ReCOSTING ENERGY

POWERING FOR THE FUTURE

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EPISODE ONE of the ReCOSTING ENERGY Box Set

ACKNOWLEDGEMENTS

We would like to thank all those that have been so instrumental in helping us shape this report's findings and recommendations. Ideas, inputs, insights and analysis from many quarters have been crucial in developing our thinking and for their time and guidance, we are exceptionally grateful.

We are particularly appreciative of our financial supporters who come from a wide spectrum of the UK and New Zealand energy industry – from renewable generation, system managers, integrated utilities, distribution network operators, industry associations, and suppliers. We have called on their expertise and they have dedicated a significant amount of time to working with us to define the problems and solutions.

In addition we have benefited from significant insights from the Energy Systems Catapult and PwC, and with special input from Professor Catherine Mitchell, Dr Jeff Hardy and Nigel Cornwall.

Frontier Economics, LCP and the modelling team at BEIS have been core to developing our new metrics that for the first time compares the full system costs of generation with demand assets and actions. We hope that these metrics will be of use to policy makers, regulators and the wider energy sector to drive the best decision making.

We have also engaged, listened and noted recommendations, advice and observations from over 250 organisations from across the sector and beyond. There has been "push back", "push further" and some saying "impossible". We have adopted many suggestions, politely ignored others, but welcomed all of them, and have aimed to shape a set of recommendations that we believe meet the challenges for the future.

Despite the sector's generous support and input throughout the project our financial supporters are not responsible for, or totally in agreement with, all the outcomes. However, we hope that they, like us, believe that this is a useful contribution to shaping the future of a very exciting energy sector.

Laura Sandys, Challenging Ideas

Thomas Pownall, PhD Candidate in the Energy Policy Group, University of Exeter

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INTRODUCTION

CAPTURING THE DECARBONISATION DIVIDEND

The nature of Net Zero

Net Zero is a very different concept from the old fashioned "generate, dispatch and deliver" model that has guided our energy system to date. At the heart of Net Zero is productivity, doing more with less and reengineering business incentives away from "more" to "better". Our optimism for the future lies with our vision that Net Zero is not only a climate imperative, but also must drive significant modernisation, unlock greater productivity and deliver full system cost reductions and operational efficiencies for the benefit of consumers, the economy and the planet.

We also recognise that, while the decarbonisation destination is pretty clear, the pathway towards Net Zero will be messy. Policy, regulatory and industry responses will need to be recalibrated and flexible in the face of new opportunities, new challenges, new evidence and experiences of the interaction between carbon, capital, capacity, cost and consumers.

At the heart of Net Zero is productivity, doing more with less and re-engineering business incentives away from "more" to "better"

The Crossroads

The energy system has reached a crucial crossroads. The deployment and utilisation of varied renewable assets has shown that renewables can perform, that the system can manage the change in the characteristics and behaviour of these new assets and that there are investors and developers with confidence in the future of the decarbonisation journey.

However, we are at the foothills of the decarbonisation journey with mobility and heat still in front of us and this is the time to design our system around a new exciting and modern energy world – and capture the Decarbonisation Dividend.

We have a choice – do we continue trying to squeeze a new system, with different characteristics and new potential, into our old fossil fuel market design? Or do

we recognise that decarbonisation offers us significant advantages over the old system and change how we design, shape and regulate the sector going forward to capture these opportunities?

The New World Assumptions

SUPPORT CAPITAL NOT COMMODITIES:
£20bn per annum in capital required to decarbonise
The operational cost of generating the commodity is reducing while the need for capital is increasing. And capital is needed to unlock investment throughout the system, from consumer mini-assets to midi-sized assets and large projects. These are not easily unlocked through a commodity priced system.

DELIVERING NEW VALUE:
From Generate, Dispatch and Deliver to Optimised Utilisation
The value within the system is not the commodity but how you manage, add value to and optimise the commodity. The sector is moving from a few players to the potential of 50 million assets and actions and the value will lie with multiple actors, across blended products and services creating a patchwork of actions.

DELIVER A NEW CUSTOMER EXPERIENCE: From Commodities to Services
Services, products with embedded energy consumption, energy management and new business propositions will enable customers to purchase tailored outcomes that are interesting and life-enhancing.

Fair and equitable access to the assets that deliver value for consumers will need to be "translated" into an appropriate pricing mechanism that works for customers and allows them to benefit from the transformation.

These new customer-centric business models might well be delivered through financial services and long-term contractual relationships, unlocking their access to EVs, PV and system management products and services.

Unlocking the Value Gap

The current value sits between the silos and is restricted from flowing from one silo to another. This will need to change to optimise the system.

The Journey We Must Take

Released as a Three-Episode Box Set

EPISODE ONE:

- **Introduction:** Outlining the opportunity of decarbonisation
- **Smouldering Platform** Highlighting the problematic trajectory of our current system design
- **Executive Summary** Providing the highlights of the project

EPISODE TWO:

- **From Fossil to Low Carbon:** Making low carbon the default option, and putting in place increased barriers to fossil fuel options
- **From Silos to Whole System:** Measuring the full system impacts of actions, policies and regulation
- **From Brawn to Brains:** Greater focus on technology, digitalisation and the skills required to manage the growing complexity and dynamism of the system
- **From the Few to the Many:** Capturing the exciting opportunities to deliver citizen benefits by unlocking access and value from their actions and assets

*** NEW: New Metrics comparing the value of demand actions with generation assets ***

EPISODE THREE

- **From Supply to Demand:** Shaping the system around customers' needs and unlocking the assets they need to decarbonise
- **From Commodities to Services:** Moving from commodities traded to services procured and delivered through a wide range of capital assets and customer actions
- **From Spreading Risk to Owning Risk:** System risk being owned by business, not passed on to the consumer to pick up the pieces
- **From Subsidies to the Market:** Building a stronger PPA and merchant market and focusing support on immature technologies

