ARUP

CATAPULT Energy Systems

PATHWAYS TO A DIGITALISED ENERGY SYSTEM BY 2035

Acknowledgements

Authors

Arlind Neziri, Arup
James Philip, Arup
Marcus Morrell, Arup
Rosamund Vose, Arup
Simon Evans, Arup

Contributors

Abbas Mahmood, Energy Networks Association
Adam Bell, Stonehaven
Alan Newbold, Arup
Alan Thomson, Arup
Andy Kervell, Arup
Andy Turner, Palantir Technologies
Ankit Patel, Arup
Beatrice Nassi, Arup
Beccie Drake, Arup
Ben Leland, Energy Systems Catapult
Caro Ames, Arup
Carolina Tortora, ESO
David Huddleston, Arup
Dave Sylvester, Arup
Eloise Thatcher, Energy Systems Catapult
Erwin Frank-Schultz, IBM
Flo Silver, Smarter Grid Solutions
Professor Furong Li, University of Bath
Gavin Starks, Icebreaker One
Greg Johnston, Energy Systems Catapult
James Edwards-Tombs, ESO
James Houlton, Amazon Web Services
Jo-Jo Hubbard, Electron
Lily Cairns Haylor, Advanced Infrastructure
Professor John Scott, University of Bath
Dr Julian Padget, University of Bath
Laura Sandys CBE, UK Government Energy Taskforces
Lucy Anderson, Arup
Professor Lewis Dale, University of Bath
Mark Enzer OBE, Mott MacDonald
Matt Webb, UK Power Networks
Professor Nigel Turvey, University of Bath
Dr Richard Dobson, Energy Systems Catapult
Sarah Hayes, Independent Consultant
Steven Gough, Arup
Tom Lowe, Thermal Storage UK
Tom Wilcock, Arup

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Foreword

Decarbonising the energy system requires people, technology, innovation, and deployment across the sector and beyond. However, to achieve this effectively, safely, securely, resiliently and fairly to deliver the substantial benefits of digitalisation, designing governance at the outset is crucial. As we have seen in other examples, retrofitting governance after the event is both painful and expensive. This paper is a timely reminder that governance is as important as the solutions we are implementing, to bring down the cost and carbon of our energy system.

Marking out the 'extremes' of how governance could be achieved, then setting out possible pathways within those boundaries, this paper brings to life the options we have to ensure the sector continues to accelerate efforts to realise a net zero energy system, and the role of industry, government, and the regulator in achieving it.

There are strategic questions around digitalisation to consider such as: who sets digital and data standards, how are energy companies held accountable and monitored against obligations, and what technology and infrastructure is still required to facilitate a decarbonised energy system. Each of these questions and more are explored in this paper, highlighting the vital importance of a system of governance to help accelerate the fantastic progress the sector has already made in digitalisation, since the Energy Data Taskforce in 2019.

Drawing out both the opportunities and challenges to 2035, the pathways explored in this paper set out options and decision points we need to consider as a sector. I'm delighted to see these topics bubbling to the surface and being discussed across the sector.

Laura Sandys CBE
Chair of the UK Government's Energy Data and Digitalisation Taskforces

Executive summary

To decarbonise the UK's power system and deliver enduring energy resilience, significantly higher levels of electricity system flexibility will be required, achieved in part through digitalisation. Good progress has been made in recent years to digitalise the energy system. However, the rate of change is not enough to achieve decarbonisation commitments and new thinking is required.

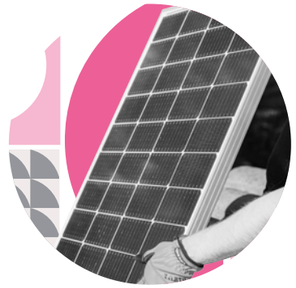
In this paper we have considered alternative pathways available to achieve a digitalised energy system by 2035, exploring between the extremes of regulatory and government driven change and industry driven change.

We have identified three plausible pathways, **"Government leads", "Industry cooperation then competition"** and **"Combined leadership and collective action"**, each with different interventions or levers to effect change, benefits and disbenefits.

We have assessed the likelihood of each pathway achieving a desirable future energy system, enabling the identification of one preferable pathway, **"Combined leadership and collective action"**. This pathway is most likely to enable the fast development of an optimised future energy system, delivering positive societal, environmental, and economic outcomes.

This paper is a call to action for greater collaboration across industry, academia, government, and the regulator. We identify some high-level actions including creating an energy sector data sharing infrastructure; collaboratively defining the governance model, and roles and responsibilities; providing clarity on interventions; and developing people and skills. In exploring the available pathways, we hope to inform meaningful conversations about the crucial roles that all stakeholders in the sector may play. This is to provide greater certainty and clarity so that next steps can be taken.

Government leads:
Government decides the rules of the game and industry plays



Combined leadership and collective action:
Regulator and industry collaborate on the rules of the game and collectively play

Industry cooperation then competition:
Industry collaborates on the rules and then competes in the game

Relative likelihood of achieving a future energy system that by 2035 is digitalised, decarbonised, decentralised and democratised

	Government leads	Combined leadership and collective action	Industry cooperation then competition
Digitalised	● ● ○	● ● ●	● ● ○
Decarbonised	● ● ○	● ● ●	● ● ○
Decentralised	● ● ○	● ● ●	● ● ●
Democratised	● ● ●	● ● ○	● ○ ○

Key benefits

Government leads	Combined leadership and collective action	Industry cooperation then competition
• Consumer centricity • Visability across the value chain • Standardisation	• Clarity on principles and development • Best practice • Outcome focussed	• Significant capital investment • Innovation ecosystem • Cross-sector thinking

Key disbenefits and challenges

Government leads	Combined leadership and collective action	Industry cooperation then competition
• Creativity and innovation • Skills and capabilities • Social acceptance	• Balancing priorities • Defining interactions • Coordination and cooperation	• Technology lock-in • Monopolisation • Focus on financial value

Introduction

In 2021 the UK government committed to decarbonise the UK's power system by 2035. This will require significantly higher levels of electricity system flexibility achieved through new assets, market structures, and digitalisation to ensure resilience across the system.

