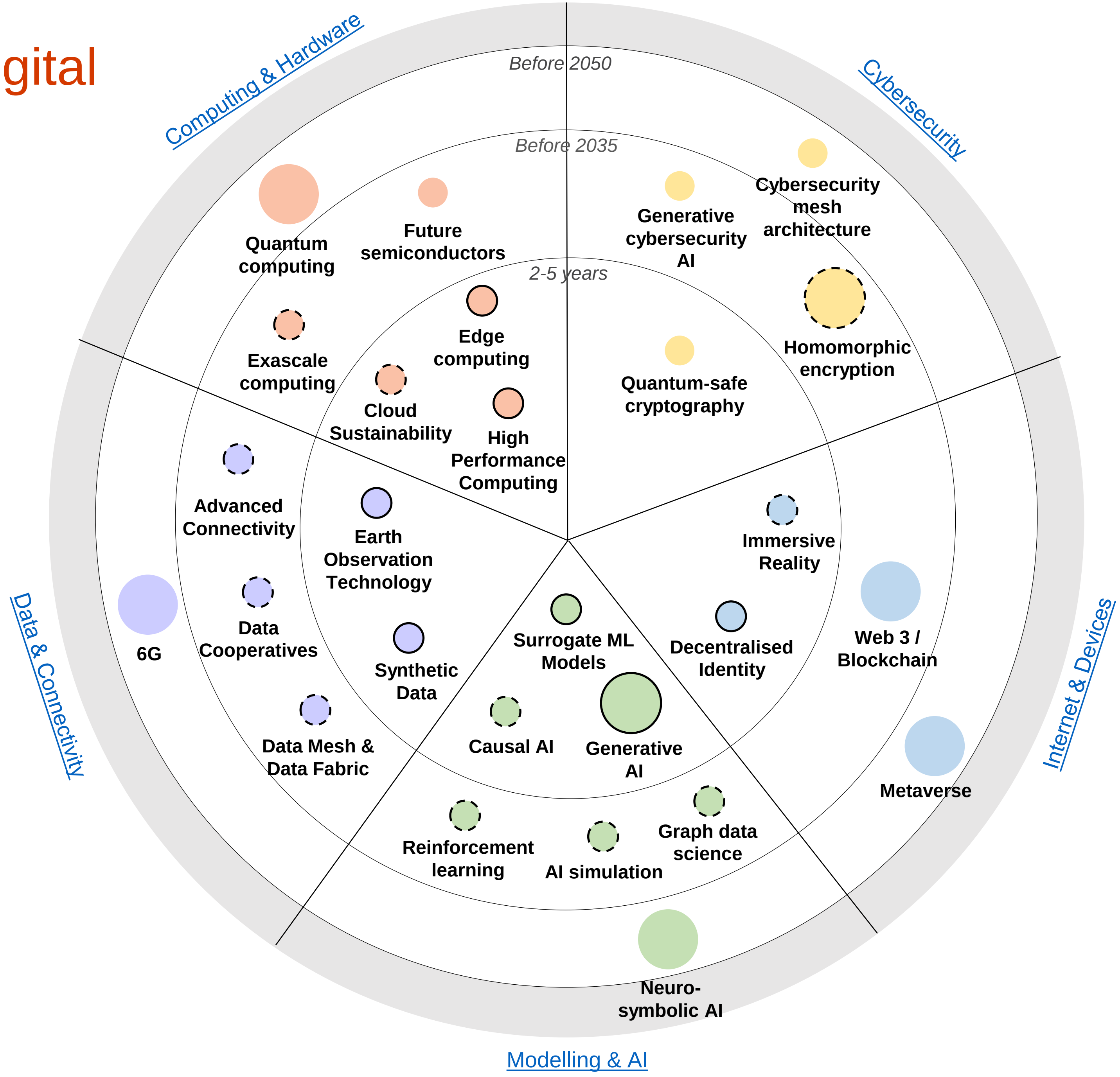
- Monitoring technology developments and building relationships with technology ecosystems
- Deeper investigations, including identifying use cases and making internal recommendations towards adoption and/or risk mitigation
- Raising internal awareness and understanding of emerging technologies

We are seeking opinions and challenge from external advisors on our draft priorities for 2024. The draft priorities have been developed through internal stakeholder engagement on our technology radars. The radars summarise the ESO Innovation team's current understanding of the potential impact, maturity, and timescales to adoption of relevant emerging technologies. Also included in this document are summaries of the radar segments, accompanied by the internal stakeholder feedback.