Building on ReDesigning Regulation and ReShaping Regulation

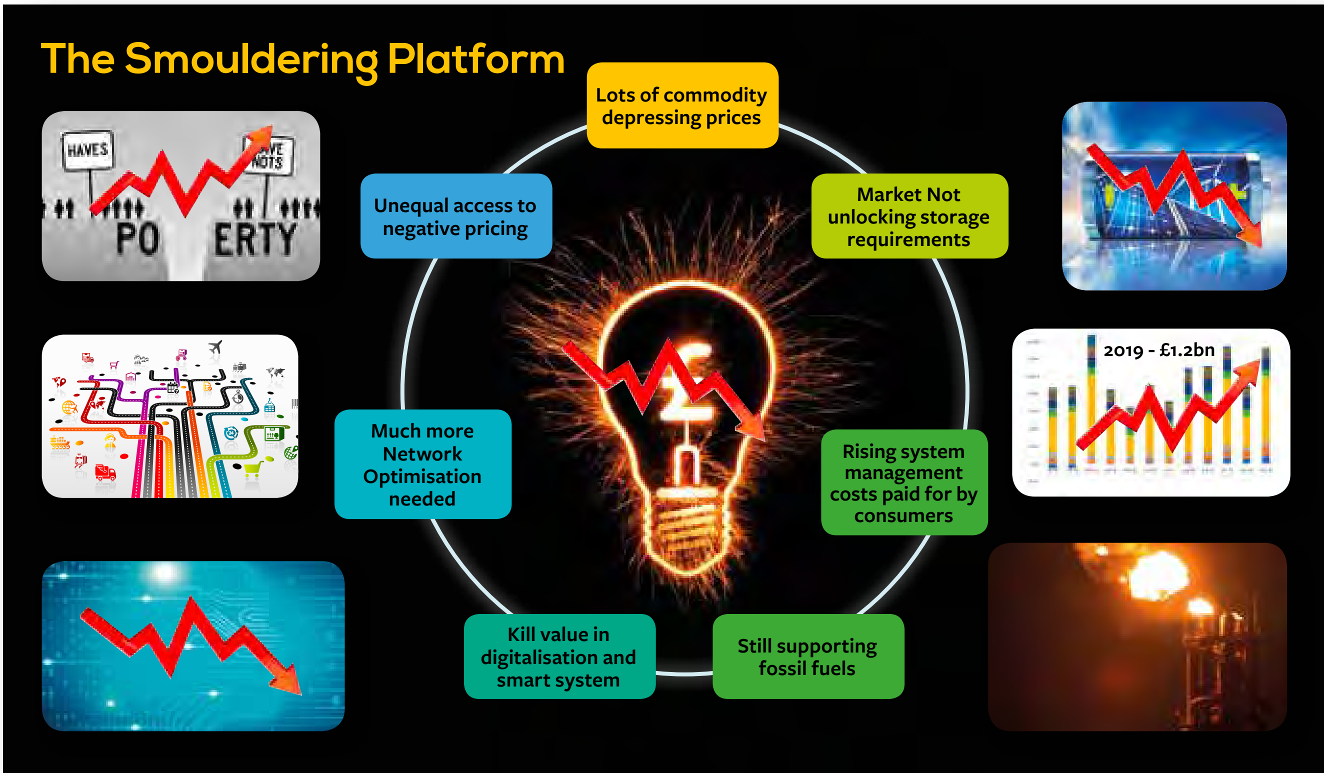
- **Start at the "plug" not the power station:** Consumers must be the first driver of value
- **Get More from Less:** Optimising the full system costs, unlocking the new value through data, digitalisation and exciting new business models
- **From the Few to the Many:** Moving from a linear system with few actors to multiple actors, actions and assets interacting to offer new opportunities and benefits, and pose new risks

TODAY

IS THERE A SMOULDERING PLATFORM?

Today's Realities, Tomorrow's Risk

Some believe that we can muddle through and simply extend our current arrangements as we go. This would be to ignore some of the misalignments that exist today and will be exacerbated into the future – potentially turning a smouldering platform into a burning one.



THE COMMODITY NEEDS PROCESSING
We are focused on generating lots of commodity with not enough focus on storage, hydrogen and the processing of excess commodity. This will result in growing waste, increased curtailment costs and system management challenges.
RISK: We will create 'milk lakes' and 'butter mountains' without investment in processing, managing and adding value to the commodity

MARKETS NOT UNLOCKING THE RIGHT ASSETS
Markets designed to optimise the system are limited in scope, short term in nature and are being cannibalised. They are evidently not unlocking investment in commodity "processing".

Long term storage in particular, which has a different investment journey, cannot be served by the current short-term market structures.
RISK: With not enough "processing" assets on the system we will require significantly increased investment in the commodity – and its waste – costing the consumer more.

DEPRESSED COMMODITY PRICES
It is calculated that by 2030 renewable electricity could cost $10/MWh which will require more government "top-up" to unlock the capital investment. Support mechanisms further depress prices, distorting the merchant and PPA markets.
RISK: As the current system

depresses prices further, more and more government support will be needed to unlock the investment at the same time as undermining the merchant and PPA markets

SOCIALISING THE RISK WITH CONSUMERS PICKING UP THE PIECES

With the increasing misalignment between supply and demand, the responsibility for the risk does not sit with those that create it but is picked up by consumers. The Energy System Operator (ESO) used to manage 5% of the market and is now having to balance up to 17%.

THE CHANGING WORLD OF COMMODITIES: THE DATA JOURNEY
In 1967 1 Mega-Byte cost $1million; today the estimated cost of sending a 1 Mega-Byte file is $0.001

RISK: While commodity prices might fall, the costs move to system management and become an increasing part of consumers' bills, attracting very negative attention while also posing a risk to the system stability

STILL SUPPORTING FOSSIL FUELS

Markets, government schemes and regulatory requirements are still pivoting towards fossil fuel outcomes. Staggeringly, low carbon priorities are not embedded in licences and obligations across monopoly actors or within government schemes.

RISK: We still allow through regulation and policy for some of the dirtiest flexibility responses to be rewarded and the important value of flexibility flows to fossil fuels rather than decarbonised options

Proportion of fossil fuel generation

Table 1: Value, size and carbon intensity of electricity markets

Market	Value (2019)	Size (2019)	Carbon intensity
Balancing mechanism	£590m	Abs: 20,000 GWh Net: 630 GWh	Fossil fuels >99% of turn up
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Source: BEIS 'Carbon in Flexibility Markets' workshop, 14th October 2020, p. 10

KILLING DIGITALISATION AND MODERNISATION

With too much commodity at low prices there will be fewer incentives to invest in optimisation, and new technologies to unlock greatest value or utilisation of the range of assets on the system.

RISK: We don't have investment in the crucial digital system management tools

UNEQUAL ACCESS TO NEGATIVE PRICES

While there are benefits flowing to those that have the assets able to participate in negative pricing opportunities, these benefits are only available to those with the expensive capital assets.

RISK: While a limited problem today, this will become an increasing inequality going forward with the fully loaded costs of the system falling on those who do not have access to these assets.

And then to the Customer...

The Customer is the Victim at the end of the line

The energy sector is almost unique in passing on all risks to customers with very little risk self-managed, and limited penalties for passing risk from part of the system to another. In other sectors more risk is absorbed, driven out or mitigated by companies through supply chain pressures, service and contractual relationships, product differentiation and appropriate "ownership" of risk.