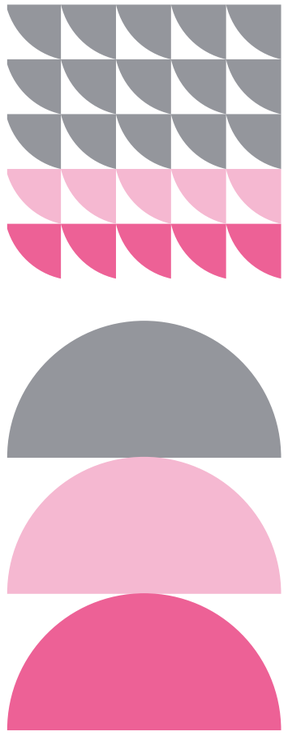
Digitalisation refers to the increasing interaction and convergence between the digital and physical worlds. It is both a social and a technical challenge, and requires consideration of people, process, data, and technology. In the energy sector, digitalisation touches a broad number of actors and disciplines across the spectrum of generation to consumption, including asset management, system operation, and consumer interaction.

Whilst good progress has been made in digitalising the energy system since the Energy Data Taskforce in 2019, our current pathway and the rate of change will not result in meeting decarbonisation commitments. New thinking is required, considering alternative pathways to realise a digitalised energy system by 2035. In this paper we have explored the range of possible pathways between the less plausible extremes of regulatory and government driven change, and industry driven change. We have identified three plausible pathways, with aspects of both regulatory and industry driven change.

For each pathway we present different combinations of interventions or levers to effect change, as well as benefits and disbenefits. We have also assessed the likelihood of each pathway achieving a desirable future energy system, one that is digitalised, decarbonised, decentralised, and democratised. These principles have enabled us to identify one pathway that is most preferable.

This paper is a call to action for greater collaboration. Collectively, industry, academia, government, and the regulator can transform the energy system and unlock its potential through digital technology and data – achieving both a digitalised and decarbonised system by 2035.

This paper is written for all sector participants, with a specific focus on leaders in industry, academia, government, and the regulator. It hopes to inform meaningful conversations about the crucial roles that all stakeholders in the sector may play.



Future energy system

We envisage a future energy system that is digitalised, decarbonised, decentralised, and democratised by 2035[1]. While the focus of this paper is on plausible pathways to a future digitalised energy system 2035, the four principles are interconnected and so it is important all are enabled in parallel.

Digitalised

There will need to be a fundamental change in the way we produce our energy as electricity demand intensifies, and transport and heat intensifies. As a growing number of assets connect to our electricity networks, and take part in an increasingly open energy market, the system will become more complex, making the activity of balancing supply with demand increasingly challenging.

Managing this heightened complexity efficiently and effectively necessitates the digitalisation of the energy system, alongside the discoverability of, and controlled access to accurate and readily usable data. Digitalisation and standardisation can support greater interoperability and the integration of energy consuming sectors. Seeing how these sectors interconnect will enable policy makers to take a whole systems approach to our energy system.

Decarbonised

The UK government has set out ambitious plans to create a net zero power system by 2035, subject to security of supply. This involves a rapid acceleration in the deployment of wind and solar capacity, storage capabilities, nuclear power, heat pumps and electrolyser capacity to produce hydrogen. Whilst there is uncertainty regarding how the electricity system will decarbonise, the pathways presented within this paper focus on governance and could enable any energy mix that emerges.

Decentralised

To achieve the UK's net zero goals, our future energy system will need to be comprised of a series of new technologies. Integrating these will require massive structural changes to the ways in which we produce, distribute, and consume electricity.

The system is moving away from centralised sources supporting a large base load, such as energy generated in thermal power stations, towards smaller and distributed generation.. A more decentralised model will provide greater flexibility to balance load demands resulting from more variable and distributed energy resources connecting to the grid. We will require specific localised understanding in energy production alongside more dynamic modelling of the energy system. These changes mean all stakeholders will need to fundamentally adapt their roles and responsibilities in the energy market.

Democratised

Better access to information and technology across the entire energy value chain, particularly in local markets, will help enable democratisation. Improved access and visibility of the whole energy system enables solution providers, consumers, and communities to become increasingly engaged in a more open energy market. In turn this supports a secure and fair energy system for the end user.