We have included only our Data and Digital Radar in this document. Energy technologies, including for generation, smart grids, energy storage, transport, heat and carbon capture, are also within the scope of our horizon scanning. The Energy Technologies radar has not been included in this pre-reading material, due to the ESO Technology Advisory Council's focus on guiding the ESO's data and digital transformation.



Data & Digital Radar



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Potential impact on UK Energy Sector

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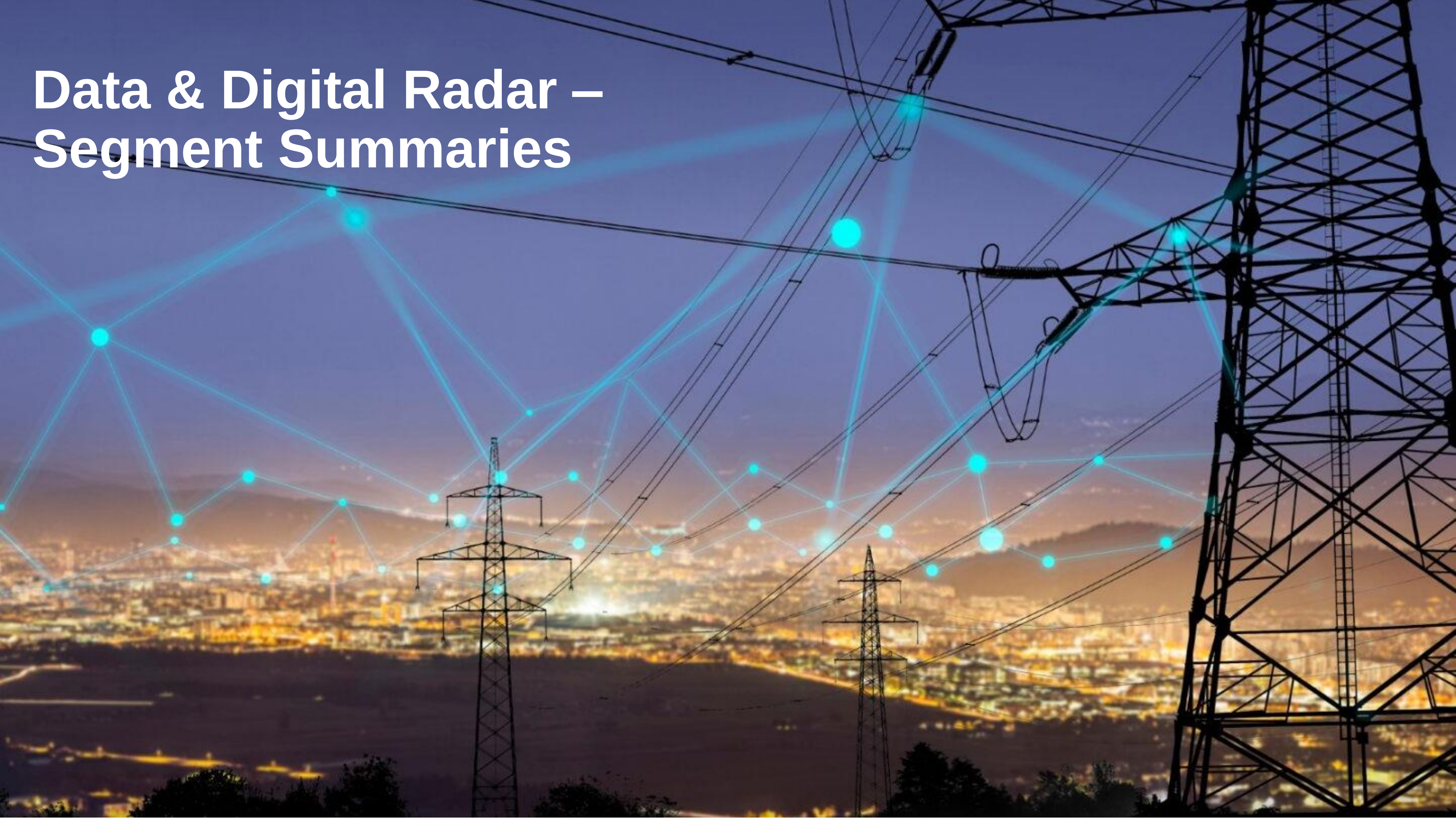
Early adoption (TRL 5-6)

