Electricity Networks Strategy Group

A Smart Grid Routemap

February 2010

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ENSG – who we are and what we do

The Electricity Networks Strategy Group (ENSG) provides a high-level forum which brings together key stakeholders in electricity networks that work together to support the Government and Ofgem in meeting the long-term energy challenges of tackling climate change and ensuring secure, clean and affordable energy.

The Group is jointly chaired by the Department of Energy and Climate Change (DECC) and Office of Gas and Electricity Markets (Ofgem), and its broad aim is to identify and co-ordinate work to help address key strategic issues that affect the transition of electricity networks to a low-carbon future.

The ENSG smart grid working group has been tasked by DECC and Ofgem to produce a high level smart grid vision, published on 2 December 2009, and this smart grid routemap.

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Ofgem statement

Ofgem has been actively engaged, as joint-chair of the ENSG's SmartGrids Working Group, in the delivery of the Routemap. We are very grateful for the time and enthusiasm that the members of the Working Group have committed to this important work and we welcome its publication.

We are now putting in place the £500m Low Carbon Networks Fund (LCNF), an important part of the 5th Electricity Distribution Price Control Review. We think the ideas and momentum created by the Working Group provides a valuable basis for identifying projects that should seek funding from the LCNF and the Innovation Funding Incentive.

We will, with the help and advice of an independent expert panel, be selecting LCNF projects through a competitive process. As we will need to decide which projects the LCNF will fund, we think it is important to make clear that we cannot, given this role, endorse any specific ideas or proposals in the Routemap.

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Executive summary

The Electricity Networks Strategy Group (ENSG) endorses ‘A Smart Grid Routemap’ as a high level description of the way in which a UK smart grid could be delivered to contribute to the realisation of Government carbon targets and end-customer benefits.

The ENSG believes that it is critical to deliver a range of well targeted pilot projects between 2010 and 2015 in the expectation that many of them will prove to be technically and economically successful and therefore available for UK wide application from 2015 onwards.

The ENSG believes that any smart grid developments must create the right mix of technical, commercial, industry and regulatory change to overcome a diverse set of challenges.

In particular, ENSG would emphasise a prioritised, coordinated and concerted approach to public engagement, security and data privacy, the development of common and open standards and any identified cross industry changes.

To do this effectively requires linkages across Government policy, regulatory development and industry wide change programmes with a particular emphasis upon the relationship between smart metering and wider smart grid developments. The smart grid routemap must recognise the smart meter roll-out programme and respect its timetable.

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The UK Government's low carbon strategy and Ofgem's Low Carbon Network Fund and RPI-X@20 project are the key context for the development of smart grid

Government

UK Low Carbon Transition Plan

In July 2009 the Government published 'The UK Low Carbon Transition Plan – National Strategy for Climate and Energy'. This white paper outlines the broad set of policy measures, targets and principles that will allow the UK to deliver its five-point-plan to tackle climate change. It also provides the framework against which the role of smart grid can be identified, and offers a benchmark against which the smart grid vision must be tailored.

Renewable Energy Strategy

The UK has signed up to the EU Renewable Energy Directive, which includes a UK target of 15 percent of energy from renewables by 2020. This target is equivalent to a seven-fold increase in UK renewable energy consumption from 2008 levels: the most challenging of any EU Member State. The Renewable Energy Strategy sets out how everyone has a role to play in promoting renewable energy, from individuals to communities to businesses.

Ofgem

The Low Carbon Network Fund (LCNF)

In December 2009 Ofgem, the UK's energy regulator, announced a funding mechanism of £500m over the period 2010 to 2015 to support 'large-scale trials of advanced technology including smart grids', as part of DPCR5 – the five-yearly Distribution Price Control Review that Ofgem undertakes that establish incentives, revenues and expenditure allowed by the DNOs.

RPI-X@20

The RPI-X@20 review is a two year project to review the workings of the current approach to regulating GB's energy networks and develop future policy recommendations. The review will be developed with a broad number of stakeholders.

The recommendations of the review will be reported to the Ofgem Authority in Summer 2010.

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This routemap is a continuation of ENSG's smart grid vision work

Carbon reduction

- Enable and accelerate power system carbon reduction
- E.g. demand-side response to cost effectively integrate inflexible low-carbon generation

Energy security

- Increasing the network's capacity to manage a potentially diverse set of new requirements
- E.g. manage the technical risk of connecting new generation, and of changing demand patterns

Economic competitiveness & affordability

- Reduce the cost of transitioning to a low-carbon energy system, increasing affordability
- E.g. reduce need for grid reinforcement to handle new loads

"The UK's smart grid will develop to support and accelerate a cost-effective transition to the low-carbon economy. Smart grid will help the UK meet its 2020 carbon targets, while providing the foundations for a variety of power system options out to 2050.

The Vision sets out how smart grids may, directly or indirectly: maintain or enhance quality and security of electricity supply; facilitate the connection of new low- and zero-carbon generating plants, from industrial to domestic scale; enable innovative demand-side technologies and strategies; facilitate a new range of energy products and tariffs to empower consumers to reduce their energy consumption and carbon output; feature a holistic communications system that will allow the complete power system to operate in a coherent way, balancing carbon intensity and cost, and providing a greater visibility of the grid state; allow the cost and carbon impact of using the networks themselves to be optimised."

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The ENSG routemap illustrates the UK's network development objectives and a high level path to deliver the smart grid vision

- This routemap follows the ENSG's smart grid vision, which outlined a high-level perspective on what a UK smart grid could look like
- It identifies the objectives of the UK around smart grid, and the scope of the difficulties facing the UK in meeting these objectives
- This document will present a pragmatic, actionable approach to short-term smart grid projects that all industry players, consumers and government can participate in
- Ofgem's Low Carbon Network Fund provides the stimulus for these pilot projects, in conjunction with EU and private funding initiatives
- It proposes a longer term, strategic routemap to address and meet some of the challenges presented by the UK's specific situation

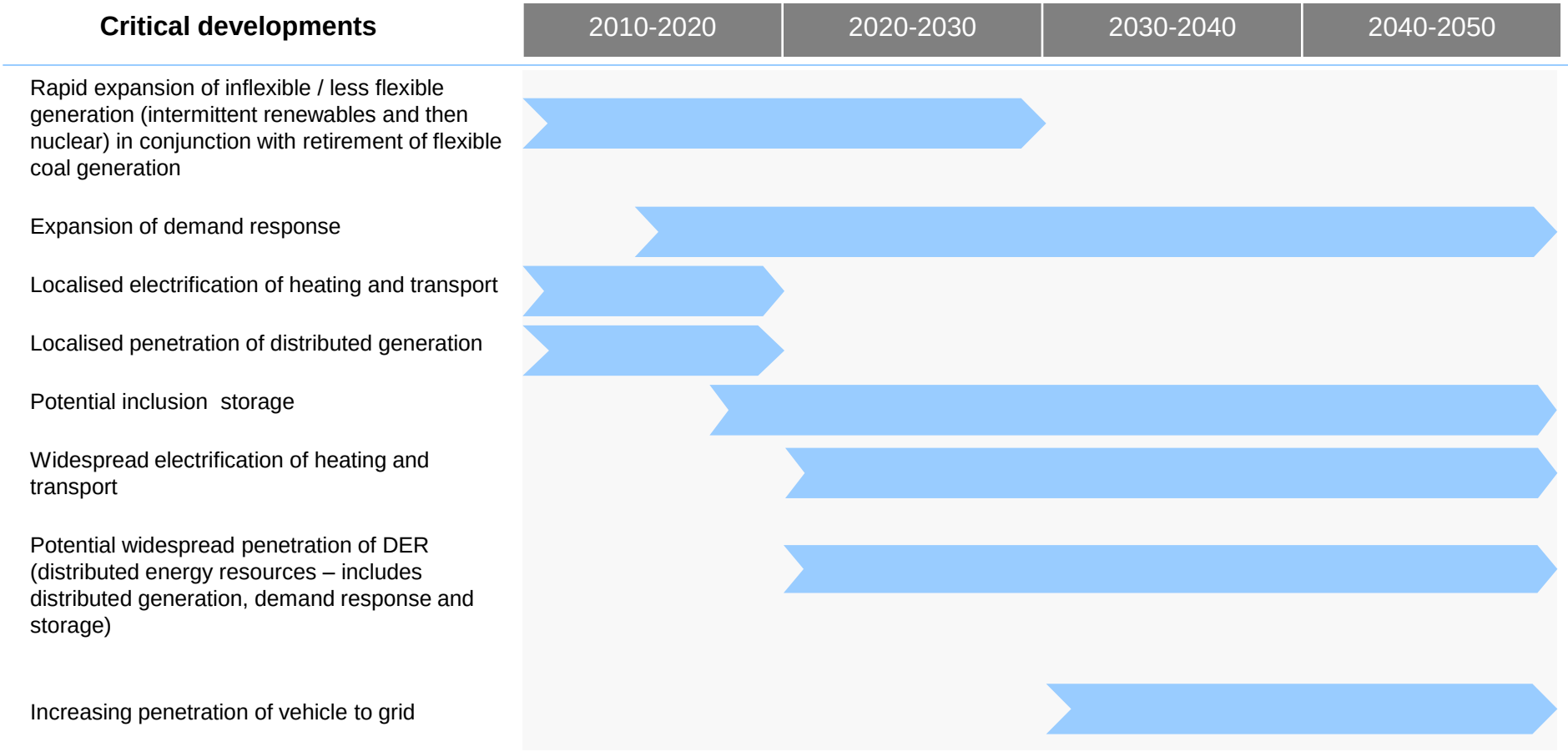
Routemap objectives

- Establish how smart grids can support cost effective and secure low carbon transition
- Create a high level view of the smart grid path out to 2050
- Input into Low Carbon Network Fund thinking
- Identify key challenges, objectives and required changes
- Provide a starting point for concerted and coordinated action on smart grid development
- Facilitate societal engagement and customer adoption given a variety of sociological challenges
- Generate an overarching framework to support detailed short and long run planning

This is a discussion document that reflects the ENSG's discussions over the smart grid routemap. It does not commit any member of ENSG to any specific action

This document focuses on distribution. ENSG's position on transmission is presented in 'Our Electricity Transmission Network: A Vision For 2020'

The UK's low carbon transition will drive the development of the UK's smart grid out to 2050



Illustrative timeline

Given this context the routemap will focus on three critical smart grid roles for the UK's planned low carbon transition

Challenge	Significance to the low carbon transition	Integrated role of Smart Grid	Routemap implications

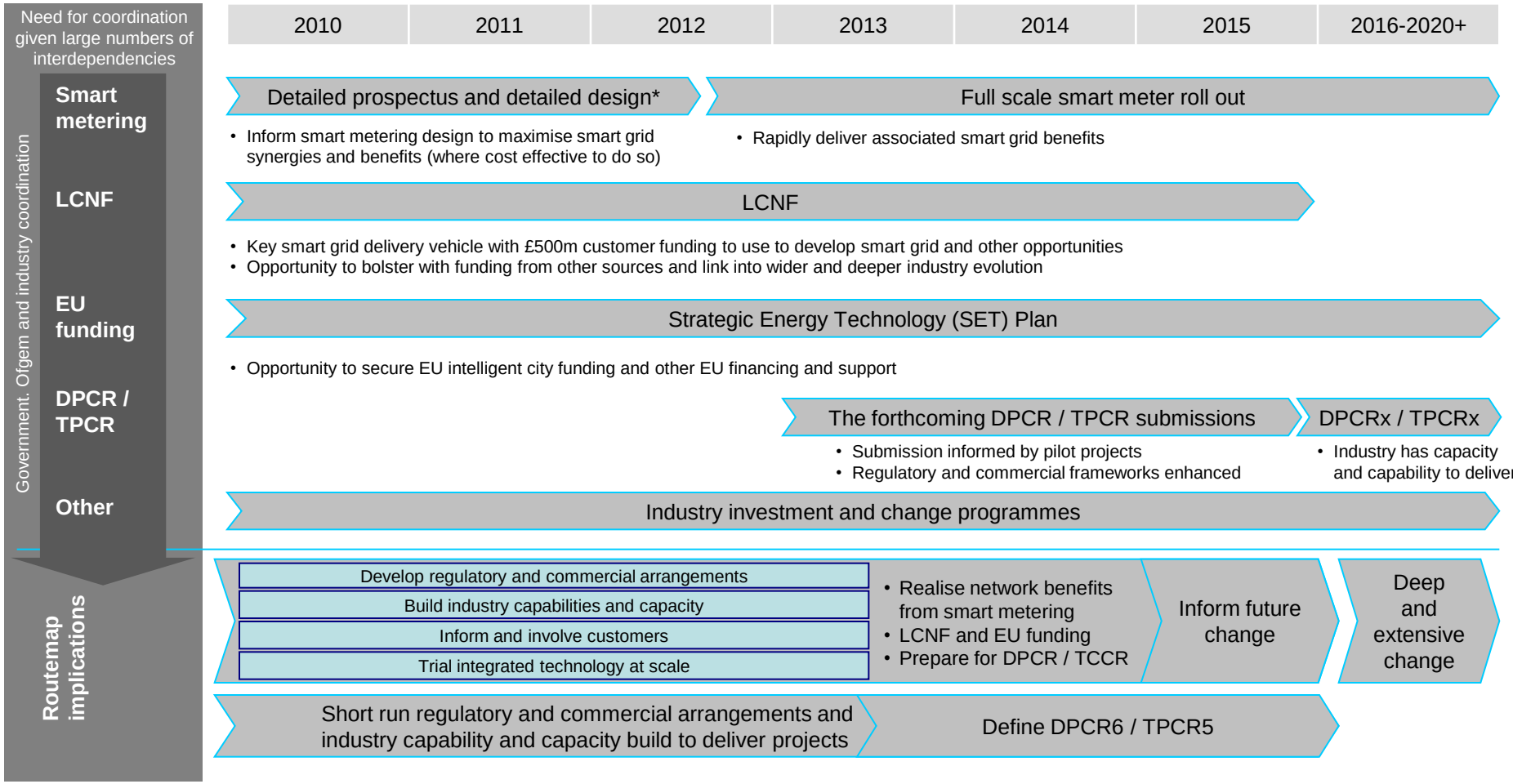
Integration of inflexible generation	• The UK's 2020 renewable target will require a massive increase in inflexible generation (intermittent renewables and nuclear)
	• Operating this level under the current system where balancing is done predominately on the supply side would result in a big increase in the UK's reserve margin and a big fall in plant utilisation as renewables are backed up by low load factor and flexible thermal plant
	• This model could be very expensive
		• Smart grid can enable the demand side, and DER more broadly, in a manner that helps integrate inflexible generation, reduce network reinforcement and maintain network stability and energy security
		• Heating and transport electrification present the challenge of higher demand and new peaks but also offer a higher degree of interruptible load and storage opportunities (heat storage and post 2030 V2G). This needs to be handled both by generation and the network (with smart grid providing the enabling underlying infrastructure) as well as in the home through smart meters
		• Distributed generation can offer a variety of power sources with varying intermittency that can be dispatched to manage network and generation constraints
		• Ultimately smart grid allows integrated optimisation of transmission and distribution connected generation dispatch, storage and demand response to reduce the total UK system costs (across generation, networks and consumers) and maintain system integrity
			• Need for integrated solutions building all the elements required for smart grid to play its critical role in the low carbon transition:
			  • Regulatory and commercial frameworks
			  • Technology and standards development
			  • Customer engagement and activation
			  • Industry capacity and capabilities
			  • Alignment with other Government policies
			• May build from narrower trials of the elements of the integrated solution but it is essential that these are brought together at scale so that they can be nationally scaled post 2015 – given the proximity of the 2020 targets
			• A particular near term emphasis needs to be the integration of large amounts of wind for the 2020 target