To compound these risks the customer has almost no way of mitigating them. Just consider the risks that they face:

- **Commodity:** War between Iran and the US, as the commodity is still linked to global fossil fuels
- **Weather:** What time of day energy is available
- **Stability of the System:** The small but important costs of the system stability are not borne by the companies that create it but passed on to consumers
- **Misleading Comparison Sites:** Some switching sites are neither transparent nor reflective of the price ultimately experienced by the customer
- **Supplier Competency:** If their supplier is a good or bad hedger
- **Supplier Failure:** All consumers end up paying for business failure
- **Quality Control:** Little transparency on whether their energy really is green or not
- **Limited Options to reduce costs:** Limited products or services that allow for mitigation of these costs
- **Smeared Cost Allocation:** Finally, all these costs are not allocated to those customers who created the problem but smeared across all consumers

If not addressed soon, customers will be angry – and rightly so – at the rising costs that should sit within businesses but which they are currently picking up

Will the platform burn?

Today is becoming tomorrow with many of the new characteristics of the system hinted at during the COVID-19 lockdown.

Some would say that COVID-19 has given us a peek into the future – and the future might not be so distant. The smouldering platform will become a burning platform if we don't address the misalignments today before we start the heavy lifting of decarbonising heat and transport.

If we continue along this trajectory:

- **Zero Marginal Cost:** Similar to other sectors the electron is losing value and will further reduce over time
- **Commodity Overload:** We will create massive milk lakes and butter mountains
- **New Dynamic and Variable Peaks and Troughs:** The new normal will pose dynamic and varied peaks and troughs with significantly increasing system stability costs – both inter-day but, just as importantly, inter-seasonal. The market design does not value seasonal differences or unlock high seasonal peak needs, with virtually no investment in winter storage capacity
- **Dumb Network System Management:** Expensive and wasteful reinforcement
- **Increased Socialisation of System Costs:** Cost of system stability and security risk rising and increasingly socialised
- **Funding Waste:** Increasing payments for constraints, imbalance and dumped electrons
- **For the Few not the Many:** Access to assets and actions that reduce bills are only available to those with capital and sophisticated energy needs, with the rest of the population picking up the costs
- **Consumers Picking the Parcel:** Risk and the costs associated are passed from one actor to the next with limited risk lying with the risk creator. At the end of the day the consumer has to pick up all these risks and costs
- **Consumer Veto:** Consumers lose support for the decarbonisation journey due to unnecessary socialised costs.

EXECUTIVE SUMMARY

SHAPING A NEW FUTURE

The current energy market design, its funding mechanisms, what markets value, and the role of consumers were conceived in a fossil fuel, top down, pre-Net Zero world. We are moving from a system dominated by few more than 200 key players to a system with millions of assets and actions. This extraordinary challenge of moving from a linear system to a messy, diverse and different system requires fundamental changes to unlock the opportunities.

The current market design and governance regime is not wholly wrong, but there needs to be a new set of ambitions and an accelerated change in policy, regulation and market design before we embark on deeper decarbonisation of heat and transport.

Overview of All Recommendations

EPISODE ONE

Objective
- **More from Less** – From Consumption to Optimisation

Outcomes
- **Reward Customers**
- **Reveal Value**
- **Unlock Investment**

EPISODE TWO

Building Blocks
- **Carbon Busting** – From Low Carbon to Net Zero
- **Fully Costed** – From Silos to Whole System
- **Deep Digitalisation** – From Brawn to Brains
- **Citizens' Dividend** – From the Few to the Many

EPISODE THREE

System Changes
- **Reward Customers** – From Supply to Demand
- **Unlock Consumer & System Value** – From Commodities to Services
- **Stop Passing the Buck** – From Spreading Risk to Owning Risk
- **Move to Market Solutions** – From Subsidies to the Market
- **Start the Heavy Lifting** – From Mature to Immature Technologies

The Decarbonisation Dividend

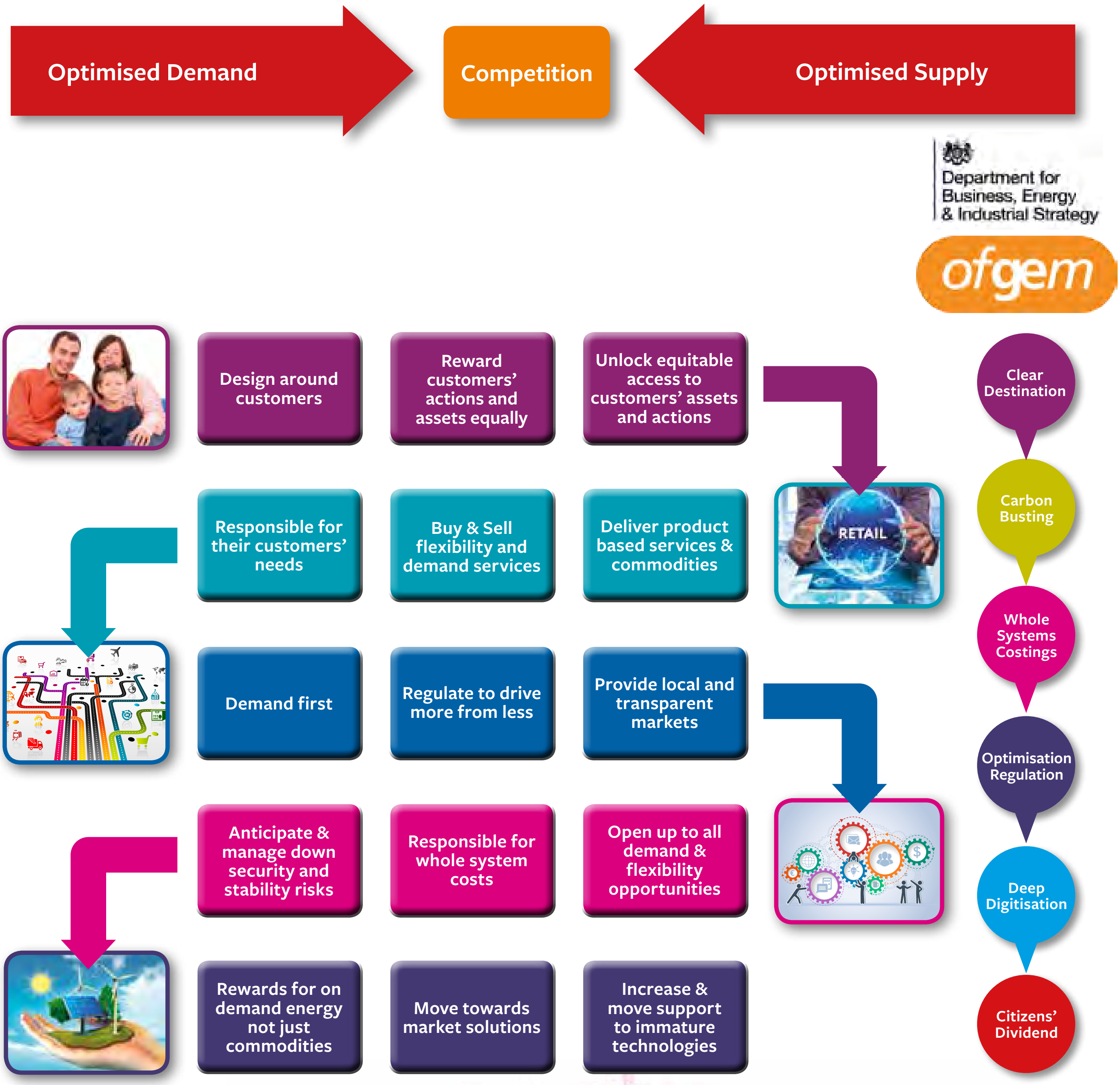
We should be able to decarbonise the whole energy system while ALSO