Wider uptake (TRL 7-8)

Draft Data & Digital Priorities for 2024
(In order of priority)

#1 AI applications for the FSO	#2 New and emerging data sources for the FSO	#3 Enablers for data sharing across the energy sector	#4 Advanced computation impacts on the energy sector	#5 Human-machine interfaces for the FSO
• Generative AI • Enabling real-time simulation support to the Control Centre • Cybersecurity threats and opportunities	• Earth observation technologies and others providing geospatial data • Synthetic data • Sensors and IoT data	• Advanced connectivity technologies • Edge computing • Non-traditional data management and data privacy approaches	• Quantum Computing • High Performance Computing • Cloud sustainability	• Immersive reality • Aiding and advising Control Centre engineers • Training, collaboration and engagement

Data & Digital Radar – Segment Summaries



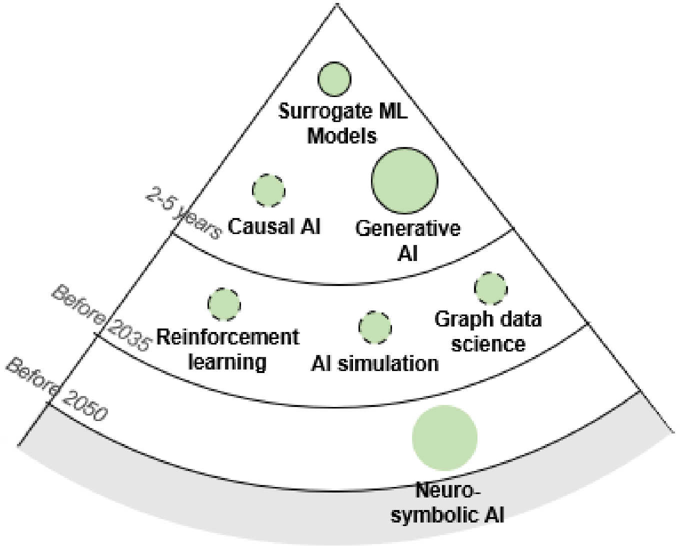
Modelling & AI

Description: The ESO uses data analytics and mathematical modelling extensively and we expect to increasingly adopt artificial intelligence technologies, including machine learning.

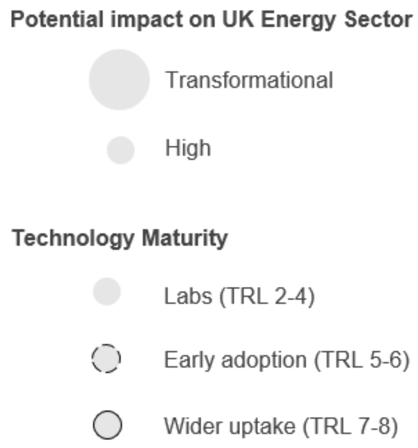
- Data analytics is the discovery and communication of meaningful patterns in data, resulting in insights.
- Mathematical modelling is the process of creating a mathematical representation of our beliefs about the world, that we can use to aid decision-making.
- Artificial Intelligence is when a machine or software performs a task that previously required human intelligence.