Electrification of transport and heating	• Decarbonisation of electricity and customer demand can be expected to electrify transport • As the UK moves toward 2050 the need to decarbonise heating can be expected to lead to electrification of heating • This could require extensive reinforcement of the electricity network and a big increase in generation capacity exacerbating the issue above		
Integration of DER	• Consumer demand and the potential of DER to support the integration of, and in the case of DG, offer an alternative to large-scale, transmission-connected low-carbon generation, could drive a big increase in levels of DER* • DER will present the network with new power flows and the associated challenges as well as the need to optimise across a variety of small DER		

All three are linked and require an integrated and optimised solution cutting across suppliers, VPPs etc. DNOs (which may become DSOs), generators, TNOs, GBSO and the customer

*Will be building on top of existing measures

The routemap will be delivered in the context of policy and industry timelines



*For more detail refer to DECC's 'TOWARDS A SMARTER FUTURE: GOVERNMENT RESPONSE TO THE CONSULTATION ON ELECTRICITY AND GAS SMART METERING'

And will take account of the variety of potential paths – informing policy and generating optionality

LENS Scenarios	Description	Role of Smart Grid	
Big Transmission and Distribution	• TSOs at centre of network activity • Large fossil fuel portfolio, significant amount of large-scale low-carbon and renewable generation capacity • Further interconnectors to Europe • Passive customers		• Cost-effectively accommodating large amounts of renewable generation on transmission network • Managing multiple interconnectors
Energy Service Companies	• ESCOs at centre of network activity with a vibrant 'energy services' market • Distribution networks develop to accommodate widespread local DG and transmission for renewable sources		• Managing widespread DG • Providing the backbone for increased usage and settlement data between third party ESCOs, suppliers and distributors
Distribution System Operators	• DSOs at centre of network activity • Active consumers • Strong government intervention • Large DG levels in distribution networks managed by DSO		• Managing widespread distributed generation • DSO balancing and optimisation • Empowering customers
Microgrids	• Consumers at centre of activity, with significant concern for environment • Enormous amount of local generation and DR schemes, with reduced utilisation of transmission and less centralised generation		• Managing widespread distributed generation and deep penetration of bi-directional flows and intermittent supply • Empowering customers
Multipurpose networks	• TSOs at the centre of activity though distribution has larger role with a pervading feeling of uncertainty • Various approaches embarked on in response to environmental concerns, but sporadic and localised • Lack of continuity, and stranded assets		• Localised smart technologies where required, e.g. connection of offshore wind

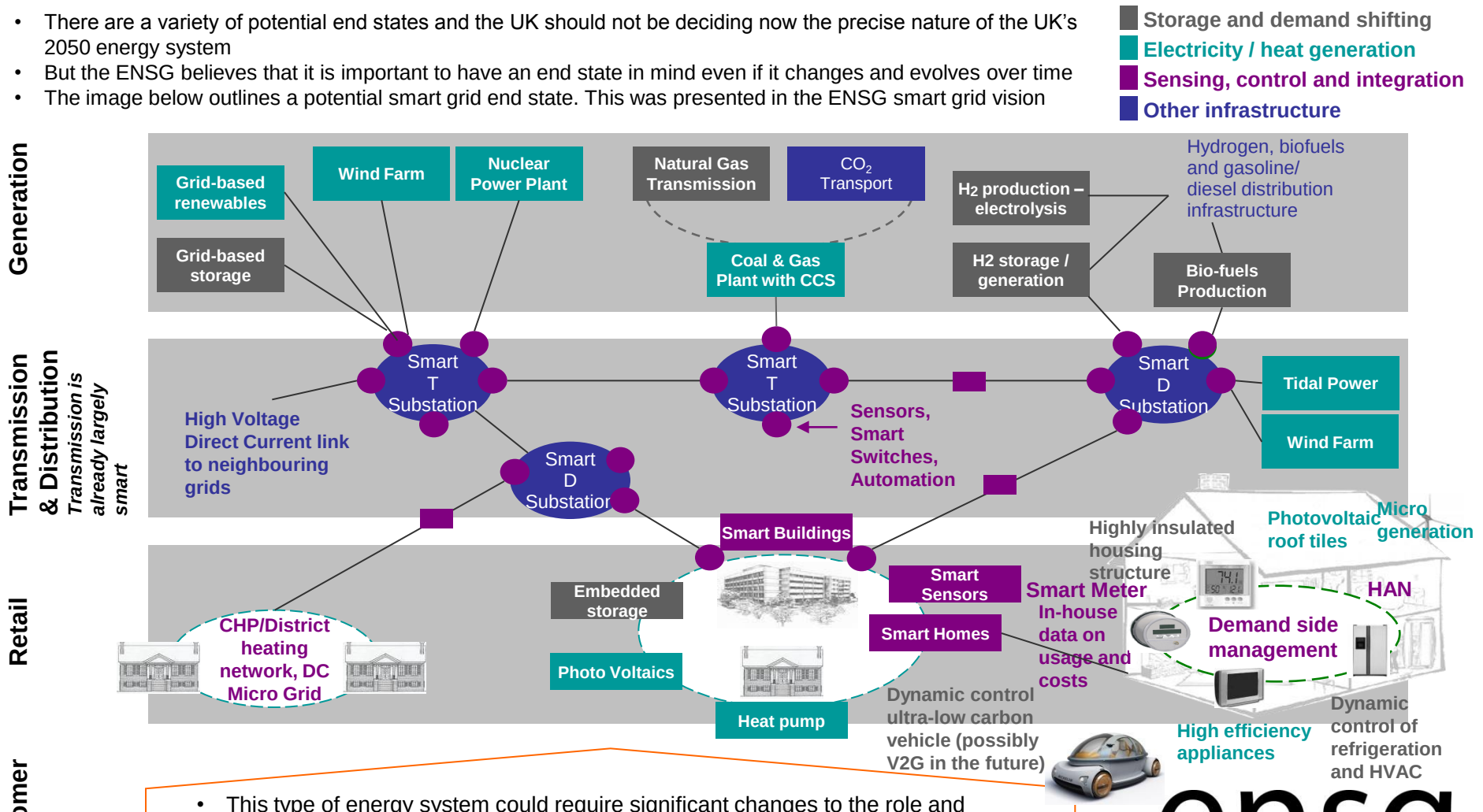
Routemap implications

- Smart grid has some role to play across all scenarios leading to a common set of challenges
- Understand cost implications of core smart grid functionality relative to benefits
- Evaluate and drive customer engagement and involvement
- Assess technical implications of a distributed energy resources
- Understand extent to which smart grid can help manage intermittent renewables
- Evaluate potential to create the necessary regulatory / commercial frameworks e.g. Incentivise DER / facilitate customer engagement and optimise DER allocation
- Put in place scalable capabilities and technologies

This is not a definitive or exhaustive list of scenarios

Ultimately the UK smart grid routemap is driving toward a smart grid end state

- There are a variety of potential end states and the UK should not be deciding now the precise nature of the UK's 2050 energy system
- But the ENSG believes that it is important to have an end state in mind even if it changes and evolves over time
- The image below outlines a potential smart grid end state. This was presented in the ENSG smart grid vision



- This type of energy system could require significant changes to the role and activities of the customer within the wider energy system allowing them to participate in the market (potential for automation of customer response)
- In transitioning to a new 'role', customers will need to be supported by energy retailers or other organisations with open access and standards widening the net for innovative products and services

Delivering the low carbon transition and the associated smart grid vision will entail identifying and then addressing a number of challenges

Target outcomes		Potential Challenges	Routemap implications
Develop regulatory and commercial arrangements	1	DNOs may develop their smart grid capabilities at different rates, impacting the service provision offered to Suppliers, customers (non-domestic and potentially domestic), generators and other parties	• Need to effectively coordinate and share learning and provide degree of centralised coordination and support to simultaneously encourage innovation whilst keeping complexity, costs and service and performance differentials down
	2	Current incentives may prove insufficient to drive scale smart grid investment	• Early feedback from the LCNF process will be fed in to further development of regulatory mechanisms
	3	Incentives may be necessary to encourage demand reduction and better energy management (i.e. load shifting)	• Demonstrate new business and revenue models and associated regulatory and commercial frameworks that support demand reduction and better energy management
	4	There may be challenges associated with balancing, settlement and wholesale markets in relation to DER etc. which need to be assessed and understood	• Consider changes to settlement to enable DER to grow at pace. Market and balancing issues need to be identified and resolutions developed over time, taking into account respective roles and potential issues with market liquidity and incentives
	5	Frameworks to enable optimised allocation of DER between system balancing and network operation may require development	• A hierarchy of needs may be required to understand how the use of end to end system control will be prioritised and responsibility and accountability allocated. Commercial and regulatory frameworks will need to be tested to see how they move toward efficient outcomes
Build industry capabilities and capacity	6	Industry will need to build on current smart grid capabilities and capacity for wide scale smart grid change and to address issues relating to an ageing workforce	• Knowledge capture, sharing and targeted business development are key. May be a need for cross-industry and Government efforts to fill the skills gap
	7	There may be potential challenges in relation to end-to-end integrated optimisation of investment and benefits across power and wider infrastructure	• Ongoing testing and development of commercial arrangements and where necessary supporting regulatory and policy frameworks
Inform and involve customers	8	A lack of societal engagement or understanding in relation to smart grid may present challenges	• Focus on understanding customer behaviour and responses and establishing open and competitive frameworks to drive customer-focused innovation • Important to deliver tangible pilots and integrate project delivery with customer education and wider public relations activities
Trial integrated technology at scale	9	Fully integrated end to end technologies are generally not yet fully scale proven	• Pilots needed to trial and prove end to end technologies and related commercial frameworks at scale
	10	Required technology to meet objectives and commercial and technological integration yet to be defined	• Development of standards is a priority to ensure interoperability and to encourage competitive innovation and scale procurement
	11	There is an absence of supporting common standards (important for interoperability)	
	12	Security threats and data protection risks may present challenges	• Manage perceptions and build security and resilience into the core of the solution – potential for a degree of centralised security management and ongoing threat / vulnerability evaluation and response

Relevant parties will need to work together to generate, evaluate and prioritise a full set of challenges and then work together toward addressing them. ENSG has developed this list of potential challenges in order to support further evaluation during the smart grid trial phase.

Ofgem RPI-X@20 and Discovery projects are a response to the potential need for change to deliver the UK's future energy system
Challenges are not ordered by priority.

As an important example, optimised expansion and use of DER is a significant driver for smart grid deployment but faces a number of challenges

The DER value chain

Optimise scale and type of DER capacity whilst meeting customer needs and providing them a fair allocation of the benefit

Optimise allocation and operation of DER

- **Customer marketing / sales, contracting, commercials and relationship management (customer relationship owned by supplier, ESCO, VPP etc.)**
- **DER allocation**
- **DER operation**

- Change of supplier
- Regulation of contracts and other commercial arrangements
- Network charges
- Market
- Balancing system
- Settlement

End to end integrated enabling technology infrastructure

DER potential challenges

Develop regulatory and commercial arrangements

- Regulatory and commercial structures may need to be developed to achieve the optimal scale of DER, establish optimised contracts and efficiently allocate and operate the available capacity given the potential benefit streams for suppliers, VPPs etc. GBSO, DNOs / DSOs and TNOs

Build industry capabilities and capacity

- The industry potentially needs to develop the required end to end and integrated capabilities to optimise the growth and use of DER
- This cuts across capabilities to engage and serve customers, technically construct and operate DER infrastructure, efficiently integrate into wider investment planning and risk management and manage real time operation and optimisation

Inform and involve customers

- Customers are probably not sufficiently aware of or engaged in DER to deliver it at scale and may have concerns (security, trust, data)
- A particular challenge exists around the customer value proposition linked into technical control and automation and DER commercial frameworks and incentives

Trial integrated technology at scale

- End to end technology has not been widely trialled at scale
- There are technical challenges including customer-facing hardware and software that enables customer operation and automation and optimised operation of DER within supplier, DNO and GBSO systems

DER benefits / benefit allocation and delivery

- Optimal generation dispatch – carbon and marginal cost
- Maintain system balance at lowest cost
- Reduce system risk and associated costs
- Drive efficient investment in generation assets

Market / VI* balancing

System balancing

Wholesale markets and the balancing system can both perform a common function with a question mark over the optimum balance and relationship in a low carbon world

- Reinforcement management – optimisation power flows, voltage and fault levels
- Network stability and resilience

Network optimisation

- It should be noted that the ‘optimum’ solution is not known and that the critical requirement is the establishment of structures that can continuously and dynamically identify and drive toward a societal optimum
- Up front analysis will be required to evaluate the nature of the ‘optimum’ outcome in order to design the structures (data gathering, quantification and analytics)

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*Vertically integrated utilities – supply and generation within the same company leading to internal balancing

The routemap has been generated by working down from the high level vision objectives whilst considering wider energy system development out to 2050

High level objectives

Preparations to deliver at scale 2010-15

Delivering the vision at scale 2015-2020+

- Carbon reduction
- Energy security
- Economic competitiveness & affordability

Industry projects and special regulatory and commercial structures

- Develop regulatory and commercial arrangements
- Build industry capabilities and capacity
- Inform and involve customers
- Trial integrated technology at scale

Policy integration | Business case development | Knowledge and learning management | Stakeholder management | Partnerships and funding

Challenges fully identified / addressed for scale roll out

Fit-for-purpose commercial / regulatory framework, and industry capabilities (including ICT, comms, skills) and structure

DPCR6 and TPCR5 frameworks and submissions | Smart meter roll out | Implementation of RPI-X@20 | Industry change programmes

- Competitive customer focused innovation
- Cost-effective integration of low carbon technology
- End to end power system flexibility and optionality
- Active customers
- Secure and resilient supply