Delivering Customer Benefits
- **Cost Dividend:** Capturing the benefits of the marginal cost of the commodity
- **Reward Dividend:** Unlocking the value and rewards of customers' actions and assets
- **Equality Dividend:** Democratising access to decarbonisation assets eg: electric vehicles, energy efficiency and zero carbon heat solutions

Modernising the Sector
- **Economy Wide Dividend:** Delivering more with less
- **Innovation Dividend:** Unlocking the value in new technologies
- **Digitalisation Dividend:** Investing in the brain of the system as much as the brawn

Accelerating Decarbonisation Investment
- **Decarbonisation Dividend:** Setting targets and mandates to deliver decarbonisation
- **Investment Dividend:** Strengthening the Market
- **Speed Dividend:** Accelerating support to deploy newer decarbonisation assets

Optimising the System



DOING MORE FROM LESS: FROM CONSUMPTION TO OPTIMISATION

To deliver Net Zero requires a philosophical change in how we look at the energy system from a consumption model to an optimisation model, driving value rather than commodity, fully utilising capital rather than wasting it and most importantly recognising, rewarding and incentivising consumer and demand side optimisation.

With the potential for millions of assets, generation, storage and hedging, we need to unlock the value and potential of a much wider group of players – a consumption model will stand in its way.

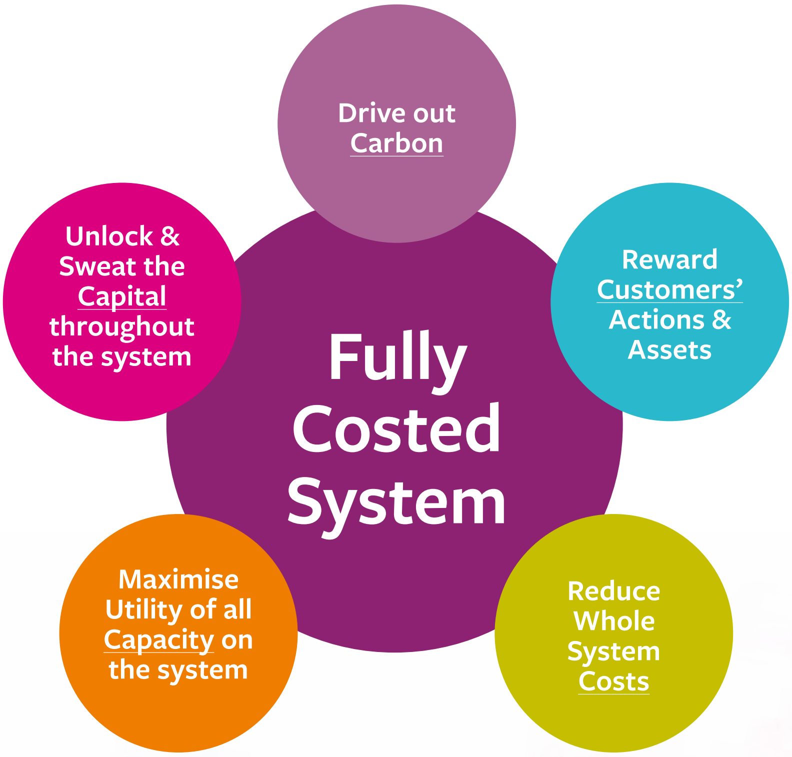
We are still designing our system around a few traditional energy players shaped around a vanilla top-down system with the customer at the end of the "plug"

Optimising the Five Cs: Carbon, Customers, Costs, Capacity & Capital

To reach Net Zero we need to replace the trade-offs posed by the trilemma with a set of efficiency ambitions accelerating decarbonisation through optimisation. This requires a changed mind-set from how much we can produce, to how best we can use all the resources efficiently. At the heart of optimisation is a fully costed system that breaks down the current silos and throws a light on how carbon and costs are moved from one player to another with the customer and the planet picking up the pieces.

Fully costing the whole system will be particularly important when decarbonising heat.

Optimisation requires a new set of incentives and market pressures to unlock new assets and actions – delivering More from Less.



Optimising the Five Cs of a Fully Costed System

All regulatory and policy actions should be guided by optimising the Five Cs, measured against the full system costs

THE DECARBONISATION DIVIDEND

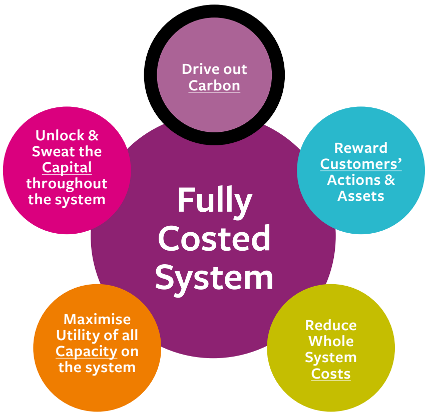
There is an exciting prize at the end of the journey to Net Zero – A Decarbonisation Dividend. These recommendations aim to deliver on some of those dividends driven by optimisation not consumption – and spreading the joy to citizens too.