1 Electricity System Operator (ESO), 2023, ESO Innovation Strategy 2023/24 – Drivers of Change

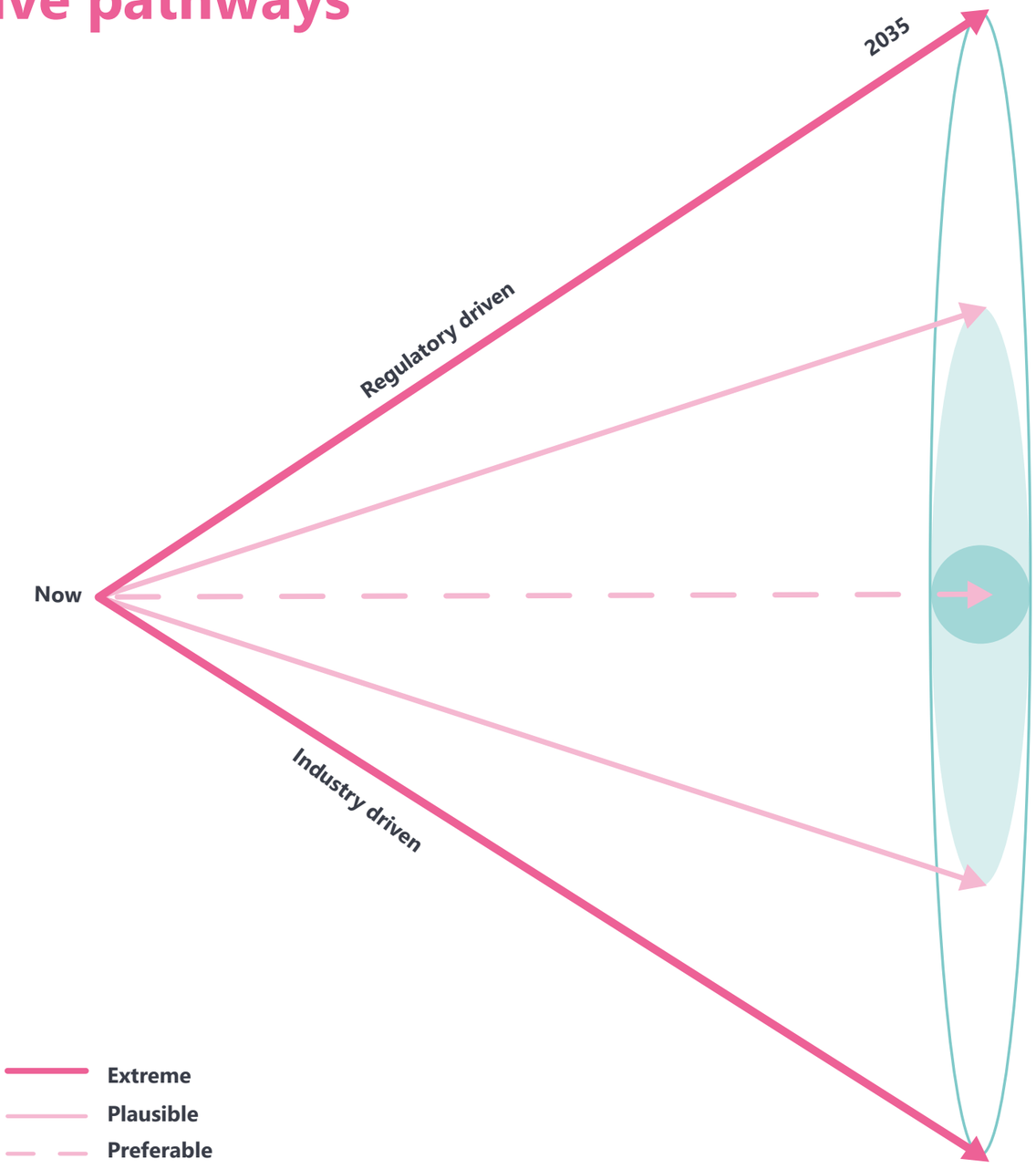
Exploring alternative pathways

A future digitalised energy system has core needs, including sustainability and data standards, Application Programming Interfaces (APIs) and a Great Britain Common Information Model (GB CIM) profile.

There are different pathways available for achieving a digitalised energy system by 2035, each with their benefits and challenges. In this paper, we have explored the range of pathways that sit between the less plausible extremes of government and regulatory-led change and industry-led change. Overleaf we summarise two extreme pathways, **"Regulator plays"** and **"Big tech joins the party"** two more plausible but sufficiently differentiated pathways, **"Government leads"**, and **"Industry cooperation then competition"** and a preferable pathway **"Combined leadership and collective action"**.

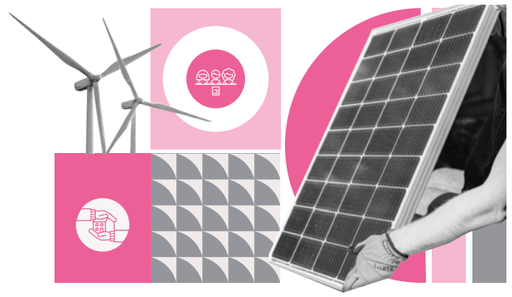
Through analysis of alternative pathways, it is evident **"Combined leadership and collective action"** is most likely to enable the fast development of an optimised future energy system, delivering positive societal, environmental, and economic outcomes. This pathway is built around sustained coordinated collaboration between the regulator, government, and industry, allowing for the division of roles, responsibilities, ownership, and management of system architecture according to strengths. This preferred pathway, reflects the decisive action and pace of change required to meet the government's 2035 decarbonisation commitment.

"Combined leadership and collective action", **"Government Leads"** and **"Industry cooperation then competition"** are described in detail later within this paper, alongside possible interventions, benefits, and challenges.



Regulator plays

Government leads



Combined leadership and collective action

Industry cooperation then competition

Big tech joins the party

Regulator plays:

Regulator decides the rules of the game and plays the game itself.

The government and the regulator opt to revoke the licenses of several network operators due to critical failures and concerns over cyber security. A precedent was set by the renationalisation of rail franchises and water companies. The nationalised network operators consolidate into one state owned network operator and become a proxy of change for much of the sector to follow. The network operator creates data standards, API's, a GB CIM profile and provides a use case for the utilisation of smart meter data. A nationalised network supports capacity building within the regulator and government departments. This improved expertise helps manage and monitor the compliance and development of the digitalised energy system via upcoming RIIO price controls.
The remaining networks opt to comply with the new standards due to fear of having their licences revoked.

The digitalised energy system achieved by 2035 is not optimal, lacking innovation and flexibility. However, it supports a net zero grid and consumer engagement.

Government leads:

Government decides the rules of the game and industry plays.

Government and the regulator collaborate with industry in developing a digitalised energy system. Government action is driven due to fears around market competitiveness, system cyber security and technology lock in. Industry, both existing plays and new entrants, desire clarity and assurances to invest in innovative and creative solutions.

Industry collaborates and supports the government and regulators to articulate clear outcomes in areas such as data standards, infrastructure, cyber security, and sustainability. There is a proactive approach to avoid technology lock-in, including competition rulings, effective licensing and RIIO price controls and monitoring.
This pathway enables the development of a coordinated and optimised digital energy system, through understanding the different capabilities of actors, the role each can play and the development of trust between the industry and the government and regulators.

The industry is allowed the freedom to innovate, and the government and its regulator enables a consumer centric energy system that features a strong level of interoperability.

Combined leadership and collective action:

Regulator and industry collaborate on the rules of the game and collectively play.