Feedback from ESO SMEs

- **Real-time simulation** and scenario modelling support to the Control Centre is a long-term ambition for AI in the ESO. Parallels with how Formula 1 teams use simulations during races.
- **Digital Twins** are not addressed in the radar, but many of the underlying technologies are. The ESO is already prioritising Digital Twins through the Virtual Energy System Programme.
- We'll also need to monitor **industry adoption**, particularly in 'faster than thought' decision-making roles which could impact energy system stability or cause unexpected consequences through AI interacting with each other.



Technology Area	Draft Priority	Description	Relevant applications/implications
Generative AI	High	Generative AI can create new content in various forms, such as text, video, code, and even protein sequences, based on the data it was trained on. It can be adapted to a wide range of tasks.	• Synthetic data for modelling applications • Productivity assistance (e.g. for drafting code) • Customer service applications
AI Simulation	High	The combined application of AI and simulation technologies, bringing improvements in efficiency and/or realism.	• Real-time simulation applications • Training applications
Reinforcement Learning	High	A type of ML in which the system learns from its mistakes, through positive and negative feedback with an interactive environment	• Real-time trading • Optimising design decisions
Surrogate Machine Learning Models	High	Many analyses require a large number of computer simulation runs and are therefore time-consuming. Surrogate ML models could get to the answers faster, using a ML model trained on data obtained via intelligently probing the original simulation.	• Predicting system behaviours • Optimising design decisions • Calculating risk
Graph Data Science	Medium	GDS is the application of data science techniques to graph data structures to draw insights and make predictions.	• Explore network effects that are not easily modelled with tabular data
Causal AI	Medium	An AI that can learn cause and effect relationships within data and use this to inform outputs, which are inherently explainable. Conventional ML solutions do not address causality.	• Supporting intervention and policy decisions • Addressing ethical concerns for AI such as bias
Neuro-symbolic AI	Low	The combination of ML models and symbolic systems (e.g. knowledge graphs) to create more robust and trustworthy AI.	• Address current AI limitations • Automation in operations

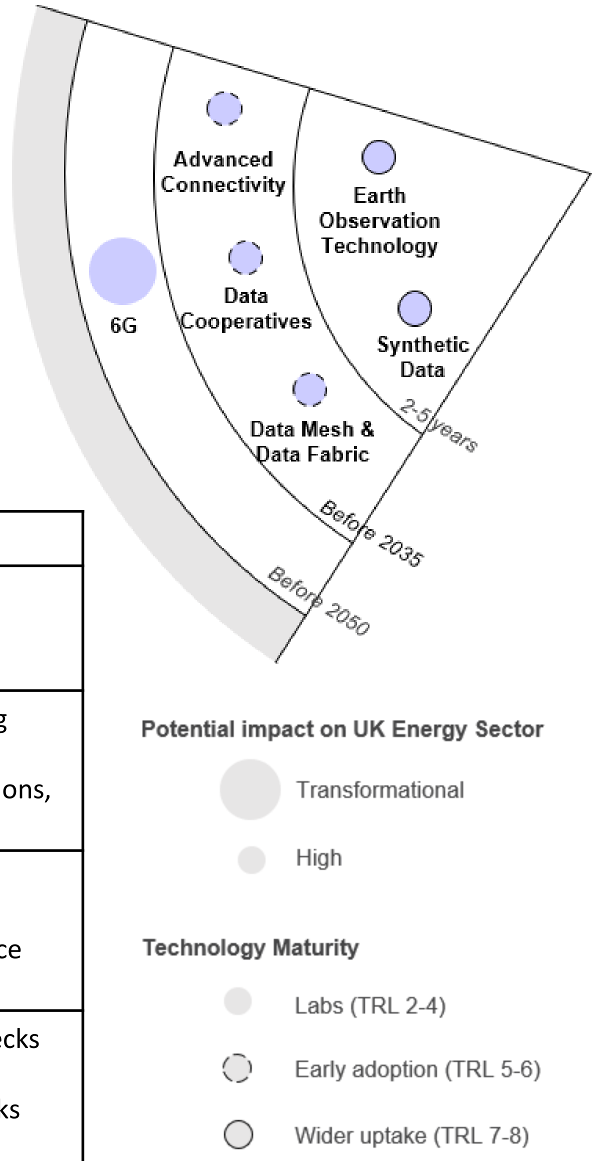


Data & Connectivity

Description: New ways of collating, processing, sharing and storing data, including advances in connectivity. The amount of data generated to support energy operations continues to grow with new sources of data coming from innovations in sensors, space technologies, IoT and synthetic data. As the scale of data continues to grow, we need to consider new architectures that may overcome some of the limitations of traditional centralised approaches to data management. Advances in connectivity promise to allow real-time sharing of data that can unlock new business models and boost automation.