Dividend	Barriers	Challenge	Recommendations
Drive out Carbon			
A Modern, Climate-Safe Energy System Low carbon solutions quickly squeezing out fossil fuels throughout the system	**Fossil Fuel Bias** There are still far too many cases of fossil fuels taking priority and discriminating against low carbon options	**Restack the Deck** What measures are needed to give priority to low carbon and drive out the inbuilt "bias" towards fossil fuels	**Carbon Busting** Clarity of direction, changed incentives, and significantly increased barriers to defaulting to fossil fuels
Reward Customers			
Crucial Value for Customers Customers and their actions will become a growing and ultimately a critical part of the energy system with so much more value flowing in their direction	**Designed around Supply of Energy, not Demand** The customer is still the victim and has limited access to the assets and actions that enable value to flow in their direction	**Access to Assets and New Services** How to release the capital all customers need to access and benefit from decarbonisation assets	**Demand is Equal to Supply** In a fully costed system, customer demand is of equal value to supply and can be unlocked through new market design and new asset-based services
Whole System Cost			
Reduce Costs All actions and policies to account for and reduce whole system costs and allow for value to flow across the silos of today	**Silos Capturing Value** Policy and regulation consider and cost the system in silos and do not "trust" the power of demand actions	**Squeezing Value from the System** Complexity of fully costing the system and assessing the impacts of one actor on another	**Accountable for Full System Costs** All policy, regulation and markets need to account for full system costs with a value to avoided costs to the system and consumer
Maximise Capacity			
Doing More With Less Optimise the capacity on the system increasing the productivity of assets and focus as much on the processing of energy as its production	**More is More & Siloed Actions** The system is designed around rewarding the quantity of a commodity not the value of services or functions provided	**Changing to More with Less** Moving from a consumption to an optimisation model reflecting the new assets and actions required to turn the commodity into a utility	**From Commodities to Service** Incentivising outcomes not inputs through valuing services not the commodities and driving risk into businesses not sitting with consumers
Unlock & Sweat Capital			
Accelerate Investment & Maximise its Utility Efficiently use all assets on the system, unlocking significant investment and reducing waste	**Artificial Silos** Silos preclude revenue stacking, while rewarding wasted energy and not unlocking investment in serious system gaps	**Capital not Commodities** How to unlock capital in a most efficient manner delivering the appropriate assets designed around the system needs	**Deepen Support & Build the Market** Focus support on immature technologies while underpinning the open market

THE BUILDING BLOCKS

Without addressing the "plumbing" issues embedded in the system, investment will be slower, more expensive and more carbon intensive. Interim destinations and ambition are crucial, carbon preferencing must be stopped, and the system must be fully costed not in silos. It is also crucial that all measures and policies deliver a Citizens' Dividend that is tangible and visible to voters.

CARBON BUSTING:
From Fossil to Low Carbon



Optimising the Five Cs of a Fully Costed System

AMBITION: Provide clear timeframes for decarbonising the different energy sectors, and reform all perverse regulations and market design rules that prioritise fossil fuels

While the journey will be messy, the destination needs to be clear to unlock investment and accelerate action. A 2030 destination will reduce capital risk, bringing down costs, and provide greater urgency for regulation.

There are too many government and regulatory measures that allow for fossil fuel responses to be the default. An immediate restacking of the deck from fossil fuels to decarbonised energy sources would further unlock investment and pressure on the whole system to pivot away from fossil fuel solutions.

Policy Ambition and Clarity

- **Policy Mandates:** 80% mandate on suppliers to provide decarbonised electricity by 2030, with a different but clear trajectory for heat and transport
- **Overall Cost Target:** Set a target cost for whole system decarbonisation by 2050. The Energy Transition Commission estimated that we should aim for $60/MWh*

No tax or mandate should be imposed until consumers have easy and affordable alternatives. Government's task is to drive action to enable customers to have access to realistic choices

Restacking the Deck

- **Change the Merit Order:** Put demand first, and flexibility and low carbon second for all players throughout the system
- **Boring "Fossil" Bureaucracy:** Remove onerous reporting requirements for fossil fuel procurement that are currently applied to all actors and support mechanisms
- **Review Support Mechanisms, Markets and Regulations :** No government or regulator should support mechanisms that favour fossil fuels
- **Tighten up the Renewable Energy Guarantees of Origins Scheme:** Reform of REGO – no more green washing

* www.energy-transitions.org/publications/making-mission-possible/

The carbon intensity record of regulated companies and some government support schemes is shocking

Table 1: Value, size and carbon intensity of electricity markets

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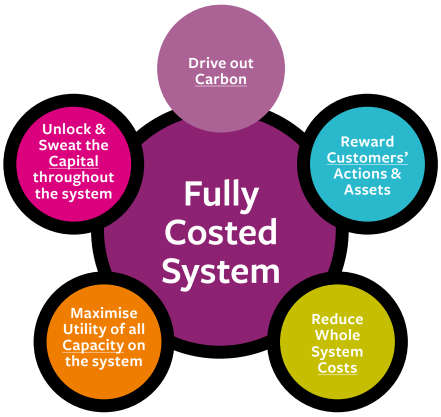
FULLY COSTED SYSTEM:
From Silos to Whole System



Optimising the Five Cs of a Fully Costed System

AMBITION: Drive greater optimisation of the whole system considering full system costs and giving equal value to demand as to supply

Whole system costings and visibility of knock-on impacts will be crucial to unlocking the value.

- **A Fully Costed System:** A fully costed system methodology must be used by all regulated assets, regulation and policy to uncover the knock-on costs and reveal the value sitting between the current silos
- **New Metrics valuing demand side assets and actions:** Fully valuing all assets on the system and providing a level playing field between demand and supply will reduce overall costs
- **NAO Audit:** The full system costs of regulation and policy should be audited every five years, highlighting the missed money and costly "silos".

KEY FINDINGS FROM OUR NEW METRICS

Comparing Whole System Value of Demand and Generation Assets

Value for Money: Demand-side measures can provide better value than generation technologies

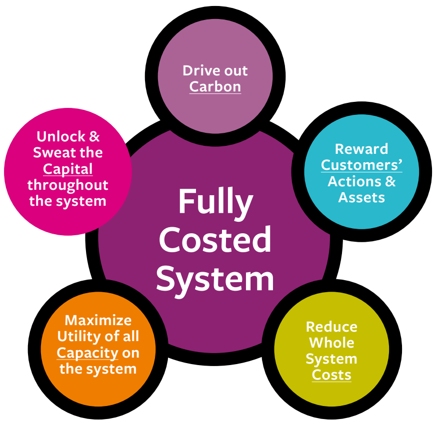
Whole System Benefit: More demand-side measures can reduce overall system costs

A Level Playing Field: Demand assets require equal access to all revenue opportunities as generating assets

Always a Player: Demand assets must always be considered as an equal option to that of generation

MORE IN EPISODE TWO

DEEP DIGITALISATION:
From Brawn to Brains



Optimising the Five Cs of a Fully Costed System

AMBITION: Develop a smart, responsive, network of energy and information to deliver a more productive, stable and optimised system releasing value across the varied, diverse actors, assets and actions

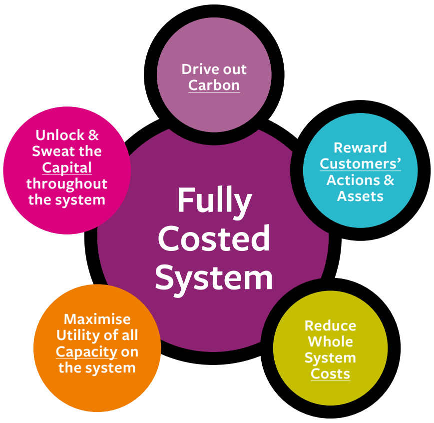
TVs were internet enabled before there was universal uptake of streaming services but provided optionality to consumers

The system will be moving from 500 players to 50 million actions and assets so whole system digitalisation will be crucial – for the security and stability of the system and, importantly, for unlocking value sitting in silos and captured by analogue business models. Data is the feedstock, digitalisation is the prize and the Energy Internet is the ultimate destination.