Government and the regulator collaborate with industry in developing a digitalised energy system. Government action is driven due to fears around market competitiveness, system cyber security and technology lock in. Industry, both existing plays and new entrants, desire clarity and assurances to invest in innovative and creative solutions. Industry collaborates and supports the government and regulators to articulate clear outcomes in areas such as data standards, infrastructure, cyber security, and sustainability. Collectively an approach is estabilised to avoid technology lock-in, including competition rulings, effective licensing and RIIO price controls and monitoring. This pathway enables the development of a coordinated and optimised digital energy system, through understanding the different capabilities of actors, the role each can play and the development of trust between the industry and the government and regulators.

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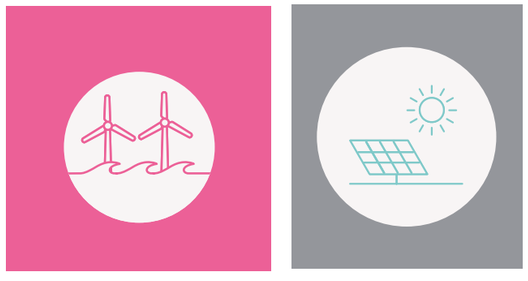


Industry cooperation then competition:

Industry collaborates on the rules and then competes in the game.

Government and the regulator indicate their willingness to pursue a non-prescriptive regulatory approach on digitalising the energy system. This is driven by a lack of specialist knowledge and competing priorities in government. Industry is allowed to collaborate on the rules, before competing again.
While not all market actors are onboard, a critical mass collaborate to achieve a consensus on arrangements such as APIs, a GB CIM profile, data and sharing standards, monitoring, and other information models. Collaboration and building consensus makes the development of the digitalised energy system much slower.

A small number of highly innovative firms become increasingly protectionist and dominate the direction of travel, with less agile players struggling to compete. Innovation and development of the system is unbalanced, due to the sector's focus on commercial gain.

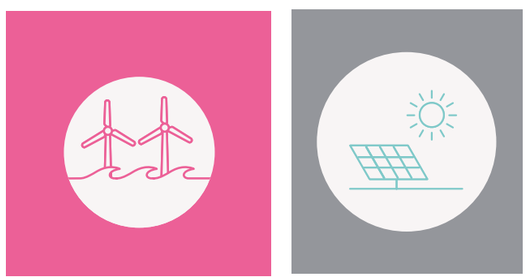
A fragmented landscape for operators and consumers emerges. Interoperability is limited, and the sector fails to utilise all the opportunities that arise from a digitalised energy system.

Big tech joins the party:

Big tech decides the rules of the game and monopolises the game.

A lack of government intervention and direction creates opportunities for big consumer technology firms to enter the industry. They see a digitalised energy system as a key part of increasing their IoT offering of consumer smart home devices, appliances, and systems, or industry smart networks and assets.
These companies develop and provide both the system architecture and technology to digitalise the energy system. This includes connecting network and system operators to smart meters, which integrate with the big tech companies' existing home offerings. There is integration of energy data to their range of batteries, car chargers and higher consumption devices.
This all strengthens their product offering and prioritises revenue and profit. In the future, elements such as home controllers for heat pumps and solar panels could all be added to big tech offerings.

This approach allows for the rapid digitalisation of the sector and creates greater consumer engagement. It comes at the cost of a fragmented and siloed ecosystem, with consumers increasingly tied to specific providers and switching proving difficult.



GOVERNMENT LEADS

Government decides the rules of the game and industry plays

The government takes the lead in driving the development of a digitalised energy system. This is due to the perception that the industry is lacking urgency and is risk adverse, as was seen with the slow rollout of smart meters. Government is keen to be seen as acting in the public interest in the face of growing criticism and scrutiny of other privatised sectors. The government acts unilaterally and with minimal consultation in defining the system structure. This includes data and sharing standards, APIs, a GB CIM profile, cyber security, and sustainability standards. This creates the core foundation of a digital spine and the wider data sharing infrastructure. Standards are enforced via license conditions, requiring networks and operators to present digital transformation plans in their RIIO price control submissions.

Proprietary solutions are allowed if they do not increase the risk of technological lock-in and can work seamlessly with the digitalised energy system. Solutions must also be interoperable with other networks. This can be achieved via a base level interoperability test or demonstrator, which is yet to be developed, or a socio-technical framework, currently under development by the Virtual Energy System (a programme enabling the creation of an ecosystem of connected digital twins of the entire GB energy system). This pathway provides certainty for market investment and results in a consumer-first digitalised energy system. It also supports new technology adoption and ensures the system is flexible and responsive to demand. However, drawbacks include industry being restricted in its scope to develop creative, innovative solutions. A lack of consultation limits industry buy-in and they develop to the minimum standards. In addition, the regulator and government are both limited in internal digital expertise, requiring hiring consultants or attracting talent from competing sectors. Finally, this approach requires a lot of political capital and could be slow if the regulator lacks the ability and authority to legislate at an appropriate pace.

Interventions

The following interventions or levers are likely in this pathway.

Key:

- **Collaboration and Integration**
- **Policy and Regulation**
- **Capabilities and Leadership**
- **Governance and Standards**
- **Technology and Infrastructure**

Short Term 2023 - 2025

- Government and regulator enable streamlined access and utilisation of smart meter data.
- Government defines GB API Interfaces and CIM standardisation.
- Government and regulator move rapidly on competition laws.
- Standards for data and metadata, and sharing are implemented as key parts of price control and licensing conditions.
- Government and regulator define the structure and governance of the data sharing infrastructure.
- Government and regulator provide clarity on best practice, visibility of assets and their performance.
- DESNZ and Ofgem focus on building internal capacity and capability.
- Government provides standardisation of cyber security standards.
- Implementation of sustainability standards relating to energy smart appliances.
- Government defines accountability arrangements, for example for monitoring, standards and implementation.
- SCADA and (near) real time monitoring implemented.
- Continuation of smart meters rollout.