Continuity and certainty in Government objectives and policy

The routemap must be objective not technology driven

Delivery vehicles

Target outcomes

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There are a series of sub outcomes to be delivered by projects between 2010 and 2015 in order to prepare the UK for scale deployment

Develop regulatory and commercial arrangements

- Open and common technical standards (UK/EU / global)
- Open access regime
- Competitive end to end industry integration
- Industry incentives aligned with societal benefits case
- Competitive customer contracting (through retailer, supplier, VPP, ESCO etc.)
- Customer protection and support
- Optimised creation and allocation of DER
- Market , settlement and network charging development

Build industry capabilities and capacity

- Integrated strategies and new business models
- Network smart meter benefit realisation (develop DNO capabilities to drive network benefits from smart meter data)
- Build smart grid capabilities and knowledge
- Develop partnerships
- Integration of new network systems with organisational, people and process development
- Development of new customer products and services and ESCO / VPP etc. business models – building on existing models and relationships

Inform and involve customers*

- Take account of fuel poverty risks and opportunities
- Leverage customer relationships to drive the required engagement
- Public understanding of smart grid role, benefits and implications
- Customer proposition development and marketing
- Customer segmentation and targeting
- Customer behaviour learning and development
- Customer data gathering

Trial integrated technology at scale

- Communications – smart grid synergies & network requirements
- Customer facing – innovation and product and service integration
- Network hardware – test a variety of hardware
- Network ICT – test distributed intelligence and control
- Back office ICT – develop scalable systems
- Integrated technologies – prove, learn and quantify costs and benefits
- Security, resilience and data protection

Integration of intermittent renewables | **Integration of DER** | **Electrification of transport and heating**

- **Integrated solutions**
- **Trial the components, carry out integrated trials and then scale**

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*Customer relationship owned and managed by supplier, ESCO, VPP etc

And a variety of considerations in relation to the delivery vehicles for 2010 to 2015

Policy integration

- Integrated smart grid / meter thinking and action
- Other policy areas include electric vehicles, eco towns, building efficiency etc.
- Allows opportunity to jointly fund and expand scope of projects
- Policy can be considered in relation to central and local Government and the EU

Business case development

- Industry and societal business case
- Relationship between benefits and regulatory and commercial framework
- Understand key sensitivities and cost benefit unknowns
- Investigate relationship between benefits and key scenario elements
- Use to inform change priorities

Knowledge and learning management

- Ensure all learning and data is shared across the industry
- Framework in place to comprehensively analyse impact of new commercial and regulatory frameworks
- Sufficient resource allocation to knowledge and learning management
- Consider opportunities for centralised management and delivery

Stakeholder management

- Consider a wide set of stakeholders including customers, local and national Government, Ofgem, industry, the EU and other translational organisations
- Consider that some stakeholder management may be best achieved centrally (Gov agencies etc.)
- Acknowledge marketing and PR elements to project delivery and benefit realisation
- Collaboration

Partnerships and Funding

- Obtain from a wide set of potential funding sources
- Drive C-level engagement and understanding
- Consider different DNO ownership structures and target risk/return
- Consider allocation of business resources from corporate etc. in addition to internal business capital allocation
- Consortia building and engagement

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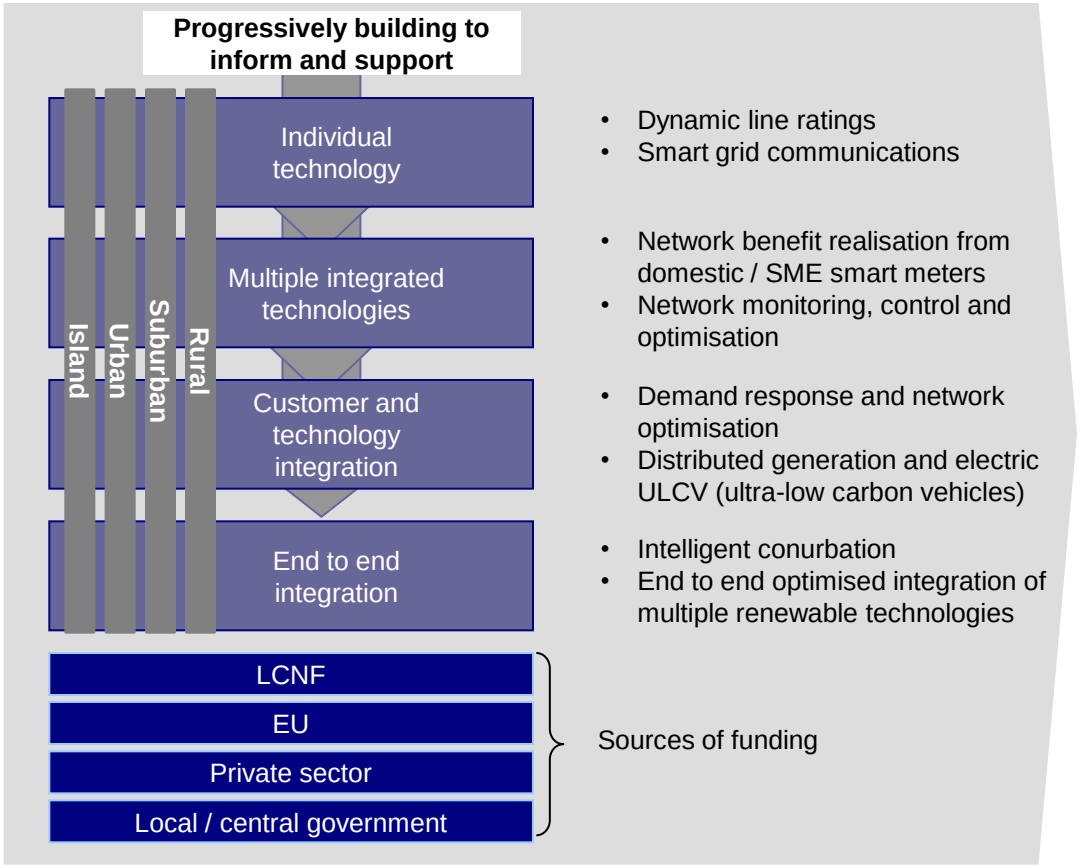
The target outcomes will be delivered by a variety of different projects with varying levels of effort required for delivery and benefit harvesting

Project types | **Example projects** | **Effort drivers**



- Dynamic line ratings
- Smart grid communications

- Network benefit realisation from domestic / SME smart meters
- Network monitoring, control and optimisation

- Demand response and network optimisation
- Distributed generation and electric ULCV (ultra-low carbon vehicles)

- Intelligent conurbation
- End to end optimised integration of multiple renewable technologies

Business change

Geographic scale

Consortia size and complexity / number of stakeholders

Functional depth and complexity

Standardisation and infrastructure integration

Customer interaction

Funding complexity

Commercial and regulatory support

- Different projects will require a different level of effort from participants in order to deliver the project objectives. The effort drivers provide a view of the core elements that drive the level of effort required to deliver any given project
- It is expected that generally the level of effort will increase as the projects move toward end to end integration
- However this is not necessarily the case of an individual technology if applied across a large geography could require a significant amount of effort

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Detail on effort drivers

Effort drivers	Implications
Geographic scale	• Projects can be broad or localised in geographic scope • Localised projects are more suited to trialling deep functionality • Projects across a larger scale – e.g. a county, or distribution region, may want to test 'shallow' but uniform functionality – e.g. applying sensors to a region's substations
Functional depth and complexity	• Applying a functionally deep technology or process change has particular impact on integration with legacy systems • A 'shallower' functional approach may result in lower complexity and a shorter implementation time • Deep functionality may offer greater learnings and skill development
Customer interaction	• Customer buy-in is vital on many smart grid initiatives, while others will be 'invisible' to customers • Where customer interaction is necessary, customer engagement through marketing and other customer facing activities should be considered just as important as technology or commercial considerations • Further customer interaction will require significant efforts to be effectively managed • Need industry collaboration as retailers / suppliers currently hold the customer relationship
Commercial and regulatory support	• If the project stretches across the value chain, requires new commercial or market arrangements or plays against current regulatory incentives then there will need to be special commercial or regulatory structures • Require appropriate incentives through industry charging mechanisms

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Further effort drivers

Effort drivers	Implications
Business change	• For all parties involved in smart grid pilots, some level of internal business change will be necessary • Business change could be deep and involve people, processes, organisation structures and culture • Interested parties need the capability to identify LCNF (and other) opportunities and win them - requiring a degree of internal promotion and sponsorship
Consortia size and complexity / number of stakeholders	• In some cases, consortia are a natural way to approach implementing smart grid projects • Depending on the scope of the projects, such consortia may involve multiple stakeholders across the value chain, or businesses new to the utility space • Will present significant challenges to address commercial constraints and contractual conflicts across the supply chain
Standardisation and infrastructure integration	• The challenge around establishing technology standard is a potential hurdle for smart grid pilots, especially those which may be implemented prior to standards being agreed • Standards need to be forward thinking to accommodate future requirements • Standards need to be defined at the appropriate level to ensure interoperability, but not constrain innovation • Coordination with EU and potentially global standards
Funding complexity	• LCNF funding will constitute maximum of 90%. The risky ’10%’ for DNOs may be challenging to justify to management, requiring a clear business case with benefits stretching into an uncertain future e.g. option value of trials for DPCR6 competitive advantage • More complex funding scenarios could operate where there is finance coming from multiple partners with consideration of relative risk and return allocation

The following four slides provide an illustrative example of the potential commercial structures, technology and business models that could support the delivery of elements of the smart grid vision

- ENSG has constructed the following illustrative model, which draws together some of the commercial, business and technological aspects of a potential future system in light of the potential challenges identified, particularly around DER
- ENSG acknowledges that there are a variety of different options available and that trials will need to test and assess these different options
- The intention is to provide some high level foundations for the development of trials that will be able to assess challenges and construct and evaluate potential solutions
- This model is not intended as the answer, it is designed to support the process of designing pilot projects
- The model begins with a high level view of the end to end commercial frameworks and associated areas of business change. It then presents a set of supporting technologies and infrastructure before drawing the two together and showing how pilot projects might be aligned to the model

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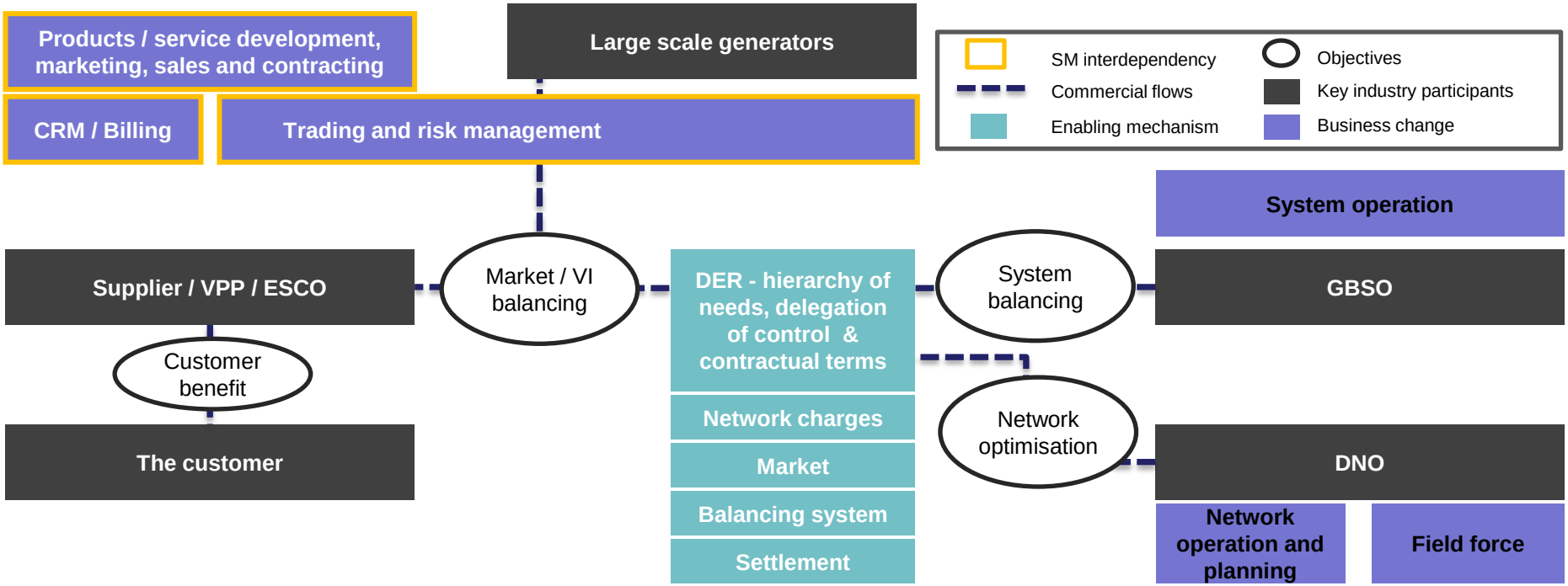
Appropriate commercial arrangements and business models are essential elements of the system and may need to be developed further



- The energy supplier , ESCO, VPP etc. will have a critical role through their ownership of the customer relationship
- Programmes outside the Low Carbon Network Fund may be required to deliver the necessary commercial frameworks and industry change
- It may be that the enabling industry wide mechanisms are delivered as part of the smart metering programme or a totally separate programme supported by / interdependent with LCNF and smart metering
- It should be noted that these enabling mechanisms are critical to the realisation of large parts of smart grid functionality and benefits – they should be a priority for development and delivery
- Industry change and capability development may be delivered and financed by the industry with limited regulatory support. Or may emerge with new entrants into the market place. But there needs to be careful centralised evaluation of progress to assess whether the right incentives / frameworks are in place