- **Key Digital Tools:** There are key digital tools required to establish the foundations that can enable the new system to operate and for value to flow.
- **Energy Enabled Products:** While consumers might not want to be managing the energy system, their products should be mandated to be "energy enabled" allowing for connectivity, optimisation and cost reductions to be captured.
- **Turbo-charge Interoperability:** There needs to be an urgent move to develop interoperability tools throughout the system, driven by open APIs and open data protocols.
- **Support Schemes:** Many investments made by government and regulation are still focused on "generation" and more needs to be directed to digital system design, efficiency tools and the digital architecture.
- **New Focus on Skills and Capabilities:** The sector and its regulation are still too focused on "the big stuff" rather than skills and softer tools required to deliver an efficient system.

> Digitalisation is crucial in order to unlock the potential of millions of actions and assets, delivering value and ensuring stability

THE CITIZENS' DIVIDEND:
From the Few to the Many



Optimising the Five Cs of a Fully Costed System

AMBITION: Design the system for citizens, offering opportunity and rewards, as equal actors in building a decarbonised system

The Citizens' Dividend could be seen by many as a "nice to have". However, this is a crucial component of the new system to ensure that through the decarbonisation journey citizens share the value and experience rewards and enhanced services.

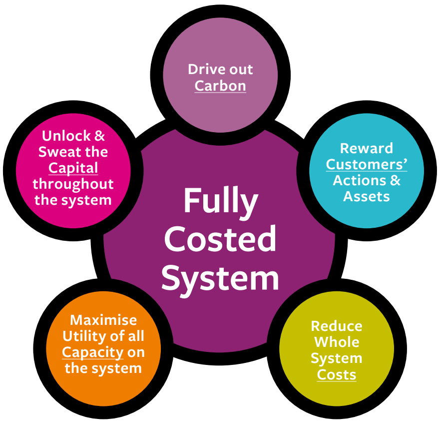
We now have an opportunity to reshape the system to deliver what would have been seen as impossible in the past.

- **Focus on Demand as much as Supply:** A system designed around customers' real needs, wants and choices.
- **Everyone is a Player:** Fanciful a few years ago, today our ambition must be that every home and business can play a valuable role, not sitting on the side lines.
- **Rewarding Customers Equally:** Incentives and access to support, markets and opportunities must be equally available to customers' assets in order to share in the rewards.
- **Payback for Support:** There needs be an explicit Citizens' Dividend sharing in the rewards from those who benefit from government support.

Consider that every household could become part of the energy system, delivering value and system actions – and be rewarded for this!

SYSTEM CHANGES:

DEMAND AND SUPPLY ARE EQUAL



Optimising the Five Cs of a Fully Costed System

AMBITION: A system designed around optimising customer demand actions and assets, recognising their value to the whole system. Fair and equal access for consumers to funds, markets and investment for demand assets and actions

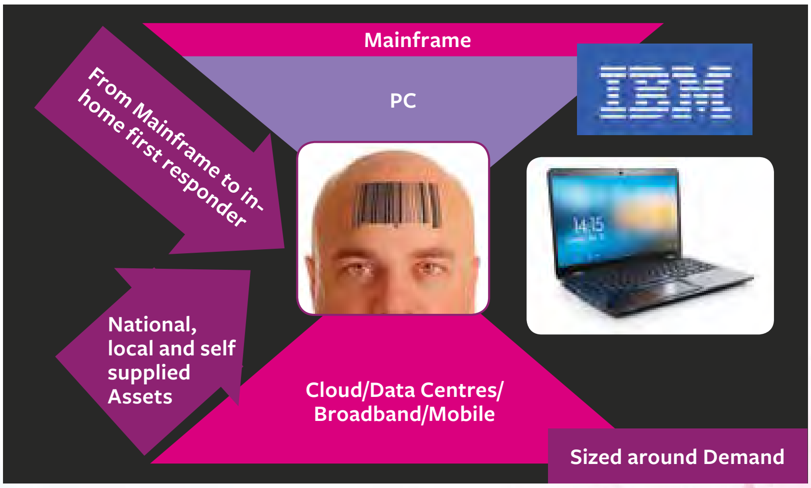
Unlock the Rewards for Customers, open up access to the assets required for Net Zero and deliver an excellent service and experience, by designing the system around demand not supply.

While energy has come a long way, the system is still primarily shaped around "What can you do for us?" rather than "What do you need from us?"

Designed for Customers

Design the whole system from the customers' needs, recognising that the system is there to serve customers. Consumers must be offered choice, differentiation and tailoring, reversing the current top-down design. Customers' role in the decarbonisation of heat will be particularly important and ways to optimise their needs must be in place.

As with data, the consumer has limited interest in being active but new services should be developed, and shaped to automate and optimise their needs



The world of data moved from being designed around mainframes to being shaped by consumers' personal computers served by local, national and in-home capacity, with optimisation automated by the system, not the consumer

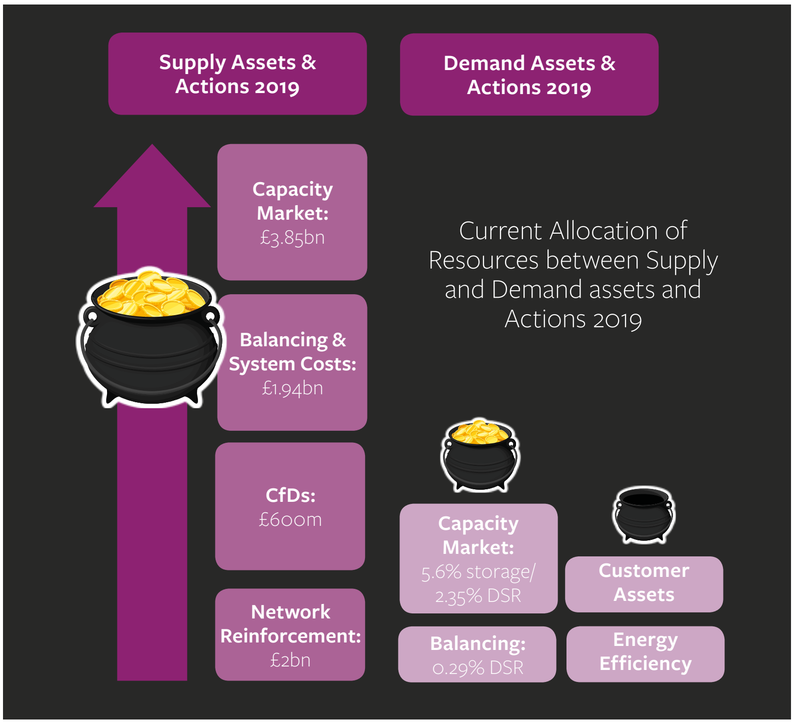
Powering Up Customers

The role and value of customers is still marginalised with flexibility, demand actions and, most importantly, energy efficiency sitting on the side-lines and not considered central to cost reductions, stability and security of the system.