Feedback from ESO SMEs

- **Data Mesh** concepts are part of the high-level design for VirtualES.
- ESO could benefit from investigation of **geospatial data** applications, with **drones** being another relevant technology.
- Increasing coverage and redundancy in channels are important reasons for investigating **advanced connectivity** technologies. Relating to our responsibilities for energy system resilience.
- To balance a decarbonising and decentralising energy system, our Control Centre has a greater need for data from industry. **Standards** are expected to be key accessing the data required and unlocking benefits from IoT devices.



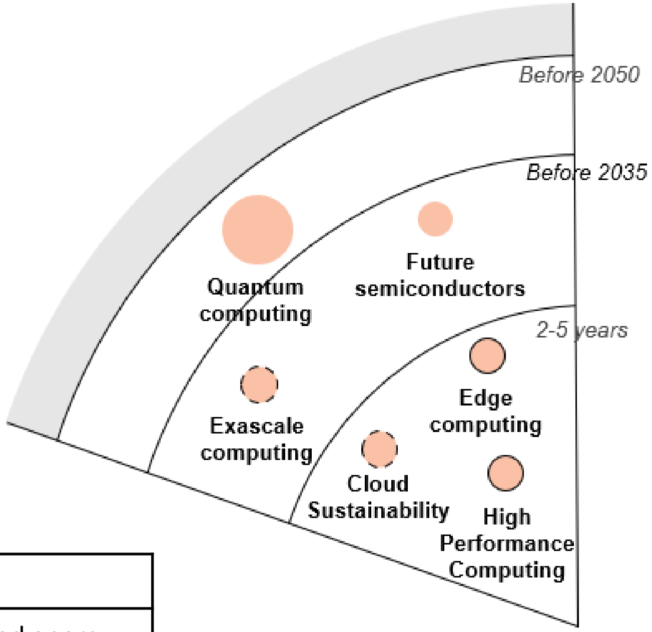
Technology Area	Draft Priority	Description	Relevant applications/implications
Earth Observation Technology	High	The use of satellite-mounted, remote sensing technologies to monitor land, marine and atmosphere. Earth imaging data is processed and analysed to extract different types of information.	• Short- and medium-term forecasts of renewables, as well as siting assessments • Asset monitoring applications
Synthetic Data	High	Artificially generated data, in contrast with real data which is directly observed from the real world. It can be a supplement or alternative to real data which can be expensive, imbalanced, unavailable or unusable due to privacy regulations.	• Better annotated data, to enhance training datasets for AI models • Enabling open innovation through hackathons, demos and prototypes
Advanced Connectivity	High	A group of maturing technologies offer opportunities for new connectivity solutions. The key technologies are low-power wide area (LPWA) networks, industrial Wif-Fi, 5G, high-altitude platform systems (HAPS) and low-earth orbit (LEO) satellites.	• Smart buildings and factories that manage energy consumption • Automation and monitoring of maintenance and engineering operations
Data Mesh & Data Fabric	Medium	New approaches to data management. In a Data Mesh individual teams manage and build their own data products in a distributed architecture. Data Fabric uses new technologies such as semantic knowledge graphs and embedded ML to optimise data management.	• Reduce operational and technical bottlenecks common to centralised data management • Automation of repetitive data pipeline tasks • Healing failed data integration attempts
Data Cooperatives	Low	A 'bottom-up' data institution for facilitating the secure sharing of data amongst participants for mutual benefit.	• Innovation in services and products • Sharing threat intelligence
6G	Low	Planned to succeed 5G and will use higher frequencies, providing higher capacity and lower latency.	Could enable the extensive deployment of sensors connected to digital twins of the physical world.