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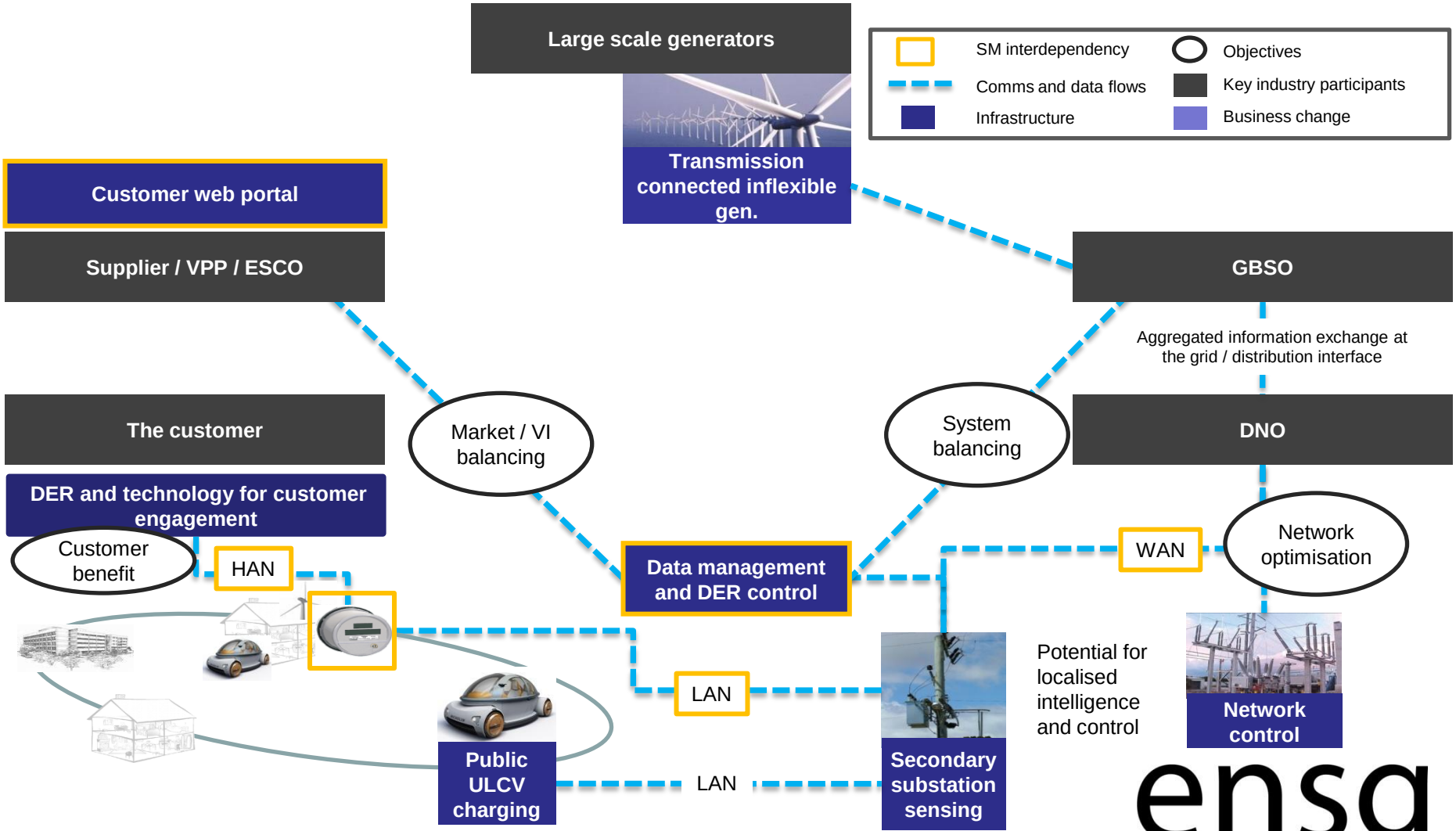
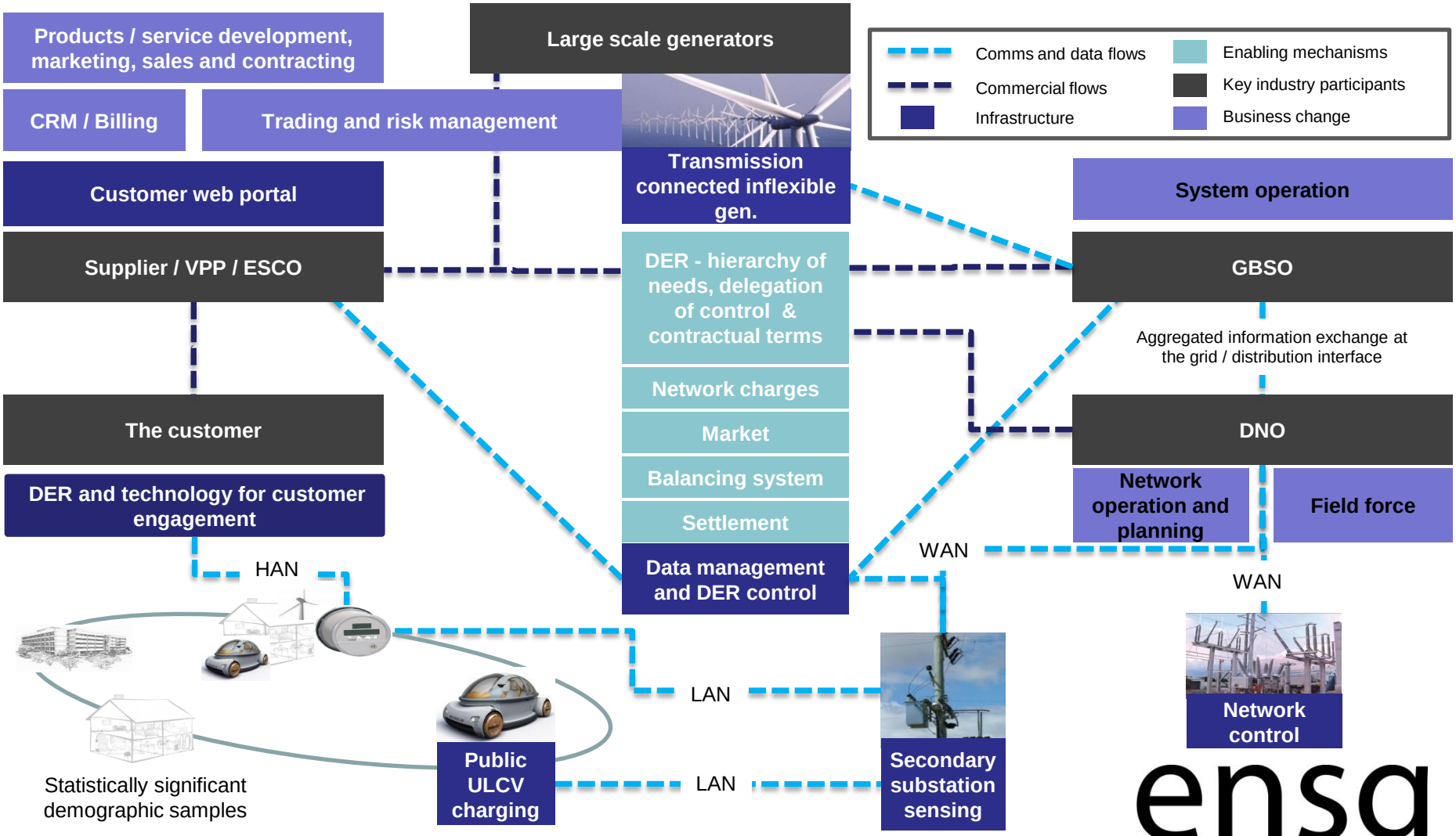
Any changes would need to be supported by a degree of investment in smart infrastructure to provide the necessary data, control and functionality

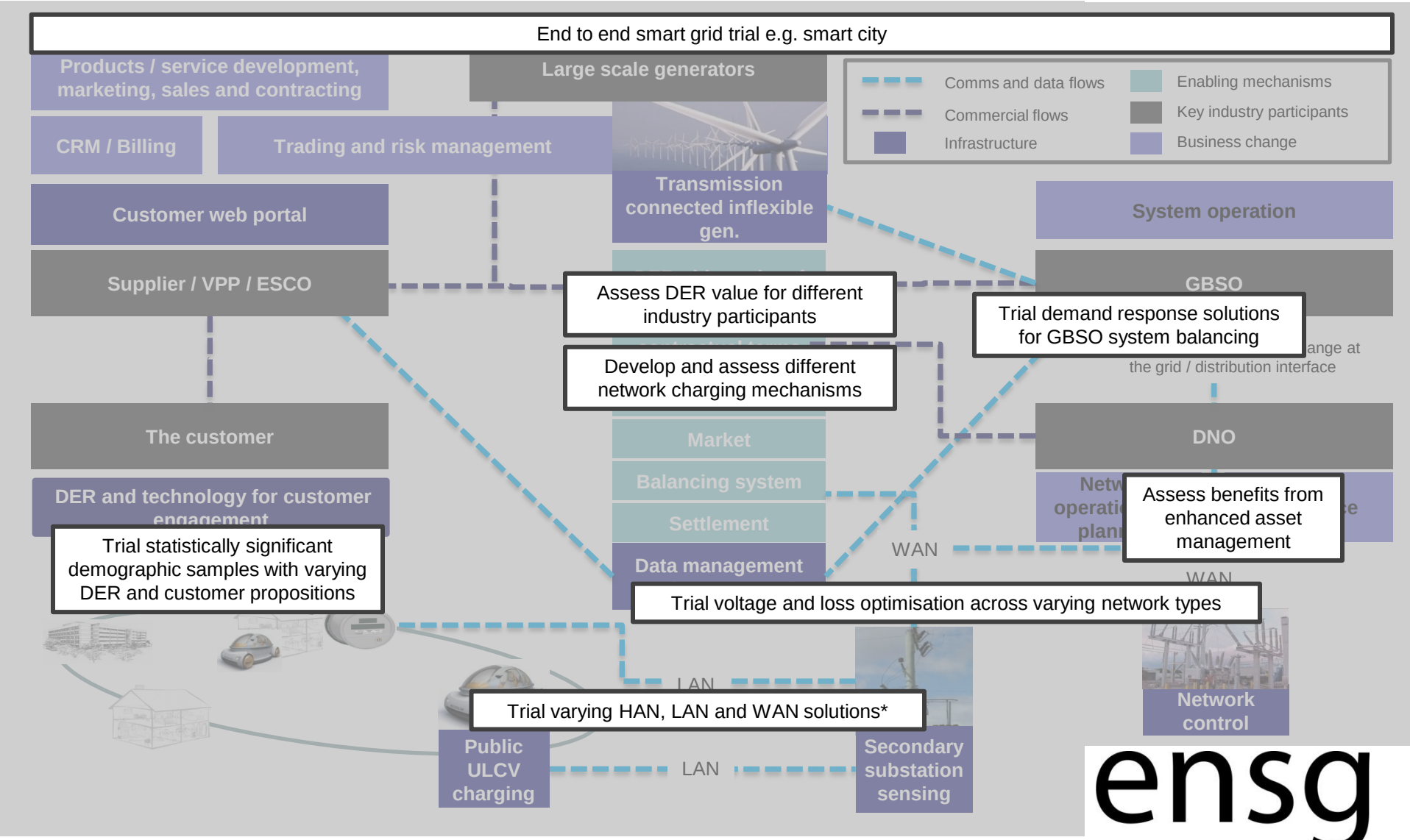


Communications from the customer do not have to go via the substation – this is not necessarily the right technical solution it is just one example

An integrated response that brings together commercial structures, infrastructure and business change under a supporting regulatory and policy framework may be necessary



Pilots can test constituent parts but it is essential that fully integrated end to end and scale solutions are also trialled



*High degree of overlap with smart metering

The nature of the challenge and thinking about potential responses draws out a number of key implications

- Implement objective driven trials that clearly contribute to delivering the UK's cost effective and secure low carbon transition
- Coordinate and operate trials across the value chain
- Explore and realise smart meter / grid coordination benefits where possible whilst not undermining the smart meter delivery timeline
- Review and potentially develop industry structures (settlement, wholesale markets and balancing)
- Consider developing certain supporting industry structures centrally rather than as a part of any one pilot project e.g. changes to settlement
- Prepare for business change to be an important part of the solution

ENSG has developed an illustrative set of projects that could play a role in supporting the delivery of the smart grid vision, in conjunction with a degree of centralised change

Detailed projects can be found in the Appendix
Not an exhaustive list

Number of each sub project type is indicative

Sub projects	#	Target outcomes delivered	Relative Effort
• Active Dynamic Rating • Active Voltage Control (assess CBA assumptions) • Super-Conducting Fault Current Limiters • Smart meter communications pilots (HAN, LAN and WAN – emphasis smart grid synergies)	10	1 3 2 4	
• Active network monitoring • Active DG Curtailment • Power Electronic Applications • Embedded Storage • Integrated Active Network Mgmt. (assess CBA assumptions) • Smart asset management	10	1 3 2 4	-
• Demand side management trials • Integrated smart meter / smart grid trials • Scheduling and dispatch of DER / DER commercials / value evaluation / customer proposition and commercials • Network integration of smart appliance / smart home – commercials / allocation • Security, resilience and data protection • Trialling of new network charging regimes	8	1 3 2 4	-
• Smart grid city • Intelligent city • Rural smart grid • Island smart grid • End to end integration of intermittent renewables	5	1 3 2 4	

Individual technology → Multiple integrated technologies → Customer and technology integration → End to end integration

Increasing customer interaction

Increasing value chain integration

Increasing commercial development / regulatory evaluation

Very high
High
Medium
Low
Very low

- **Individual projects could then test functionality and support development and scaling e.g. DER value evaluation and industry allocation**
- **Regulatory structures should be tested where relevant across the projects**
- **Centralised knowledge management and societal engagement could be a suitable approach**

1 Develop regulatory and commercial arrangements

2 Build industry capabilities and capacity

3 Inform and involve customers

4 Trial technology at scale

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The sample project list gives an indication of how a set of projects could establish a platform for a smart grid roll-out

Sample projects	CBA benefit evaluation	Transport / heating electrification	Core smart capability development	Inflexible generation integration	DER integration	Commercial development	Customer engagement
Active Dynamic Rating	◑	◑		◑	◑		
Active Voltage Control				◕	◑		
Super-Conducting Fault Current Limiters			◑		◑		
Smart meter communications pilots (HAN, LAN and WAN)			◑				◑
Active network monitoring	●	◑			◑		
Active DG Curtailment			◑		◑	●	
Power Electronic Applications			◑				
Embedded Storage			◑	●	◔		
Integrated Active Network Mgmt.	●		●	●	●		
Smart asset management	◑		●				
Demand side management trials	◕	◑		●	◕	●	●
Integrated smart meter / smart grid trials		◕					●
Scheduling and dispatch of DER / DER commercials / value evaluation / customer	◕	◕	●		●	●	●
Network integration of smart appliance / smart home – commercials / allocation		◕			◕	●	●
Security, resilience and data protection			●				●
Trialling of new network charging regimes		◑	●	◑	◕	●	
Smart grid city							
Intelligent city							
Rural smart grid							
Island smart grid							
End to end integration of intermittent renewables							

Dependent upon scope but should look to cover majority of objectives in a fully integrated way

● Very high ◕ High ◑ Medium ◔ Low ○ Very low

This is an illustrative list of projects. ENSG is not suggesting that the UK should necessarily deliver this particular set of projects or that these projects if delivered would achieve all the target outcomes.

The capacity of any given project to deliver against these objectives will be dependent upon the specifics of project scope and the way in which the project is delivered.