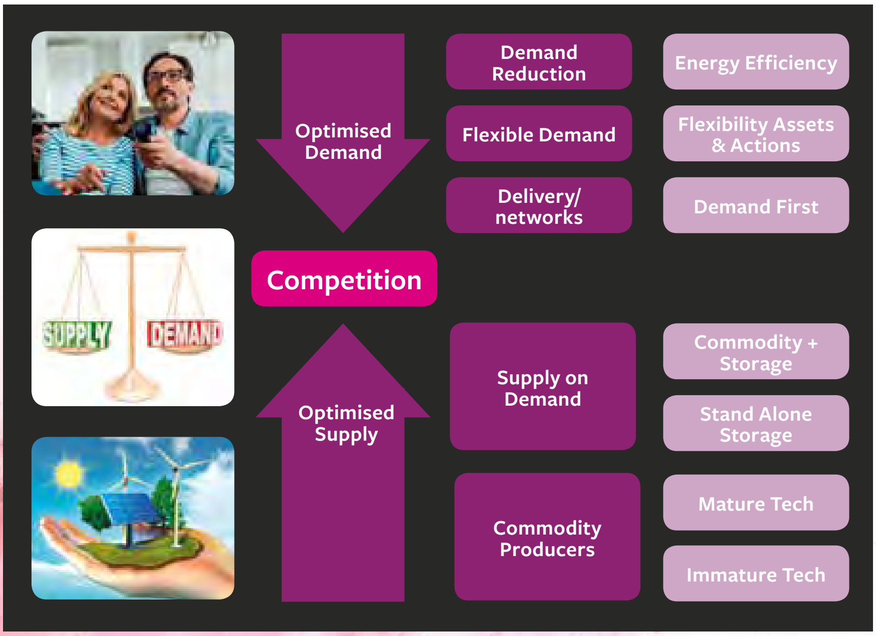
As the capital costs of truly participating and gaining value from the system is a big ask for most customers, it is important that customers are also considered equal when it comes to government support schemes and market mechanisms, commensurate with their contribution to the whole system costs.

Demand and supply might not be equal in scale but but in value it is – and that crucial value needs to be unlocked and promoted.

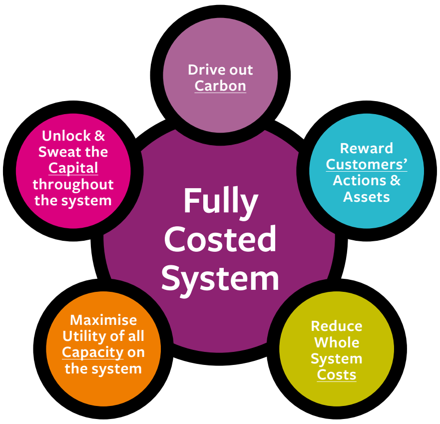
- **Fully Value Demand:** Full value needs to be attributed to demand actions and assets using the new metrics
- **Equal Access to all Support Mechanisms:** Miniaturised CfDs, and the Capacity Market must be available to reduce the cost of demand assets and energy efficiency at all scales. These will no doubt be accessed by retailers of these assets not the consumer.
- **Equal Access to all Markets:** All energy markets need to be accessible to demand actions, inclusive by design with open data standards and automatable.
- **Promote a Flexibility Purchase Agreement:** Introduce similar market options for the sellers and buyers of demand services to those of supply.
- **Energy Efficiency – the Turbo-charged Value:** Move energy efficiency from just a social need to playing an integral role in the energy system delivering full system value through permanent demand reduction. Our new metrics reveal the significant value for energy efficiency.
- **Energy Enabled Products:** Mandate product standards – from fridges to air conditioners – to be energy-enabled, allowing customers to automate how they optimise their energy use.



Below: New competition between Demand and Supply: this will start a new competitive tension between demand assets and actions and supply options ensuring we “size” our system around optimising demand first



UNLOCK CONSUMER & SYSTEM VALUE:
From Commodities to Services



Optimising the Five Cs of a Fully Costed System

AMBITION: Combine services and markets, unlocking the many capital assets needed in all parts of the system

Value is created by utilising assets to their capacity, by rewarding those that add value and through internalising risk that is more efficiently managed by businesses than by consumers.

Service models focus on outcomes driving efficiencies and innovative propositions designed to add value at least cost – and least energy consumed. Prioritising services drives risk to be internalised, delivers a reduction in consumption and provides certainty of cost and service. It also allows for more added value to be provided through greater tailoring to customer needs.

On the generation side we need to promote the storage and "processing" services so badly needed and not being unlocked through the current commodity markets.

The Mobile Phone market moved from commodities to products and service contracts, unlocking exciting products while also reducing consumption of the data and telephony "commodity"

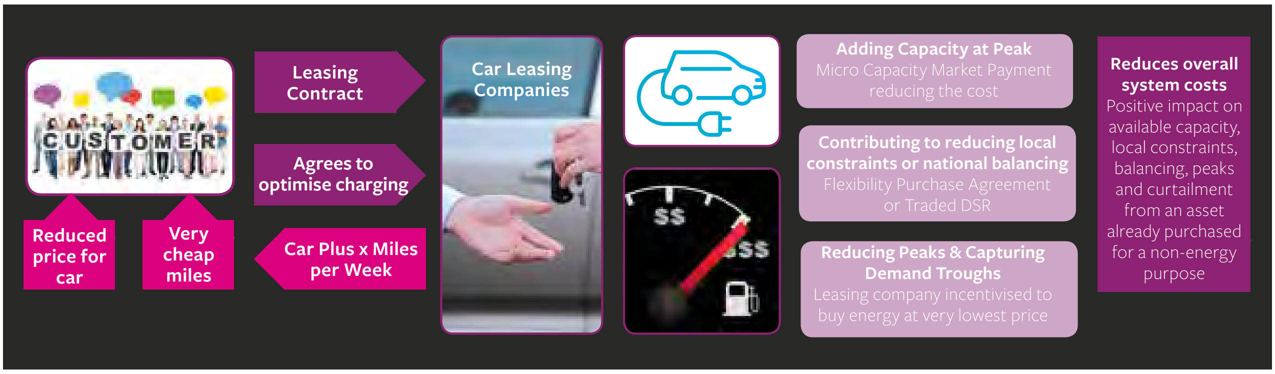
Customer Services

We can provide real choices to consumers tailored around their new and changing needs and contributions. This is not to restrict consumers from buying commodities but offering them diverse choices on how and what they decide to pay for. In addition service contracts by their nature aim to deliver more with less as they internalise the cost of the energy and are driven to manage the costs more efficiently than just passing them onto consumers.