Computing & Hardware

Description: For the last 40 years improvements in computing performance have been mainly driven by Moore's Law, the prediction that the number of transistors on a chip (integrated circuit) will double every two years. This progress has enabled the creation of supercomputers with computing speeds in the petaflops and even exaflops. Thanks to cloud computing, access to supercomputing is growing and is no longer limited to government and scientific research projects. In the 2020s we are likely to reach the physical limits of Moore's law and computing advancements will require different kinds of innovation in hardware. In parallel, a new kind of computing, Quantum Computing is maturing.

Feedback from ESO SMEs

- **Organic storage** is a nascent technology which we may want to monitor or encourage our vendors to explore.
- Technologies that can bolster **modelling accuracy and/or speed** are always of interest (e.g. HPC and Quantum)
- We must take the **environmental impacts of our compute** seriously to remain a trusted voice for net zero goals.
- **Edge computing** is a mature technology but worth keeping in our radar as FSO use cases are not well explored yet. Expect to see use cases relating to Distributed Energy Resources (DERs).



Potential impact on UK Energy Sector

- Transformational
- High

Technology Maturity

- Labs (TRL 2-4)
- Early adoption (TRL 5-6)
- Wider uptake (TRL 7-8)

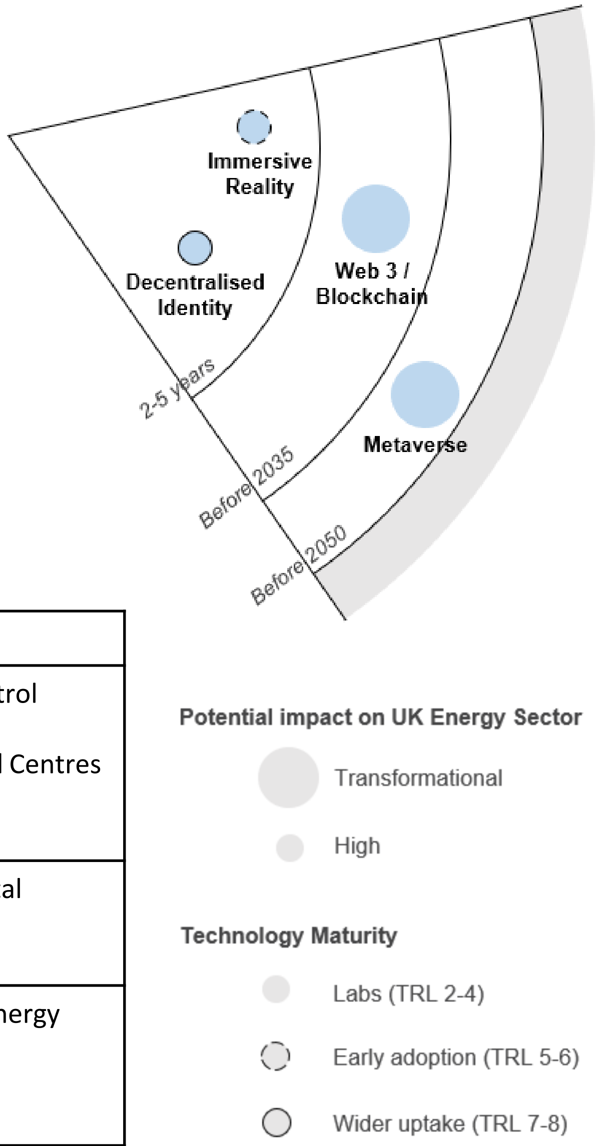
Technology Area	Draft Priority	Description	Relevant applications/implications
Quantum Computing	Medium	A new kind of computing that exploits the weird properties of subatomic particles. It has the potential to massively speed up computations for certain kinds of problems in optimisation, simulation, machine learning and cryptography.	• Large scale coordination of distributed energy resources • Long-term system planning • Large scale system simulations
Cloud Sustainability	Medium	Data centres are responsible for approximately 3% of global energy demand. Increasing pressure from customers, investors and regulators is motivating IT organisations to set sustainability goals.	• Colocation with renewables • Demand-side response • Carbon accounting
Edge Computing	Medium	Edge computing means processing data close to where it is generated i.e. at the 'edge' of a distributed computing network. The edge refers to devices used remotely (e.g. smart phones) and to connected physical assets (e.g. wind turbines, cars, smart buildings).	• Faster processing for sensor and IoT data, enabling optimisation of energy distribution • Resilience against unpredictable network disruptions and cyber threats
High Performance Computing	Medium	HPC is the use of multiple supercomputers to process complex and large calculations. HPC systems are typically more than one million times faster than the fastest laptops or servers.	• Improve climate modelling • Faster training for ML models • Real-time decisions from IoT or sensor data
Exascale Computing	Low	The largest supercomputers that currently exist.	• Granular modelling with fewer assumptions (e.g. for wind farms)
Future Semiconductors	Low	Semiconductors are vital to the manufacture of computer chips, which are manufactured via a large and disaggregated global supply chain.	• Impacts of supply chain disruption on energy sector digitalisation plans