Medium Term 2026 - 2030

- Creation of a single flexibility market across a variety of time frames for technology.
- Government defines who monitors compliance to data standards, APIs standards and data sharing.
- Price controls - RIIO increases data sharing infrastructure and digitalisation license conditions, and focuses on delivering net zero carbon targets.
- Governance and capabilities established to ensure laws and regulation are being followed.
- Further quasi - legislation supporting standardisation and interoperability implemented.
- New subsidies introduced for ongoing renewables, capacity development and integration.

Long Term 2031 - 2035

- Greater access to consumer data enabled, informing forecasting and facilitating prosumers.

Benefits

Consumer centricity
Government and regulators are focused on balancing the delivery of "direct" energy benefits for consumers with more broader consumer value, sometimes even beyond their mandate. A digitalised energy system developed with the regulator taking the lead should result in a system that is fair, equitable, avoids technology lock-in and provides genuine choice for the consumer.

Visibility across the value chain
A digitalised energy system enables increased visibility of assets, performance, and behaviour across the value chain. This enables more granular assessments of assets and their potential uses, enhanced coordination, and collaboration between multiple actors, alongside supporting both system stability and efficiency gains. Greater visibility across the value chain, particularly in data, provides an environment that supports long term investment, and new entrants into the market.

Standardisation
A regulatory driven pathway is likely to see high levels of standardisation, such as in data, data-sharing and APIs. Privacy and sustainability allow for the interoperability of assets across the whole value chain, from consumers to network operators and generators.

Risk management
Data transparency and openness allows for risk to be better managed through official channels. This also helps reduce the risk for new entrants into the sector, as there is increased visibility of the actions and capabilities of other actors.

Better asset deployment
Greater visibility of infrastructure, assets, and their operation across the value chain should result in the more precise deployment of assets and smart technologies.

These can be based on future needs for a specific time and location. It will open markets to a wider range of assets, business models and competition from potentially both large and small actors. This improves price discovery and layering time, location, and service values at both national and local levels.

Asset performance and management
Improved data gathering, quality and sharing, will allow for the more effective asset management. This includes fault prediction, optimised maintenance schedules which simultaneously extends asset lifespan and reduces costs.

Sharing asset performance data between organisations can create even more synergies and benefits and present a future business model opportunity.

Speed
A government and regulator acting unilaterally, removing a significant number of actors in the decision-making process, should allow for greater speed in implementing change and realising the benefits of interventions. This can be dependent on how accepting of interventions both the industry and consumers are.

Disbenefits and challenges

Creativity and innovation
A restrictive approach from regulators could limit the potential of industry-led innovation, from within the sector or actors outside the sector, or creation of new technologies which may be overlooked by the regulator. Development and implementation of these could be inhibited due to a lack of industry buy-in, where more expertise may reside. This could ultimately result in a suboptimal solution, where firms in the sector feel excluded, and the sector is in effect renationalised.

Skills and capabilities
Both the regulator and government have limited digital and engineering capabilities, which are required to design and implement a digitalised energy system. Significant capability development will be required, either organically through new hires, training, and up-skilling, or externally through consultants. Both approaches take significant amounts of time and investment.

Regulatory incoherence
Regulation needs to be coherent and adaptive to respond to market and technological changes. Regulatory incoherence and lack of clarity, governance, capabilities or connected thinking can all stifle investment, innovation, and ultimately the development of a digitalised energy system.

Political change
A government and regulator driven pathway is highly sensitive to the political cycle. This can encourage short-term thinking with proposals only looking to the next election or a new administration may undertake a different approach. This can create uncertainty for long-term investment plans or direction of policy. These are crucial assurances needed to encourage industry to commit, invest and innovate.

Societal acceptance
Actors in the market and some members of society may not accept government intervention. New regulations will be ineffective unless they are followed and policed to ensure compliance.

INDUSTRY COOPERATION THEN COMPETITION

Industry collaborates on the rules of the game and then competes in the game

The government and its regulator take a non-prescriptive approach in developing a digitalised energy system. This is driven by urgency, a lack of capability and signs of progress in a sector keen to avoid the criticism faced by water and transport. A lack of initial government direction slows the process of achieving standardisation and a definition of the energy system. The sector goes through an initial competitive period where actors pursue their own solutions and standards. Gradually, it is understood that collaboration on the "rules of the game" is needed to unlock the growing opportunity for commercial gain that a digitalised energy system can offer to all parties. Further incentive comes from the growing prospect of regulator intervention on standardisation and interoperability. This is paired with increasing consumer complaints about the lack of progress, as new technologies they have invested in cannot be used to their full potential.

Open-banking reforms in the UK and New Zealand, and the commercial opportunities that this presents around the deployment of new products and services in the banking sector, are used as case studies, and a key motivator for collaborating on change in the energy system. Not all market participants are onboard with collaborating, but a critical mass are. They achieve a consensus among themselves on arrangements such as data standards, technology, monitoring, and information models.

This pathway is slower in realising a digitalised energy system but allows for continuous improvement and innovation. A number of highly innovative firms dominate the direction of travel, leaving smaller or less agile players struggling to keep up. System innovation is narrow in focus, with potential commercial gain being the primary driver in targeting investment. This drives technology lock-in for areas which are developed beyond agreed upon standards. This results in a fragmented landscape, with interoperability limited and an energy system progresses at different speeds and failing to take advantage of the opportunities that digitalisation brings.

Interventions

The following interventions or levers are likely in this pathway.

Short Term 2023 - 2025

- CIM GB standard is agreed for electricity and gas.
- Industry agrees data standards on data sharing, metadata, governance, and APIs, and the structure of the data sharing infrastructure.
- Lobbying of regulators for clarity and support.
- Principle-based regulation from government, giving industry freedom to come up with innovative and creative solutions.
- Minimum level of capability implemented across all DNOs/TSOs which enables an interoperable digitalised future energy system.
- Re-skilling employees in areas of greatest commercial benefit.
- Industry-led taskforce established to identify what best practice looks like.
- Mechanisms and policies to support better data sharing between industry partners.
- Business change including industry processes, systems and governance.
- SCADA and (near) real time monitoring implemented to lower-level network devices using new/emerging technologies, enabling greater visibility and linking network topology data to retail markets data.
- Continuation of smart meters rollout.