Other objectives (as per slide 16) will be worth pursuing – the table has been prioritised and simplified for clarity

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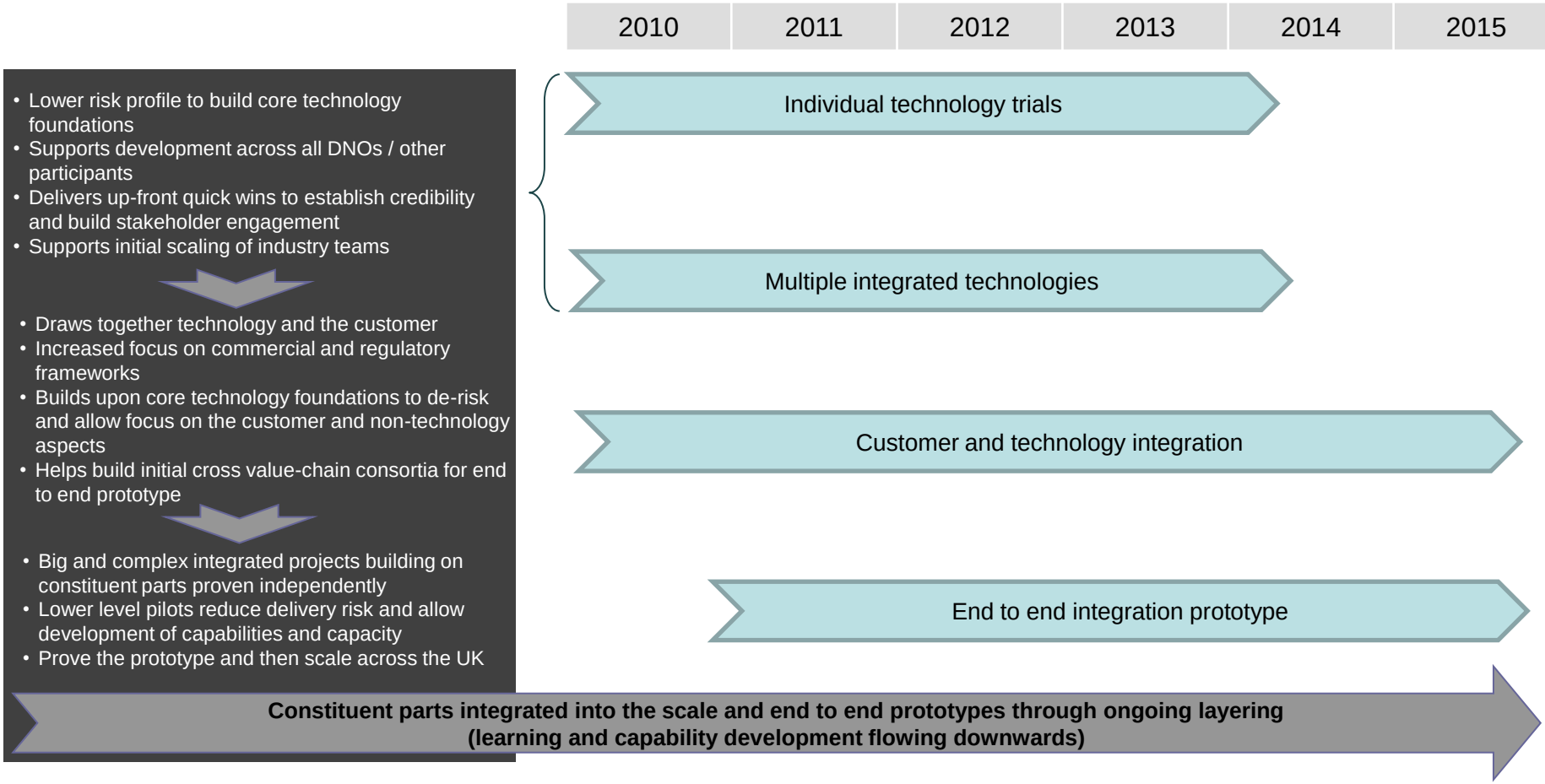
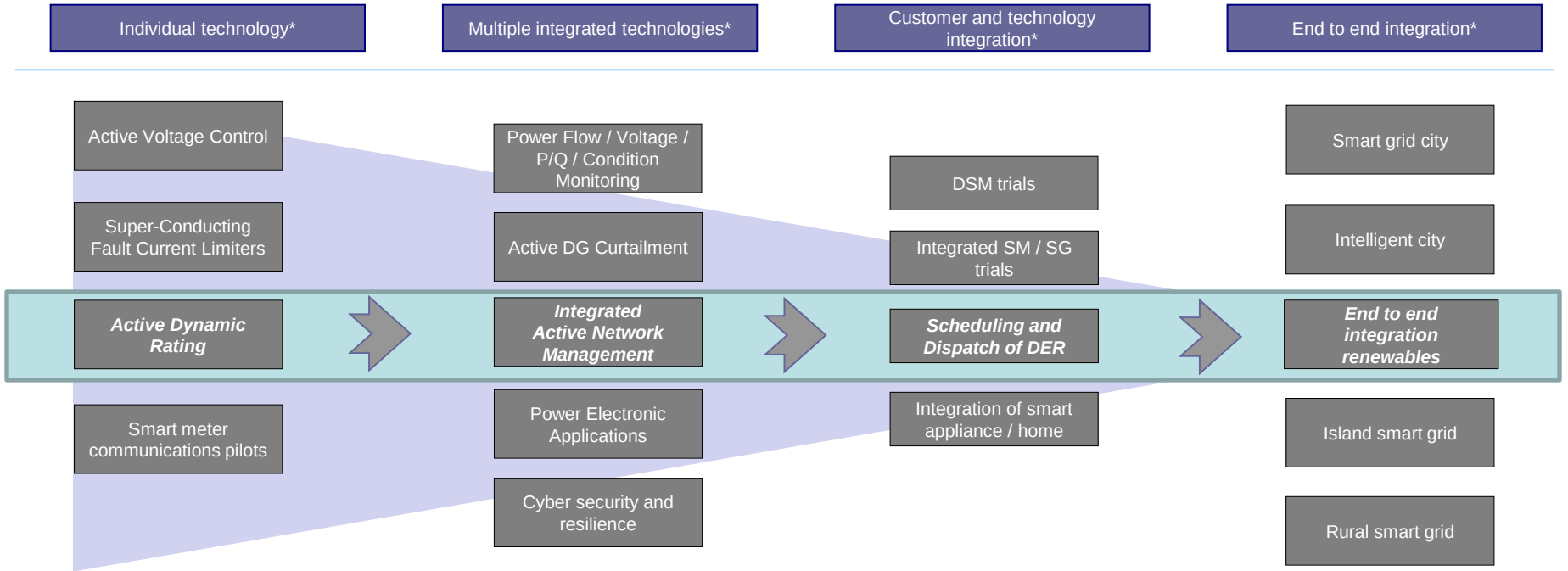
Pilot projects will continually and iteratively support each other as complexity and functionality is progressively layered



Coordination will be required to ensure that all pilot spend is driving toward a common and integrated goal



- ADR provides on the ground experience of integrating smart ICT with existing technology
- Prove out business case with reduced reinforcement costs
- Demonstrate network optimisation and means to add DER to the network without reinforcement

- ADR is a potential element of Integrated Active Network Management
- Builds on a number of regionalised ADR schemes and demonstrate region-wide interoperability
- Brings together ADR with other technologies and capabilities to prove out integrated ANM

- Integrated ANM can utilise DER
- DER for network benefits needs to be balanced against using DER to drive out benefits elsewhere
- The core ANM technologies need to be integrated with customer facing commercials and technologies

- Commercials, industry structures and associated data infrastructure tested to optimising usage of DER capacity including operation for ANM
- Optimised DER allocation considering challenges of increased renewable penetration

Learning and capability / capacity development flows from simpler pilots into the more complex – delivered through cross industry knowledge platform

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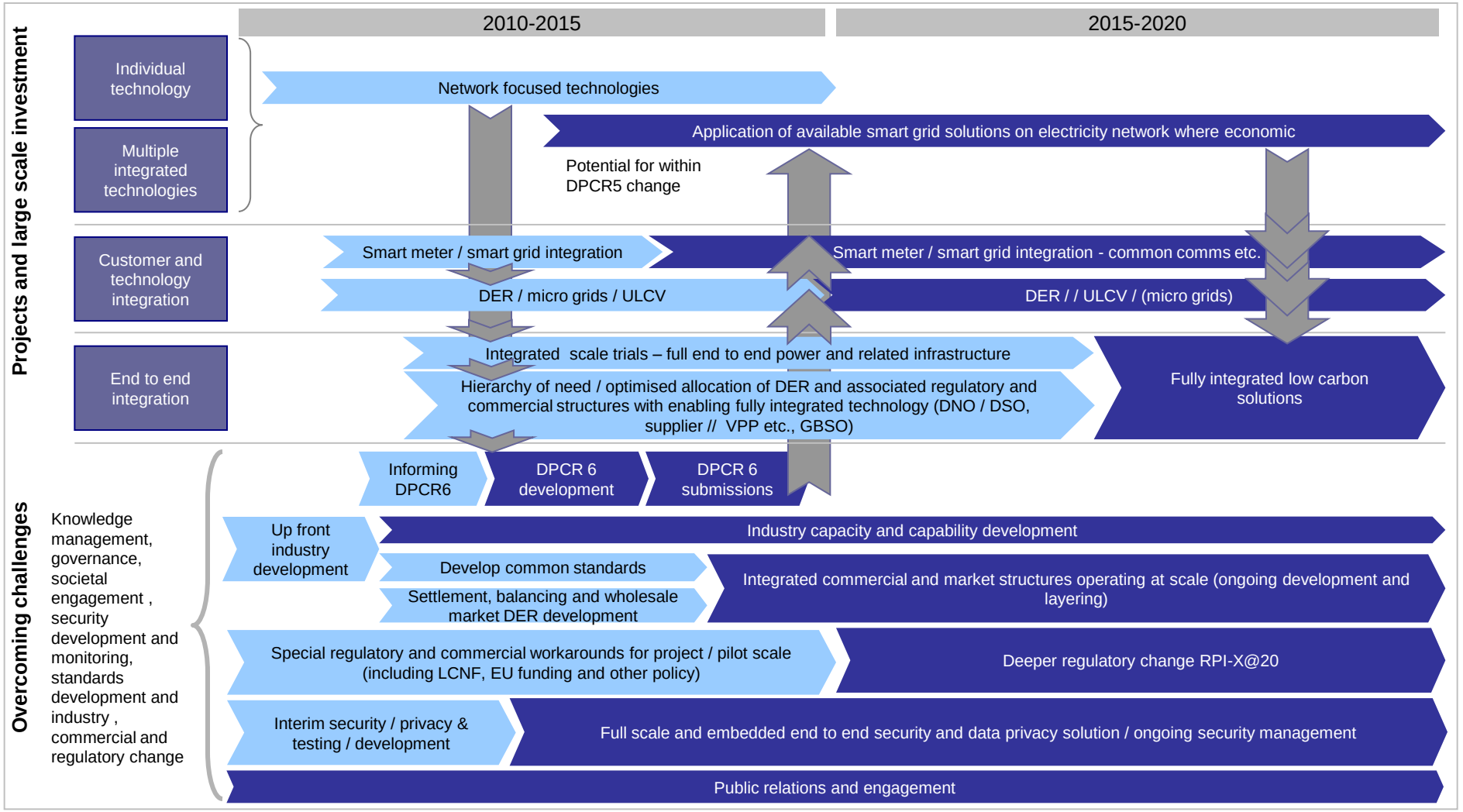
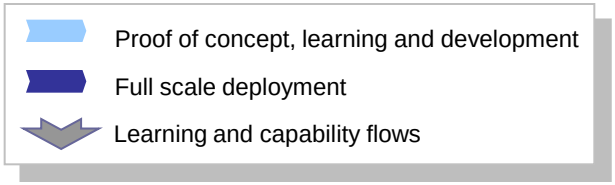
* A number of examples are given – it is not an exhaustive list of the potential trials in this category

Integrated UK smart grid routemap out to 2020 – delivering in the near term to prepare for the future

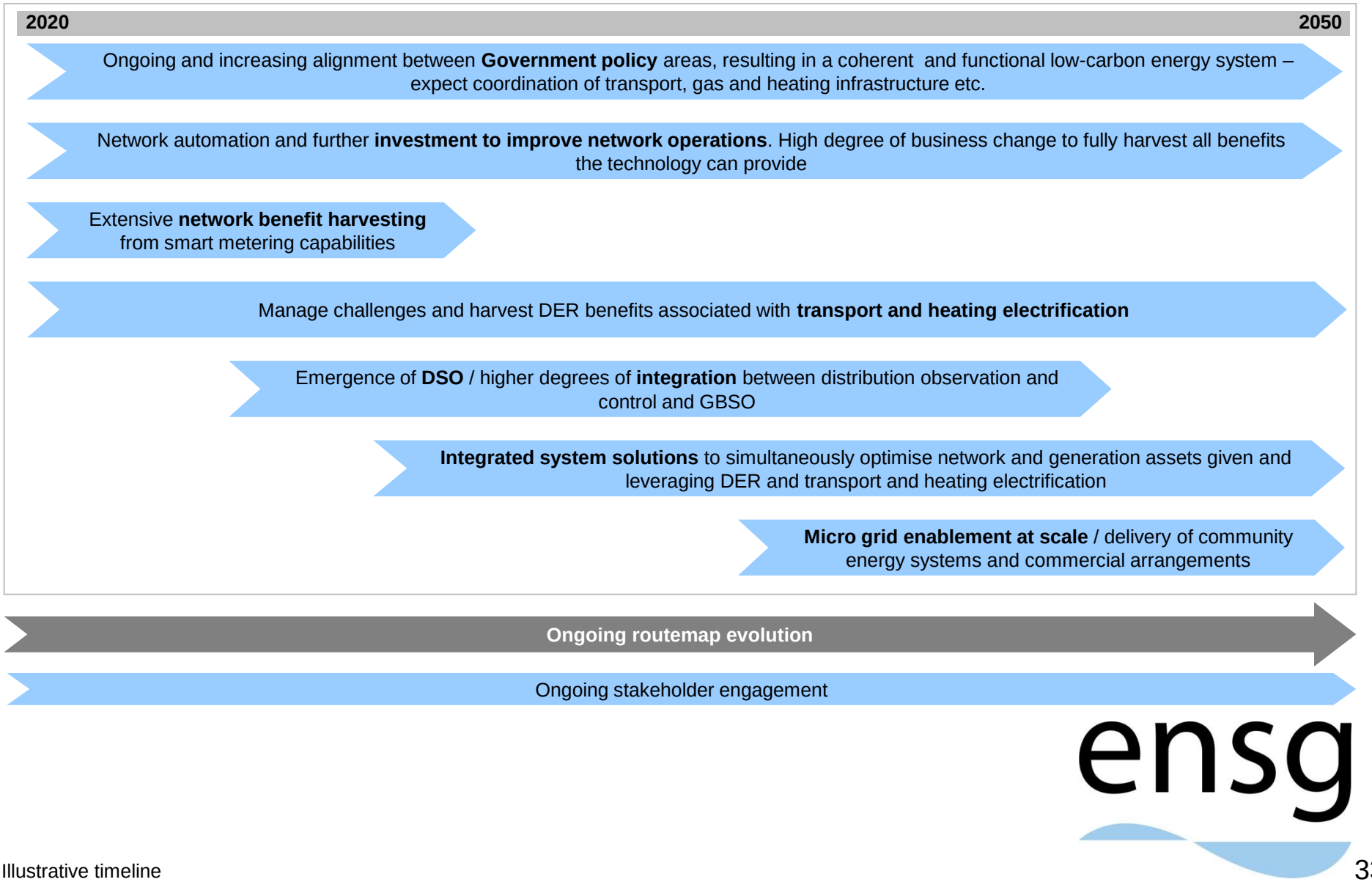


It is fully recognised that this routemap is ambitious. However, it is not intended to be a detailed smart grid plan. It is designed to help support ongoing discussion, decisions and actions. It is very important that routemap activities are delivered in a coherent way.