Internet & Devices

Description: Technologies which are expected to contribute to the evolution of the World Wide Web and the changing devices that we use to access it and other digital spaces. Proponents of ‘Web3’ advocate for the rebalance of power on the web between users and online platforms through the concept of decentralisation, enabled by distributed ledger technologies. The future internet will merge physical and virtual worlds to create immersive experiences. Innovation is expected in goggles, glasses and headsets, as well as in wearables that allow us to bring touch and sound to the internet (e.g. haptic suits, gloves and patches). Body augmentation is also a growing field of research including augmented reality contact lenses and brain-computer interfaces.

Feedback from ESO SMEs

- Blockchain is just one type of **distributed ledger technology** (DLT), it would be better not to single it out in future versions of the radar.
- DLT can create huge energy demands and has regulatory hurdles.
- **High performance computing** may help to remove large computation needs as a blocker to DLT adoption.
- Screen space is a limiting factor in the Control Centre, so we expect to find opportunities for **Immersive Reality** technologies there. However, it is viewed as a gimmick at the moment by staff.
- For adoption of Immersive Reality technologies, we will need to understand the **potential health impacts** on staff.



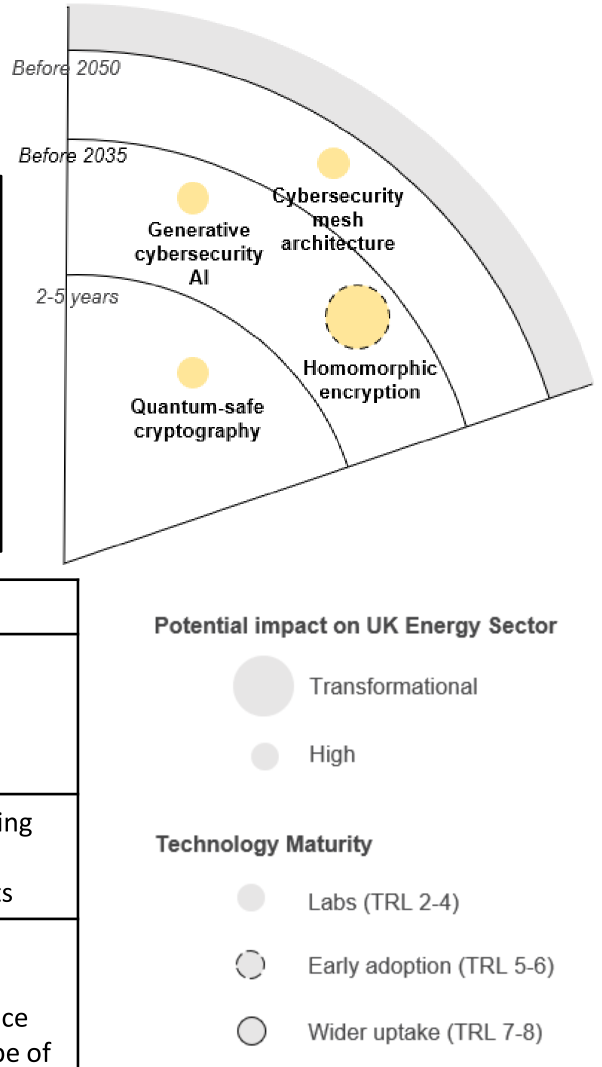
Technology Area	Draft Priority	Description	Relevant applications/implications
Immersive Reality	Medium	Technologies that use spatial computing to interpret physical space, simulate data, objects and people, and enable interaction with virtual worlds. The varying levels of immersion are referred to as augmented, virtual and mixed reality.	• Displaying information and data to Control Centre engineers • Enabling collaboration between Control Centres • Bringing Digital Twins to life • Training applications
Decentralised Identity	Low	The use of distributed ledger technologies for identify management. An identity wallet collects information from certified issuers such as user names, passwords, search history, ID numbers and buying history.	• Allows people to control their own digital identity and data privacy • Cybersecurity opportunities and risk
Web 3 / Blockchain	Low	Blockchain is a distributed ledger technology which records transactions and tracks assets, with a single view of the truth. Web3 is a proposed stack of technologies built on blockchain protocols that support the development of decentralized web applications.	• Enable participation of households in energy markets (trials in Europe) • Carbon accounting
Metaverse	Low	The metaverse refers to an evolving concept of a future internet where a combination of mixed reality, AI and real-time communications create an immersive virtual 3D world, connected to the real world. A complete metaverse will be device-independent and will not be owned by a single vendor.	• New business and social models • Remote working and collaboration solutions