Medium Term 2026 - 2030

- Creation of multiple, interoperable remote flexibility markets.
- Increased number of system integrators emerge to overcome interoperability challenges.
- Implementation of target operating model and pilot scale studies, moving away from theory, towards design, demonstration, and implementation.
- Model sharing agreed between providers for data sharing for specific purposes, beyond the regulatory minimum.

Long Term 2031 - 2035

- Government intervenes to limit the power and influence of energy monopolies to promote fair competition and innovation.
- Continuous long-term investment in skills and the development of people.
- Decentralisation undertaken whilst still ensuring coordination.

Key:

- Collaboration and Integration
- Policy and Regulation
- Capabilities and Leadership
- Governance and Standards
- Technology and Infrastructure

Benefits

Capital investment
Industry has significant capital to spend and ability to drive change where the opportunity of commercial gains exist. As the primary focus is revenue, spending is likely to be more efficient and targeted with them opting for investments that provide the biggest impact and return. However, this can be to the detriment of opportunities which yield benefits other than economic gain.

Innovation ecosystem
A non-prescriptive approach from government provides firms in the industry creative freedom when pursuing technological solutions. This is likely to result in high levels of innovation as firms compete for commercial success.

A similar ecosystem was developed in banking with the emergence of the 'FinTech' sector. This was as a result of the Open Banking legislation, with new entrants increasing pressure on incumbents to innovate their offerings.

Cross-sector thinking
The entry of large technology firms, with experience across energy and a wide variety of sectors, not only brings technological expertise, but also the prospect of different ways of thinking from other sectors. This helps to challenge the status quo, and pressures the sector to rethink current workflows and approaches.

Data ownership and sharing
The industry currently generates significant volumes of data, with valuable insights derived from this. The alignment of industry interests, and subsequent industry buy-in, could present an opportunity for improved data sharing and utilisation of the right information at the right time.

The creation of a common reference system, such as an industry developed CIM, could support the sharing of data between both firms and system models. This helps drive data standardisation and interoperability.

Collaboration across the value chain
Projects such as the Virtual Energy System are demonstrating the key benefits that interoperability and data sharing can bring to the whole energy system.

Similar approaches could allow for advancements in cost-effective strategies for locating variable renewables supply points, the use of gas fired peaking plants for grid balancing, the creation of new energy storage and approaches to support network reinforcement.

Disbenefits and challenges

Lack of interoperability
If standards are not agreed quickly, there is a significant risk of technology lock-in. Firms will pursue their own solutions with differing data standards and technologies.

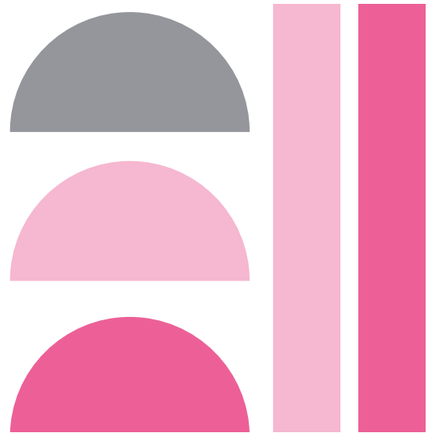
This could limit interoperability and the full potential of a digitalised energy system, and the value it could create. In addition, a lack of coordination could result in disparities in data standards such as their completeness, consistency, accuracy, and timeliness. This would impact the potential service offerings to consumers and the level of interoperability across the energy system.

Monopolisation
There is a risk of a small number of highly innovative firms dominating the market, with smaller or less agile players struggling to keep up. With their growing power, these firms could increasingly pursue development paths that result in technological lock-in. This makes the market less competitive and will increasingly force out smaller firms. Such a divergence between firms is likely to see geographical disparities emerge in the energy system services available.

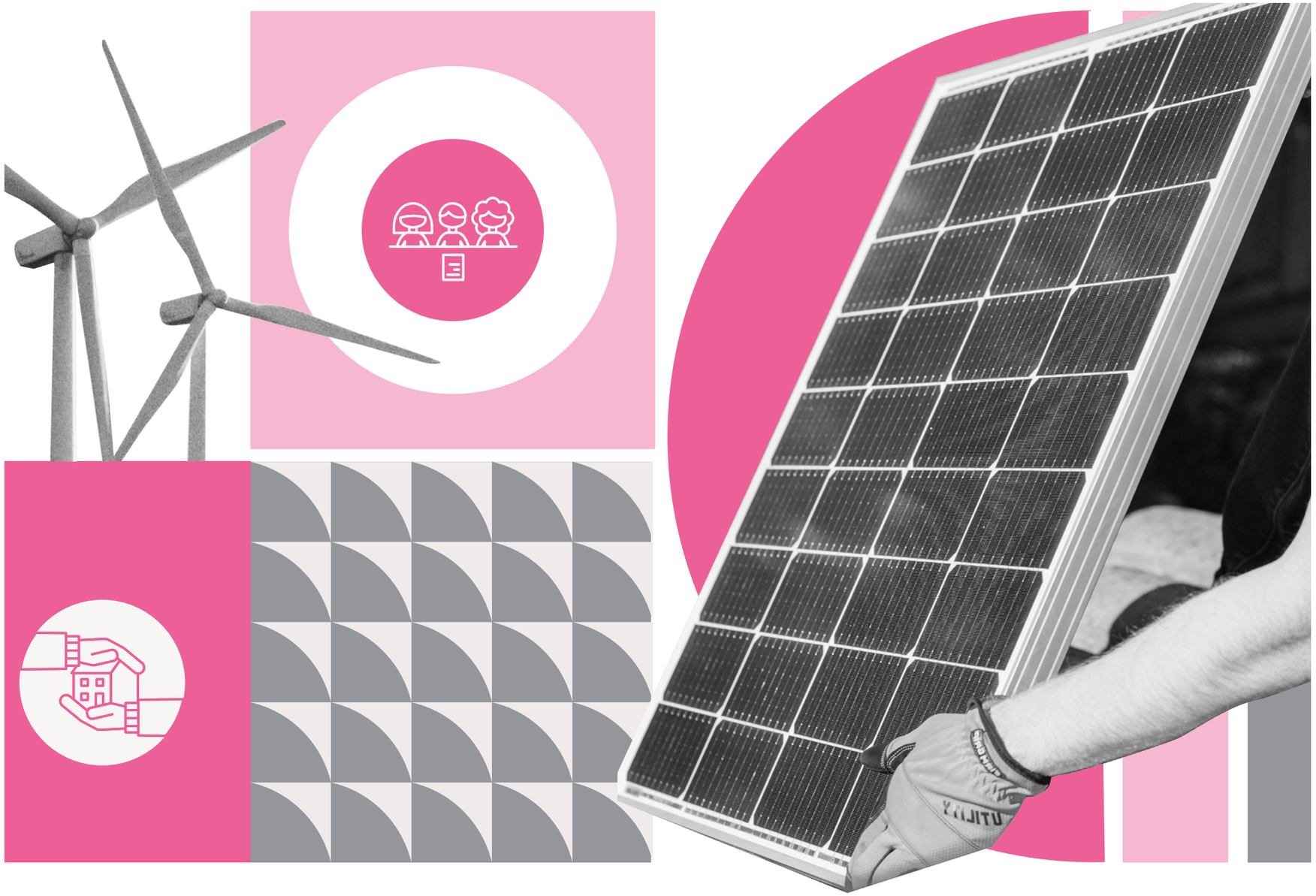
Focus on financial value
Firms pursuing development paths solely driven by financial return could result in solutions that may not be beneficial for all consumers. Issues resulting from such an approach, including technological lock-in could affect the interoperability of technologies, the ability for consumers to switch, equitable access and general consumer satisfaction.