Illustrative *timeline*

Beyond the short term, a high-level routemap plots out potential activities and indicative timescales for action out to 2050



Illustrative timeline

Across both the short and long term ENSG believes there are a number of critical considerations for the delivery of the smart grid routemap

- A high degree of coordination across overlapping policy and the end to end energy value chain
- An emphasis on getting the customer on board as a key participant
- Common open standards and open access to drive a high degree of customer focused innovation
- A think-big, start-small and scale-fast approach
- Ongoing engagement between Government (local and central), Ofgem, industry and customer representatives
- Robust, thorough and embedded end to end security and data privacy solution with a degree of ongoing centralised management and enhancement

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Concluding remarks and next steps

Concluding remarks

- 'A Smart Grid Routemap' provides a high level view of the steps that need to be taken to progress the ENSG's smart grid vision
- Uncertainty remains over the precise nature of the UK's future end to end energy system, meaning that any vision or routemap will need to evolve over time
- This document and the ENSG smart grid vision provide the foundations for this evolutionary process

Next steps

- The right governance structure needs to be put in place to provide consumer representation and engagement and a coordinated joint approach between Government, Ofgem, industry and other stakeholders
- It is critical that the governance structure supports coordination between smart grid, smart metering and other relevant Government programmes e.g. Digital Britain

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Glossary

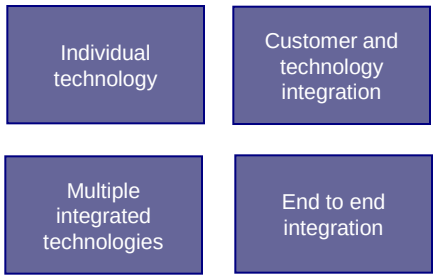
DER – Distributed Energy Resources (demand response, storage and distributed generation)
DPCR – Distribution Price Control Review
DG – Distributed Generation
DNO – Distribution Network Operator
DSO – Distribution System Operator
ESCO – Energy Services Company
GBSO – Great Britain System Operator
HAN – Home Area Network
ICT – Information and Communication Technologies
LAN – Local Area Network
LCNF – Low Carbon Network Fund
TPCR – Transmission Price Control Review
TSO – Transmission System Owner
ULCV – Ultra Low Carbon Vehicle
V2G – Vehicle to Grid
VI – Vertically Integrated
VPP – Virtual Power Plant
WAN – Wide Area Network

ENSG smart grid group members

Organisation
AEA
Association of Electricity Producers
CE Electric UK
Centrica Energy
DECC
EDF Energy Networks
Electricity North West Limited
Energy Networks Association
Energy Research Partnership
Energy Retail Association
E.On Central Networks
Energy Technologies Institute
Intellect
National Grid
Ofgem
Renewable Energy Association
RLTech
RWE Npower
Scottish & Southern Energy
Scottish Executive
Scottish Power
The Centre for Sustainable Electricity and Distributed Generation
Smarter Grid Solutions
The Carbon Trust
Western Power Distribution

Electricity Networks Strategy Group
A Smart Grid Routemap

Appendix – high level view of sample illustrative projects



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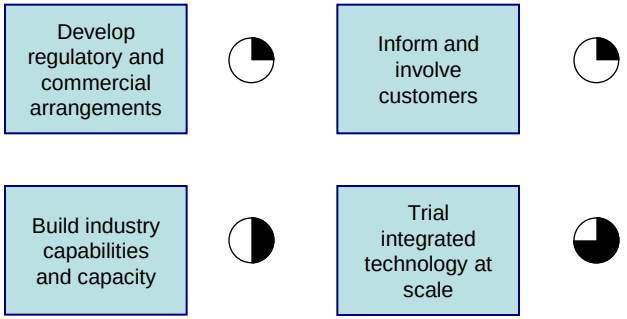
Individual technology

Potential pilot projects

Concept – Smart meter communications pilots

- As an extension of the network pilots, smart metering comms projects could test validity of different communications technologies
- Particularly valuable to trial technologies to understand localised challenges and potential synergies between smart grids and smart meters
- Could inform smart metering roll out design by investigating communication costs and roll-out strategies

Value



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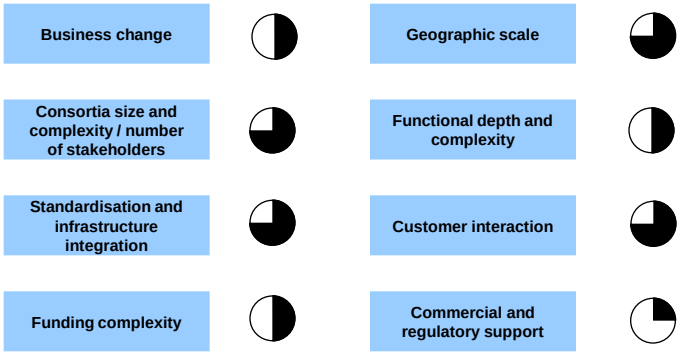


Key discussion points

- There may be a variety of different communication solutions operating in different circumstances on a needs, opportunities and challenges basis
- Any communication trials will need to be closely coordinated with the smart metering roll out

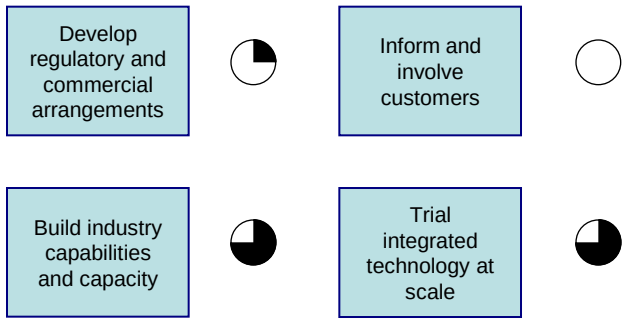
Individual technology

Potential pilot projects

Concept – Active Dynamic Rating

- Static conventional or seasonal ratings can limit the export capability of the existing network
- Further headroom can be accessed through the application of ADR
- ADR is applicable to overhead lines, underground cables and other network components, e.g. transformers
- Overhead lines are expected to provide greatest benefit through real-time monitoring of weather conditions and other parameters
- A number of challenges exist for planning, installing and operating ADR systems
- ADR has the potential to permit higher penetration of DG on to MV, HV, EHV networks by exploiting full thermal capability of equipment and avoiding network reinforcement

Value



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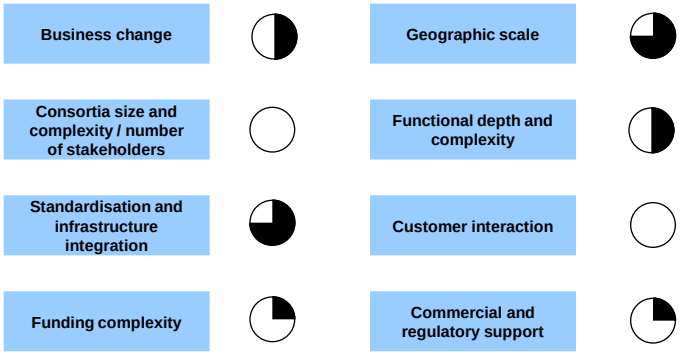


Key discussion points

- The technology has already been proved in the UK in the Skegness RPZ project
- But there could be value for other DNOs to develop ADR capabilities
- It will be important to see how DPCR5 incentives impact the level of use of ADR on a purely commercial basis

Individual technology

Potential pilot projects

Concept – Active Voltage Control

- Fine-tuning of the substation source voltage, according to the output of the generators, can prevent voltage-rise issues
- Enables the connection intermittent renewables to the MV network

Value

Develop regulatory and commercial arrangements		Inform and involve customers	
Build industry capabilities and capacity		Trial integrated technology at scale	

Effort

Business change		Geographic scale	
Consortia size and complexity / number of stakeholders		Functional depth and complexity	
Standardisation and infrastructure integration		Customer interaction	
Funding complexity		Commercial and regulatory support	

Key discussion points

- Piloting and development of this technology needs to be linked to assessments of the consequences of renewable connection
- It may be that DNOs roll this capability out at scale during DPCR5
- Opportunity to evaluate and enhance smart grid CBA

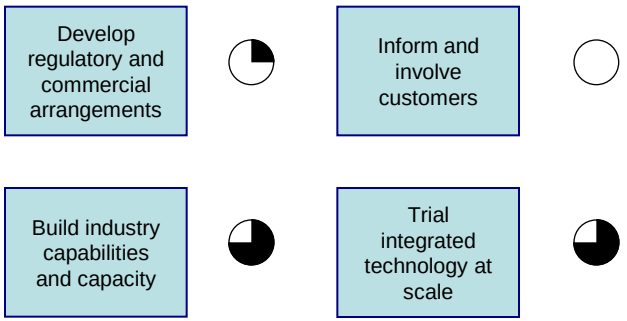
Individual technology

Potential pilot projects

Concept – Super-Conducting Fault Current Limiters

- Focussed particularly on dense urban environment
- 11kv symmetrical faults are proving a challenge to synchronous generation
- An SCFCL device accommodated potentially within the primary substation.
- A number of challenges exist in the implementing the technology, such as the recovery time of an SCFCL device
- Potentially provide increased fault level headroom to accommodate DG in super urban environments served by networks with high fault levels where future low carbon commercial development is likely to include CCHP

Value



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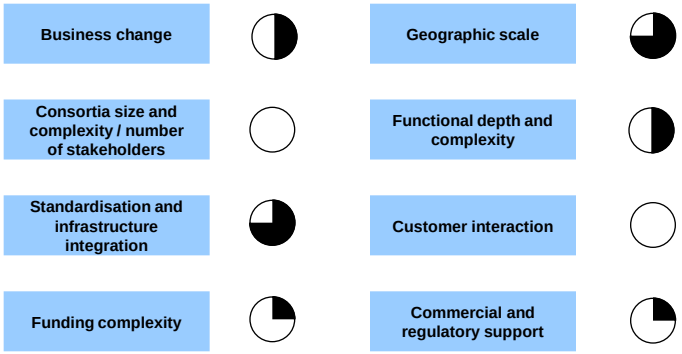

Key discussion points

- This is a technology that potentially needs to move swiftly to widespread application if certain developments occur

Multiple integrated technologies

Potential pilot projects

Concept – Active Network Monitoring

- Power flow substation monitoring at selected distributed substation sites
- Provide ability to capture HH time-stamped values from distribution substations using SCADA
- Would give an insight into real-time power flows & voltage regulation, hence capacity for DG/additional demand
- Power quality monitoring will provide visibility into p/q trends, important with DG and ULCV charging systems
- Condition monitoring technologies could provide early indications of potential failure and enable pre-emptive action

Value

Develop regulatory and commercial arrangements		Inform and involve customers	
Build industry capabilities and capacity		Trial integrated technology at scale	

Effort

Business change		Geographic scale	
Consortia size and complexity / number of stakeholders		Functional depth and complexity	
Standardisation and infrastructure integration		Customer interaction	
Funding complexity		Commercial and regulatory support	

Key discussion points

- This could be coordinated with local concentrations of DG and ULCV to inform short run approaches to managing the associated challenges
- Assess capacity to drive out network benefits and test business case

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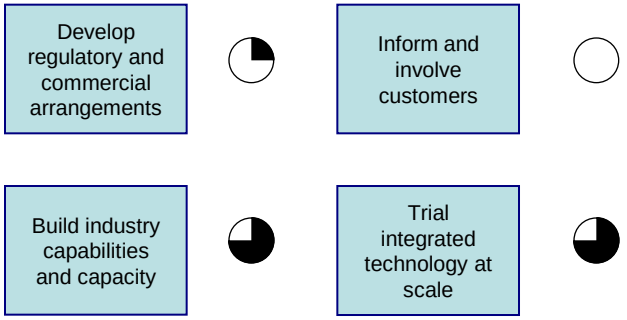
Multiple integrated technologies

Potential pilot projects

Concept – Active DG Curtailment

- Active curtailment of DG based on real-time monitoring of power flow or voltage
- Can be used in conjunction with Active Dynamic Rating to use loading constraints based on real-time rather than conventional or seasonal ratings
- Maximise penetration of distributed generation (especially intermittent) on to MV, HV and EHV networks by exploiting the natural diversity between DG output and (for intermittent generation) the reduced probability of maximum production coinciding with minimum offsetting demand

Value



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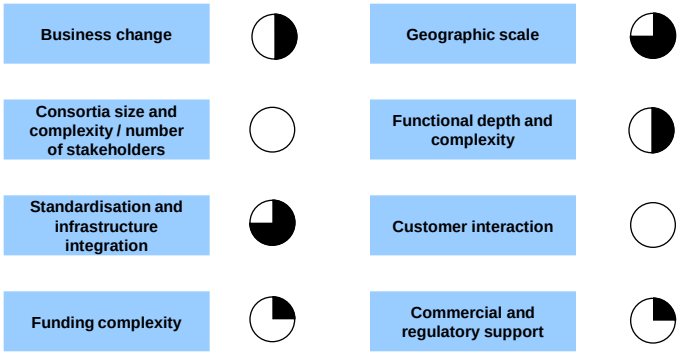


Key discussion points

- Potential for near term general application to overcome short run constraints
- Potential commercial issues to be resolved around curtailment of DG
- Collaboration with suppliers, VPPs, ESCOs etc. will be critical