Cybersecurity

Description: Organisational vulnerability to cyberthreats is growing as data and digital technologies become more integrated into day-to-day work. Additionally, cyber attacks are becoming more sophisticated and increasingly targeted at critical infrastructure. Emerging technologies in cybersecurity include algorithmic advances in encryption, the use of AI to automate or augment security operations and concepts for new security architectures that promote flexibility.

Feedback from ESO SMEs

- The cyber team are monitoring the use of **AI in cyber attacks** (e.g. for finding code vulnerabilities and for targeted phishing attacks).
- Other types of AI (besides Generative AI) have promising applications in cybersecurity e.g. **behavioural analytics**.
- There seems to be a lot of hype surrounding **Cybersecurity Mesh Architecture**, it may actually have a transformational impact on the energy system. The cyber team are investigating it.
- Technologies mentioned elsewhere in the radar can also be helpful in cybersecurity e.g. **data cooperatives** for sharing threat intelligence and **graph data science** for fraud detection.



Technology Area	Draft Priority	Description	Relevant applications/implications
Generative cybersecurity AI	Medium	The rapid growth of Gen AI has raised cybersecurity concerns, but it may also eventually become a tool to enhance security management. Generative cybersecurity AI could improve efficiency and shorten response times to cybersecurity risks and threats.	• Productivity gains in incident response and code analysis • Synthetic data for scenario-driven training • Searching for vulnerabilities and threats
Quantum-safe cryptography	Low	Large-scale quantum computers would be capable of breaking the public-key cryptosystems currently in use, such as RSA, compromising the confidentiality of communications on the Internet and elsewhere.	• 'Post-quantum' algorithms to replace existing asymmetric encryption • Hardware and infrastructure improvements
Cybersecurity mesh architecture	Low	CSMA is a decentralised and adaptive approach to cybersecurity that shifts way from traditional perimeter-based security models. In the CSMA framework, security is distributed across various end-points, devices and applications, creating a network of interconnected security nodes.	• Real-time detection and response to cyber threats, through node communications • Reduces reliance on a single point of defence and better suited to the emerging landscape of cloud computing, remote workers and IoT
Homomorphic Encryption	Low	We can encrypt data for storage and transport, but to use it we have to decrypt it, which causes vulnerabilities. Homomorphic encryption enables computations with encrypted data, so data can be analysed or manipulated without revealing it to anyone.	• Encrypted data analytics and ML • Multi-part computing • Secure against quantum computing attacks