Speed of alignment
A large number of actors exist across the sector, making it incredibly difficult to align interests. This includes achieving a consensus on issues such as data standards, data sharing and APIs.

Arriving at an agreement across the sector is likely to take a significant amount of time, and it may be the case that a critical mass of firms instead decide to go ahead with their agreed standards in the eventual hope that the rest of the sector follows. Once standards are agreed it is likely that industry move quickly to capitalise on solutions.



COMBINED LEADERSHIP AND COLLECTIVE ACTION



Regulator and industry collaborate on the rules of the game and collectively play

This pathway utilises and builds upon the existing relationship between industry and government. It aims for a collaborative and coordinated approach to achieve a digitalised energy system by 2035. Regulators begin to implement early legislation for the system's development. This is due to potential fears around market competitiveness, system security and technology lock-in, all of which can come from a digitalised energy system solely developed by the industry.

Industry, both existing players and new entrants, demanding clarity but also fearing possible government overreach, opts to collaborate with regulators to develop the system. They articulate outcomes in key areas such as data standards, infrastructure, cyber security, and sustainability. This helps the government and regulator settle on a firm pathway for the development of the digitalised energy system. For industry, it ensures that regulators intervene at the correct level. This enables the sector to make the necessary investment decisions and to develop innovative and creative solutions free from risk. Technology lock-in is avoided through the development of monitoring capabilities and metrics, competition rulings, and RIIO price controls. Price controls are also used to drive standardisation, with additional funding provided to help deploy innovative ideas, incentivise investment in skills, and reward meeting effective targets ahead of schedule. An energy sector example of this pathway could be Open Energy, a sector-wide Trust Framework, which was built by industry and funded by government, and demonstrated the value of collaborative approaches. This pathway is one of sustained collaboration and agility, playing to each actors' strengths and allowing for opportunities to be harnessed quickly. It relies on mutual trust, that regulators will avoid overreach and continuous rule change, while industry will invest in change, acting with the interests of achieving net zero and the GB energy system at its heart.

This leads to an optimal state where industry, government and the regulator collaborate to understand and agree the sector needs, which they can collectively act upon. In parallel the government gives the new FSO the remit and responsibility to make decisions on behalf of industry.

Interventions

The following interventions or levers could enable this preferable pathway.

Key:

- **Collaboration and Integration**
- **Policy and Regulation**
- **Capabilities and Leadership**
- **Governance and Standards**
- **Technology and Infrastructure**

Short Term 2023 - 2025

- Government in collaboration with the regulator and industry to establish a task group that accelerates the development and implementation of the data sharing infrastructure.
- Purposeful and empowered steering groups established with input from Ofgem and DESNZ.
- Market reformed to open the market to different players and set a clear strategic direction.
- Fair, visible and efficient strategic innovation funding mechanisms implemented.
- Technology lock-in avoided through services based architecture and design principles.
- Sector upskilling through government mandates.
- Government reviews development in other comparable sectors and parts of the world to learn from best practice.
- Digital energy system roadmap developed incorporating evidence from industry consultation.
- ESO and FSO given role and responsibility for certain digitalisation and data sharing infrastructure activities on behalf of industry, to deliver tangible outcomes within specified timeframes.
- Strategic legislation around specific areas of technology developments and supporting funding mechanisms.

Medium Term 2026 - 2030

- Whole system monitoring and decision making based on a system thinking approach.
- Government and regulator focus on integration between sectors such as water and transport.
- Mechanisms established to disseminate market driven or industry ideas or implement into regulation.
- Reforms to RIIO price controls to incentivise an agile, transparent and zero carbon system.
- Energy data sharing infrastructure operator and a digitalisation orchestrator are established to drive forwards and manage digitalisation efforts.
- Network connection of different technologies across sectors, such as EVs and heat-pumps.
- Transparency of data across the sectors.

Long Term 2031 - 2035

- Full implementation of a socio-technical framework that facilitates the data sharing infrastructure.

Benefits

Clarity on principles and development

Clarity on data standards, infrastructure, cyber security, and sustainability provided by collaboratively working together. This allows the industry and regulator to prioritise the areas with the greatest impact or benefit for consumers. Such a process provides the industry with assurances and confidence to invest and innovate at pace, without fear of a change in direction.