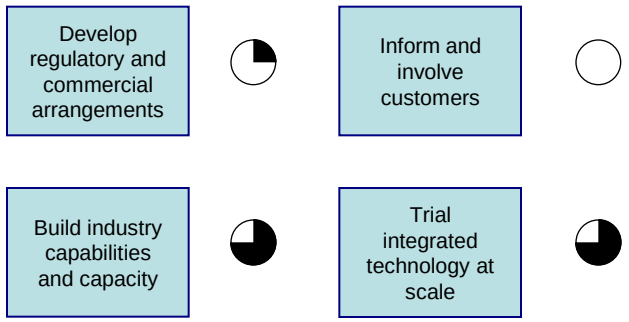
Multiple integrated technologies

Potential pilot projects

Concept – Power Electronic Applications

- Various technologies applied to the network can improve utilisation, power flow optimisation and power quality
- Devices and technologies include super-conducting cables, VSC-based HVDC links, and FACTs (Flexible AC Transmission System) devices such as Dynamic Voltage Restorers
- Technology exists, but study and planning is required to establish which technology is suitable, and how it will be applied

Value



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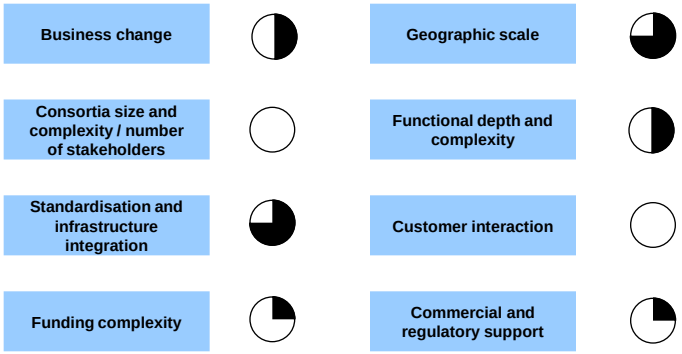


Key discussion points

- Critical to understand the cost / benefit trade-off of installing this technology under different network conditions

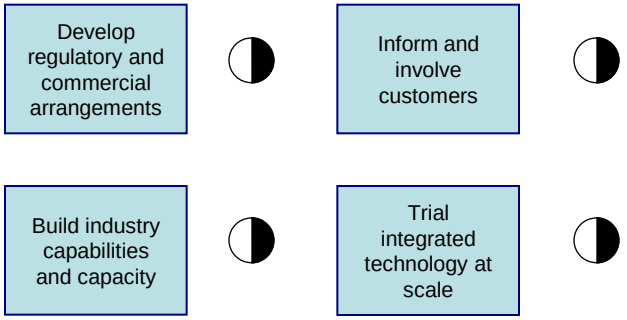
Multiple integrated technologies

Potential pilot projects

Concept – Embedded Storage

- Test capabilities around storing and use of electrical storage
- Can be used to shape the daily power profile
- Optimises network utilisation, potentially enabling higher penetrations of intermittent DG
- Potentially reduce the need for conventional reinforcement
- Potential to improve system losses
- Can provide a medium-duration standby energy source in the event of an upstream network outage
- Technologies are relatively well advanced

Value



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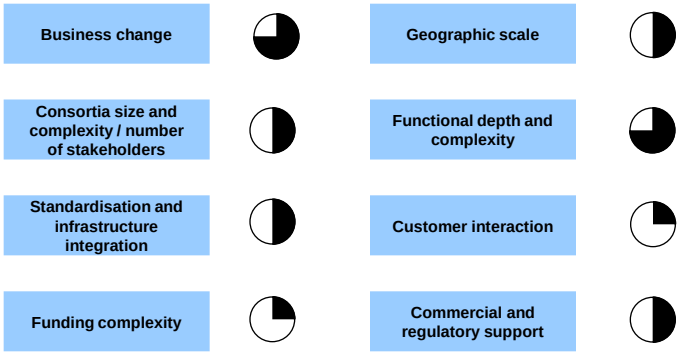

Key discussion points

- Embedded storage has significant future potential
- Need to trial a variety of different technologies at different scales
- Need to consider potential for heat based storage through pre-heating and cooling of buildings and potential interrelationship with CHP, heat pumps and district heating
- Collaboration with suppliers, VPPs, ESCOs etc. will be critical

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Multiple integrated technologies

Potential pilot projects

Concept – Integrated Active Network Management

- Provides enhanced opportunities for network optimisation (beyond conventional network automation)
- Provide proof of concept
- Evaluate opportunities and risks within controlled environment
- Will optimise capacity, DG/DER contribution, losses, and post-fault restoration

Value

Develop regulatory and commercial arrangements		Inform and involve customers	
Build industry capabilities and capacity		Trial integrated technology at scale	

Effort

Business change		Geographic scale	
Consortia size and complexity / number of stakeholders		Functional depth and complexity	
Standardisation and infrastructure integration		Customer interaction	
Funding complexity		Commercial and regulatory support	

Key discussion points

- Important to understand the costs and benefits
- Need to deliver associated business change
- Consider integrated use of DER and reflect into understanding relative value of DER for network optimisation vs. other objectives
- Utilise to evaluate material CBA assumptions around voltage optimisation and technical loses
- Specifically assess capacity to deliver energy and hence carbon savings and consider potential for widespread application to contribute to 2020 targets

Multiple integrated technologies

Potential pilot projects

Concept – Smart Asset Management

- Utilise new data flows from the network associated with edge and within network sensing to enhance asset management capabilities and performance
- Develop new asset management processes and principles and embed into working practices
- Assess the regulatory incentives to drive out asset management benefits – considering required capability investment

Value

Develop regulatory and commercial arrangements		Inform and involve customers	
Build industry capabilities and capacity		Trial integrated technology at scale	

Effort

Business change		Geographic scale	
Consortia size and complexity / number of stakeholders		Functional depth and complexity	
Standardisation and infrastructure integration		Customer interaction	
Funding complexity		Commercial and regulatory support	

Key discussion points

- Possibility of significant benefits from wide scale adoption during DPCR5 leveraging the smart meter roll out

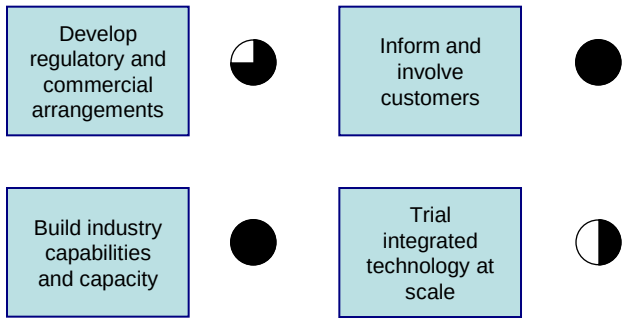
Customer and technology integration

Potential pilot projects

Concept – Demand Side Management Trials

- Geographically narrow with high degree functionality across power system infrastructure
- Integrates a variety of technologies, particularly in the home and across the distribution network
- Drive through peak shaving and shifting
- Extensive customer engagement and potential non-utility vendor interest
- Potential small consortia involving DNO and single supplier, as well as suitable vendor proprietary equipment such as fridge or heat pump
- Funding across the organizations involved

Value



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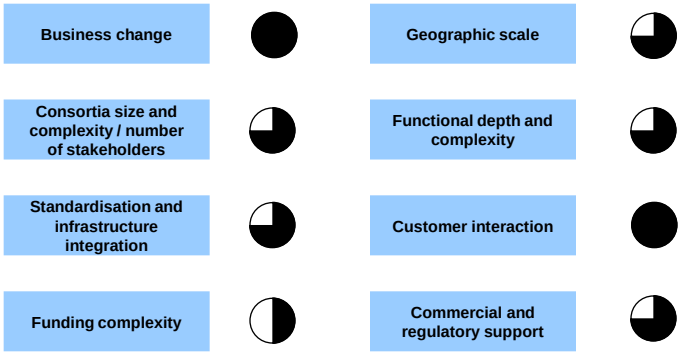

Key discussion points

- Understanding the relationship between marketing, commercial arrangements, technology and customer behaviour is critical
- Need trails to provide understanding of potential scale and inform future strategies
- Will have to integrate changes to key industry processes and systems e.g. Settlement
- High degree of interdependency with smart metering
- Need to rapidly assess best means to scale capacity and efficiently allocate given the anticipated rapid growth in inflexible generation toward 2020 and potential contribution of DSM
- Need to link with wider DER
- Collaboration with suppliers, VPPs, ESCOs etc. will be critical

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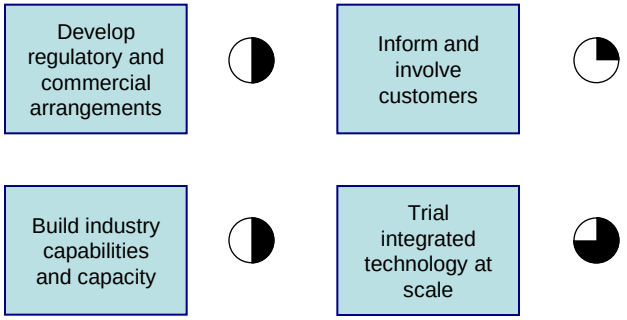
Customer and technology integration

Potential pilot projects

Concept – Integrated smart meter/smart grid trials

- Testing out the next level of integration between home and grid, but less integrated than full demand response
- For example, proven communications between meters and substation meters
- Potential small consortia between DNO and supplier around exchanging energy usage data and power quality information (without necessarily acting on that information at this stage)
- Opportunities for DNOs to develop capabilities to rapidly realise benefits from smart metering data

Value



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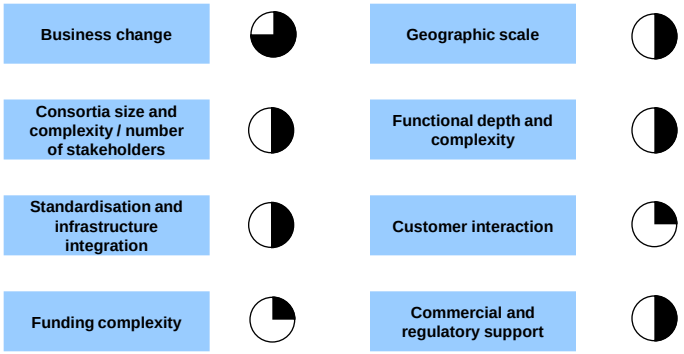


Key discussion points

- Rapid realisation of network benefits from smart metering data possible if DNOs have the capabilities and understanding to response
- The reaction of the DNOs will have a strong relationship with the regulatory framework
- Collaboration with suppliers, VPPs, ESCOs etc. will be critical

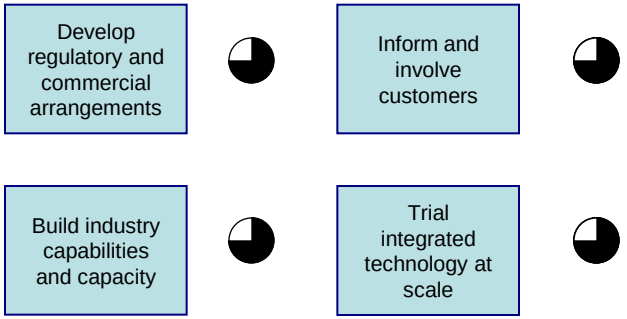
Customer and technology integration

Potential pilot projects

Concept – Scheduling and Dispatch of DER

- Virtual Power Plant (VPP) technology allows potential aggregation of local generation and demand management
- A number of geographic networks could receive a trial of this nature to examine the technical and commercial feasibility of VPP operation in the context of the UK's 'unbundled' industry structure
- Potentially could provide widespread clarification of the optionality around the potential new roles of DNOs
- Has a dependency on the provision of smart meters and associated communications

Value



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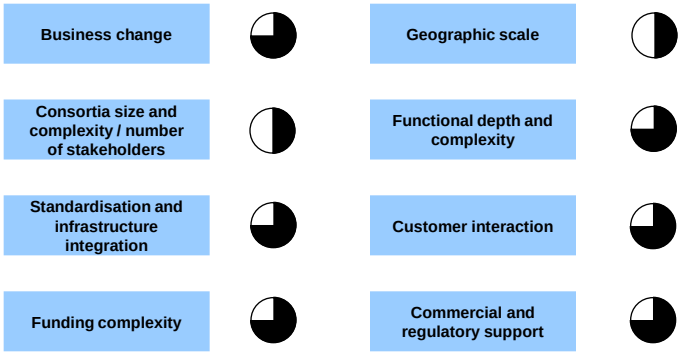


Key discussion points

- Need to consider the role of new entrants within pilots
- Strong linkage with industry structures and challenge of optimising DER allocation
- Customer interaction through suppliers etc. will be critical

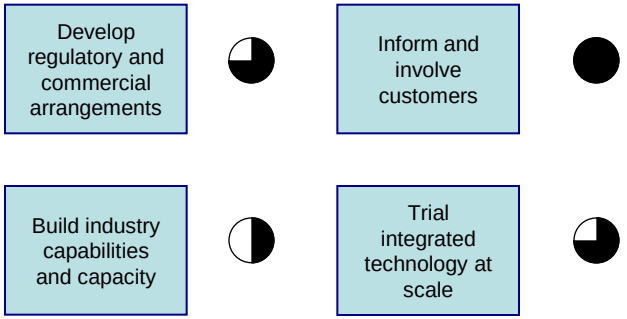
Customer and technology integration

Potential pilot projects

Concept – Network integration of smart appliance / smart home

- Involving suppliers, DNOs and third-party vendors, to investigate active demand response capabilities
- Important opportunity to test public opinion and response to demand response in a closed, tightly controlled trial environment
- Aid development of third-party open standards between HAN technologies (e.g. ZigBee) and home appliances
- Establish indicative numbers for demand response take-up
- Investigate the challenges (technical / regulatory / security) around data integration and use between third-parties, suppliers and DNOs

Value



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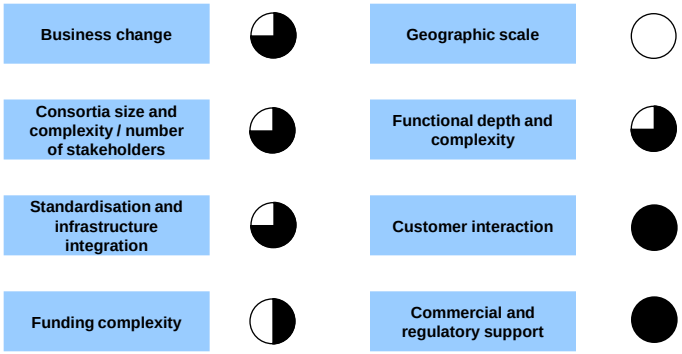

Key discussion points

- Strong linkage in DER trials
- Customer interaction through suppliers, VPPs, ESCOs etc. will be critical
- Customer focused innovation will be key with opportunities for new entrants

Customer and technology integration

Potential pilot projects

Concept – Security and resilience

- Smart grid communications and data structures must be both secure and resilient
- Aim to ensure secure access and data management for all smart grid stakeholders, across the value chain
- Will be aided by technological standardisation
- Security and resilience encompasses several factors, for example unauthorised logical access to components/devices; greater probability of component failure (software and network) due to more complex operation and interoperability; more maintenance activities, e.g. patch management

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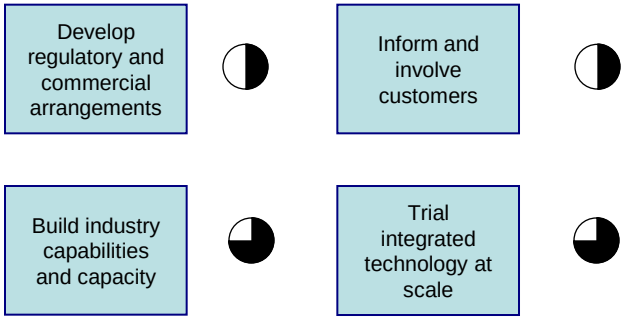

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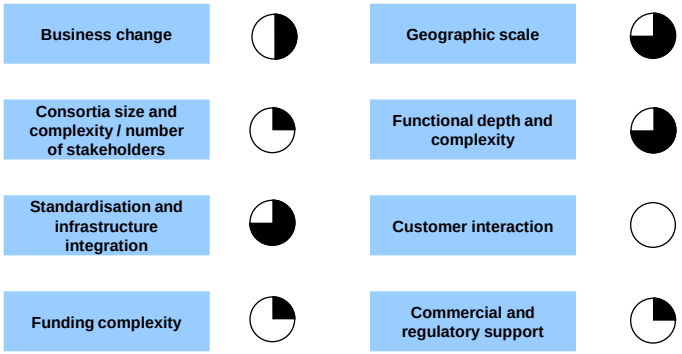

Key discussion points

- This needs to be a part of every trial but should also be tested individually to make sure all aspects of security and resilience are comprehensively covered
- Requires holistic assessment of all potential threats and vulnerability
- Require a degree of centralised coordination
- Need to consider both actual threat and perception of threat as part of stakeholder management activities – security is both about protecting and giving confidence that the protections are robust

Customer and technology integration

Potential pilot projects

Concept – Trialling new network charging regimes

- Assess potential for network charging regimes to drive toward optimised allocation of DER etc. given network constraints and opportunities
- Assess commercial / industry challenges and impact upon customer charges and billing

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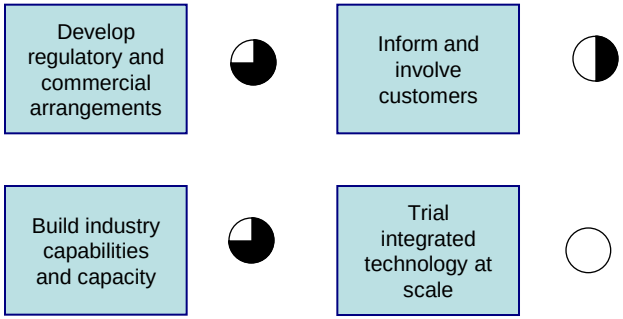

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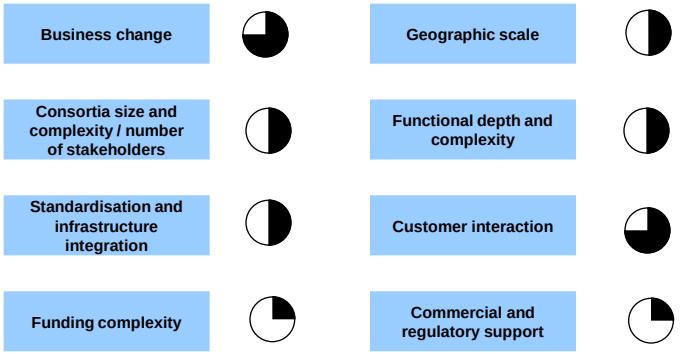

Key discussion points

- Need to compare against other means of efficiently allocating DER
- Customer equity could be an important issue and could be highly controversial

End to end integration

Potential pilot projects

Concept – Smart Grid City

- Geographically narrow with high degree functionality across power system infrastructure
- Integrates a variety of technologies to assess capacity to work together e.g. distribution connected wind supported by embedded storage, CHP dispatch and demand side management
- Showcase project with extensive customer engagement and public relations activities
- Small consortia involving DNO and supplier on proprietary technology
- Additional funding from local government

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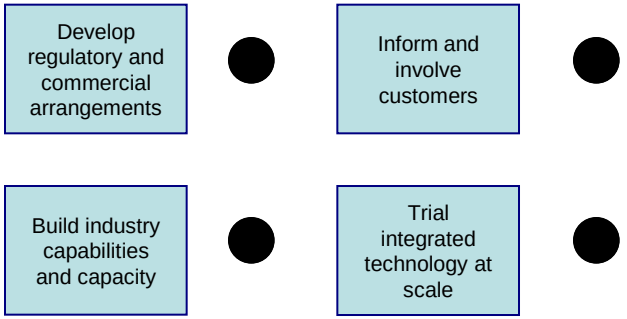

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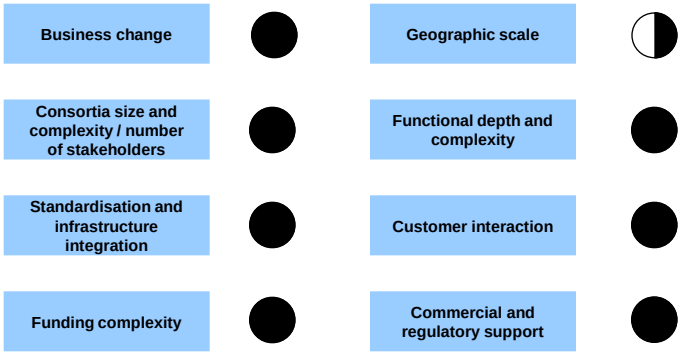

Key discussion points

- Big opportunity to capture the public imagination – public relations needs to be an integral part of the plan
- Bringing together a large number of diverse stakeholders will be critical
- Projects will be complex and risky so governance and clear SLA, risk management etc. is crucial
- Need to consider potential to integrate with EU SET funding and other funding sources
- Targeting fuel poverty could be a key element

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End to end integration

Potential pilot projects

Concept – Intelligent city

- Using the smart electricity city as its framework, the intelligent city incorporates a cityscape fully integrated with the various urban/super-urban infrastructure
- Integration with smart buildings (not just homes/industry), transport, water, waste, public safety (through real-time infrastructure information) and heating and cooling

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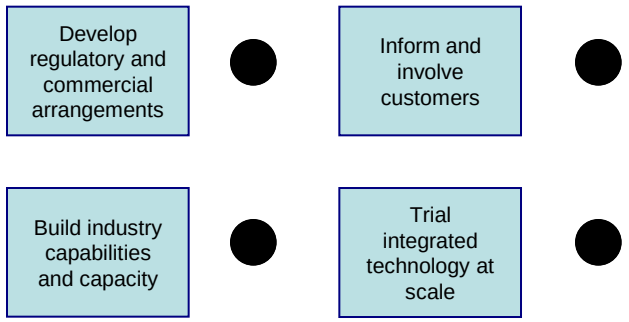

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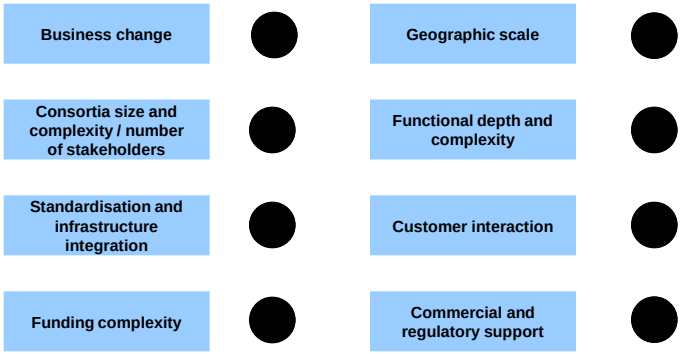

Key discussion points

- Integration with other infrastructure must provide clear benefits as opposed to being integrated for the sake of integration
- Requires significant municipal cooperation, public/private financing, and clear regulatory and commercial incentives for all parties involved

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End to end integration

Potential pilot projects

Concept – Rural smart grid*

- Consortia-developed smart network over a rural, smaller-scale archetype
- Could incorporate a number of network technologies (voltage control, ANM, dynamic line ratings)
- Also demonstrate smaller-scale DG, VPP and storage integration
- Local ULCV infrastructure in place for charging and battery exchange
- Smart home functionality, extending to smart meters and IHDs and energy efficiency information

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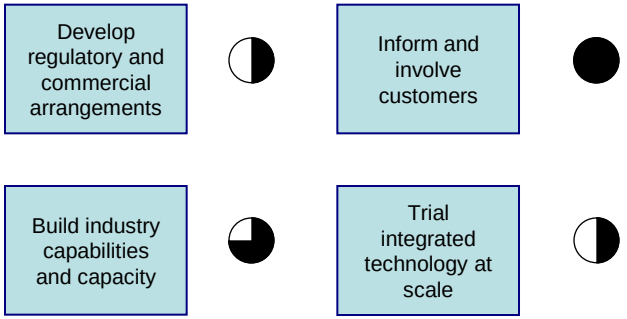

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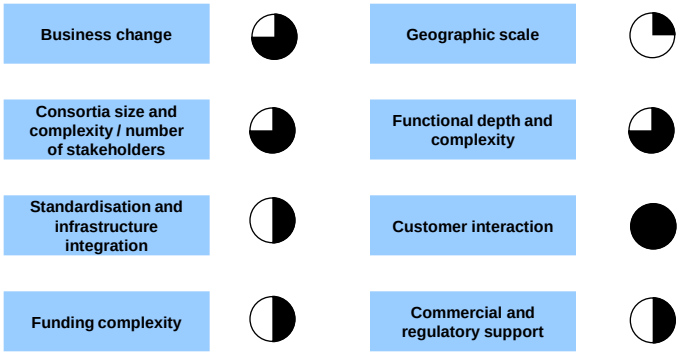

Key discussion points

- Opportunity to demonstrate community approaches to energy
- Specific considerations of customers without grid gas supply
- May present specific communications challenges

* from ENA presentation to ENSG, 12 October 2009

End to end integration

Potential pilot projects

Concept – Island smart grid

- Consortia-developed smart network over an island archetype
- Test and enable the incorporation of various forms of generation where they may be a lack of supply of other energy resources
- Test distribution capacity to handle microgeneration, distributed generation, and on- and offshore renewables
- Islands are also conducive to ULCV use

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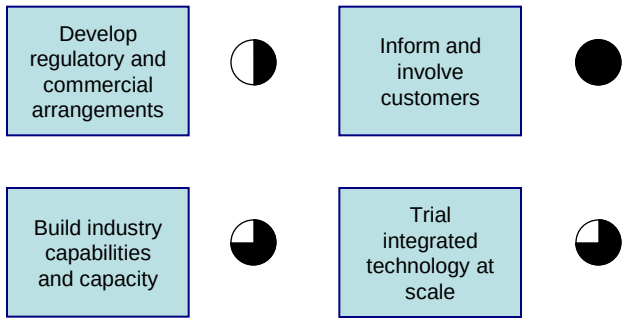

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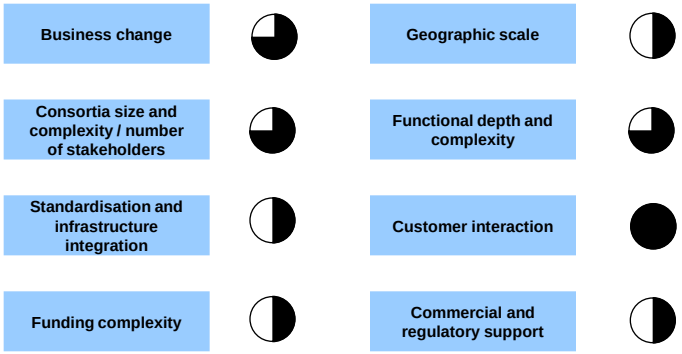

Key discussion points

- Strong community cohesion may encourage take-up of technologies and enable benefits to be widely disseminated

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End to end integration

Potential pilot projects

Concept – End-to-end integration of intermittent renewables

- Creating a 'representative model' of the UK's future smart energy system
- Potentially combines multiple DNOs, multiple cities, multiple island and rural networks, multiple forms of generation (large-scale, on- offshore wind, DER) to create a 'mini' map of the UK's total energy system
- Significant consortia, funding and regulatory challenges
- However, would be the first step towards creating a fully cohesive Smart Grid UK

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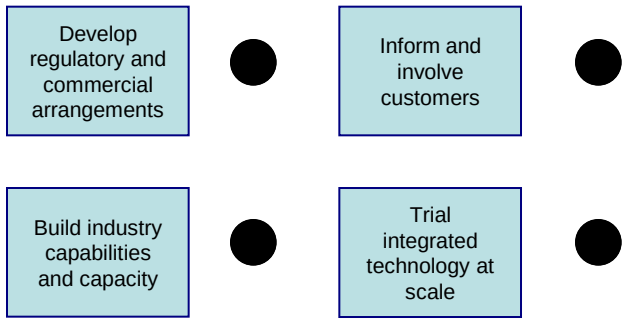

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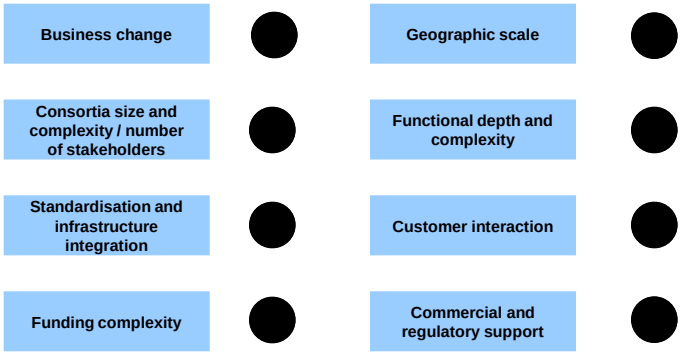

Key discussion points

- Significant value to prove out end to end solution
- Will straddle across the industry including commercial and regulatory frameworks, technology and deep industry change
- Needs to adapt to further insight about the UK's probable low carbon path

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