Best practice

Collaboration between regulators and the industry enables the creation of effective data and cyber security standards, information models, API interfaces, data, and industry best practice. This allows the sector to build on the existing CIM and accelerate the development of the data sharing infrastructure, to create default and minimum layer of interoperability, which runs throughout the digital energy system.

Outcome focused

Government can act as an enabler for change in this pathway. They can agree with industry on the outcomes required of a digitalised energy system, and what best practice should look like, without going into extreme granularity.

This allows the industry to innovate without fear of reprimand or recrimination from government. Government and regulators can focus on its strengths by delivering for consumers and limiting technology lock-in. Industry can invest without risk and unleash its creativity in developing innovative solutions.

Consumer-centric innovation

Combining a regulator's focus on delivering for the consumer, and the industry's expertise can create a solution that is fair, equitable and effective. One way is through providing genuine choice for the consumer, and avoiding technology lock-in.

Data sharing

Agreement of data standards alongside their mapping to operational benefits supports both industry actors and the FSO.

It results in improved modelling of system data, and regulators who can assess both the functioning of the system and determine areas for further development.

Innovation

Providing clarity on interventions in the system, alongside the creation of metrics to measure success, will create the certainty and trust critical for innovation. The sector can make the necessary investment decisions to develop and deploy innovative and creative solutions with lower risk. This environment rewards and encourages new sector entrants and cross-sector knowledge sharing, fuelling innovation further.

Disbenefits and challenges

Balancing priorities

Crises very quickly highlight the interdependencies and the conflicting interests within the energy system and between actors within it. In a collaborative and outcome driven pathway, there is a need to balance energy security, affordability, and energy transition needs. This needs to be done without jeopardising governmental targets, climate goals or consumer value.

Defining interactions

Interactions between system operators and markets should be well defined, to enable efficient and transparent market competition. Achieving the right level of intervention will be difficult, with the risk that regulators are intervening too much or too little. It will however ensure a base layer of interoperability between operators, helping to achieve a level playing field.

Coordination and cooperation

Currently many organisations are focused on their own IT, data developments, governance, and business outcomes. There is limited broader visibility or coordination within the sector, with wider sectors or between government(s) and regulator(s). A more collaborative, cross-sector and coordinated approach will be a key challenge.

Monopolisation

Rapid growth in particular fields means that dominant market players can emerge. A strategy with tangible milestones is needed between industry and government, regarding the development and management of digital monopolies, should they emerge.

Beyond consultation

Whilst consultation is a very critical step in a collaborative pathway, a difficult leap then needs to be taken towards implementation. Once an evidence base is established, a shift in approach from the regulator and industry is required towards demonstrators, decisions, and implementation. If a collaborative pathway is too slow, industry could move forward with product development using their own standards. Once a significant customer base is established this could drive the direction.

Culture change

A social and cultural reckoning is required to better understand the mutual benefits and synergies, which result from sharing operational data at required interfaces. Without a government and regulator supported socio-technical framework, larger actors in the sector (network owners or operators) are likely to establish their own. This could possibly be through collaboration via trade associations. This could leave other actors in the sector with little influence over the direction of framework development. This would also likely discourage stakeholders from sharing data without some form of economic incentive, instead of considering data exchange as the cultural default.

Futureproofing

Existing service regulations may prove insufficient for meeting the future challenges faced by the grid and system operators. One reason is that existing regulation tariffs have been based on past costs and not future potential, thus not incentivising innovation. New regulations, and a complimentary framework, will be required to unlock and evaluate the potential benefits that grid and service flexibility offer. Ultimately it is this innovation which will aid the energy sector in overcoming the challenges faced.

Call to action

In 2021 the UK government committed to decarbonise the UK's power system by 2035. This will be very difficult to achieve without significantly higher levels of system flexibility.

Digitalisation is both a social and a technical challenge, and requires consideration of people, process, data, and technology. It helps enable the system to develop the tools, processes and infrastructure needed to operate the current and future system flexibly.

It enables the optimising of assets across the networks so that they can be integrated at the least cost to consumers, while also facilitating the creation of a decarbonised, secure, and resilient network.

It also facilitates cross-sector connectivity and collaboration and makes systems-based thinking and action possible.

To achieve this ambition, the following key actions are required at pace in the next 6-12 months:

Collaboratively define the new governance model:
Industry, government, and the regulator needs to establish and communicate a clear governance model for the digital energy system, including the roles and accountabilities. Stakeholders can take learnings from the digitalisation activities of adjacent sectors.

Develop an energy sector data sharing infrastructure:
Government and the regulator should accelerate the development and implementation of this enabling capability through a collaborative task group with the mandate and funding – enabling that minimum layer of digital infrastructure that allows the exchange of energy data in a secure and interoperable manner.

Provide clarity on interventions:
Government and the regulator should provide clarity on where and when to intervene in the system alongside the creation of metrics to measure success. This will allow for a coordinated, efficient, and systemic approach to development; encourage investment and innovation, and reduce the barriers to entry for new market participants.

Upskill and attract talent:
Industry, government, and the regulator must attract, develop, and retain talent across all levels of experience. As the energy transition gathers pace, the nature of work for networks is increasingly focussing on digital and data skills as well as engineering skills.

Conclusion

Whilst good progress has been made in digitalising the energy system since the Energy Data Taskforce in 2019, our current pathway and the rate of change is not enough to achieve decarbonisation commitments. New thinking is required, considering alternative pathways to realise a digitalised energy system by 2035.

Within this paper, we have identified a range of pathways available to achieving a digitalised energy system, each with their benefits and challenges. We conclude that the preferable pathway is built around sustained coordinated collaboration between the regulator, government, and industry.

In exploring these different pathways, we intend not to recommend detailed actions but instead to initiate meaningful debate within the sector about the crucial roles that all stakeholders may play. This is to provide greater certainty and clarity so that next steps can be taken.