- **Unlock Capital Investment:** For customers, service contracts are more effective than commodity models that have limited ability to unlock capital investments like electric vehicles or solar panels needed by consumers to decarbonise
- **Services Remove Risk from Consumers:** Service contracts can reduce volatility and complexity for consumers, ensuring that risk sits with businesses who are better able to manage it than consumers
- **Opens up the Market to Energy Embedded in Products:** Energy delivered through product and service-led business models, such as miles embedded in a car leasing arrangement, are more easily enabled by service-based propositions

Consumer protection is a significant issue for service and long-term contracts and so enhanced consumer protection will be required to deal with financial services, contractual redress and misuse of data. However, consumers are accustomed to service agreements

An EV Service Agreement – A Model based on Mobile Phones



- Customers are offered a leasing arrangement for a car with a service agreement including x miles per week similar to a mobile phone contract.
- The leasing company optimises the charging of the car through automated services reducing the cost of the energy.
- The leasing company is able to reduce the capital costs through accessing the Capacity Market.
- The leasing company is also able to sell a flexibility purchase agreement to key players, providing greater certainty to those exposed to imbalance risks.
- The customer is delivered a cheaper cost for the asset, lower running costs and reduced volatility. The system benefits from the increased capacity and flexibility resources that assist all within the system to reduce costs.

Supply Services

There needs to be a distinction between a raw commodity and the utility value of an energy service. This creates a differential value and business model between energy as generated and energy shaped around demand. This distinction offers those who can "add value" with access to demand and flexibility assets to get a lower price for the commodity, while less sophisticated energy "retailers" can buy the fully balanced product.

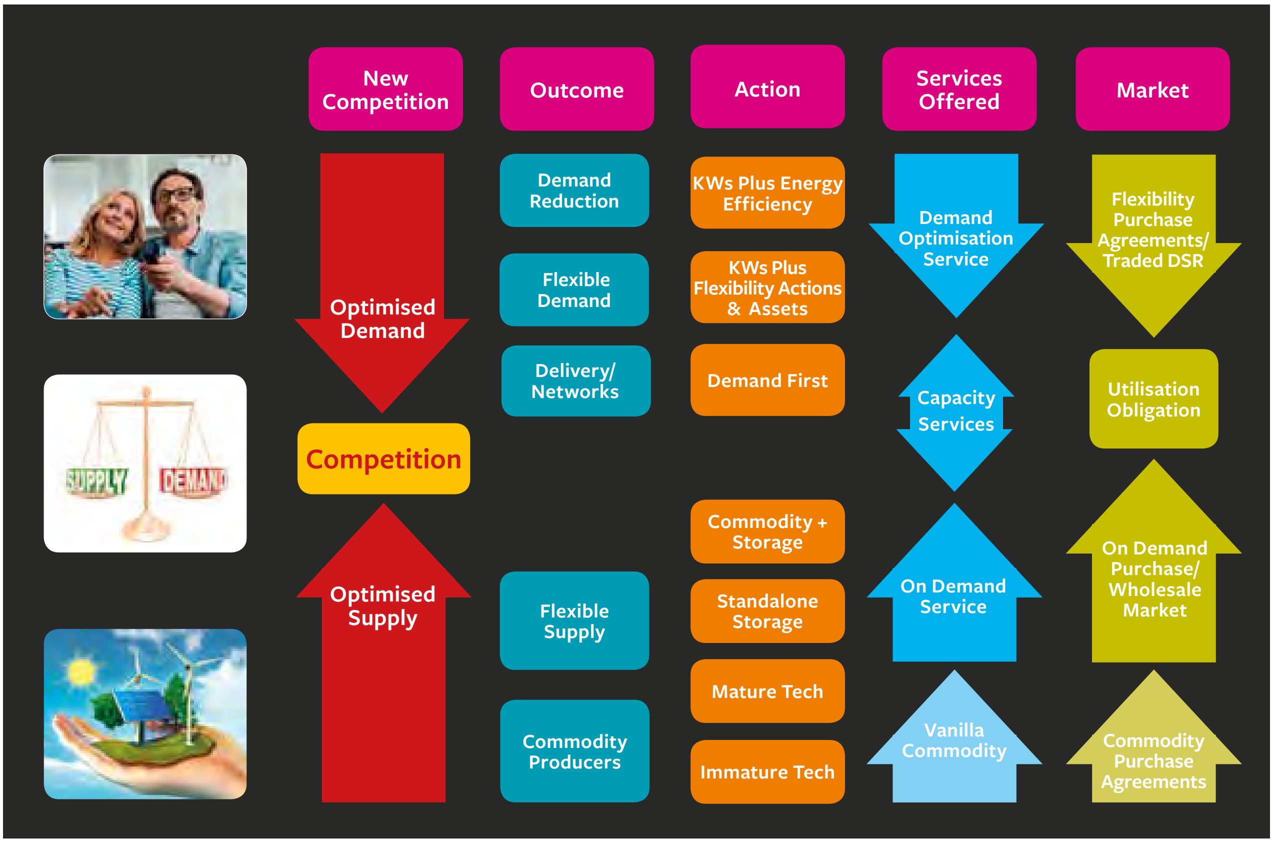
- **Split the Value between the Commodity 'as-generated' and an 'on-demand' Service:** Moving from costing the commodity to valuing its outcomes unlocks investment in better "processing" and "managing" of the commodity driving generators to add value
- **A Commodity "purchase":** Purchased as generated – appealing to those with demand and flexibility capabilities
- **On-demand Service:** Appealing to those who want a fully managed service, opening up the market to many non-energy companies with generators / developers managing risk
- **Complementing the Flexibility Purchase Agreement:** Through the Flexibility Purchase Agreement, all players within the sector can benefit from being able to balance and manage the fluctuations between demand and supply

Without distinguishing between "as-generated" and "processed" energy, we will end up with Milk Lakes and Butter Mountains.

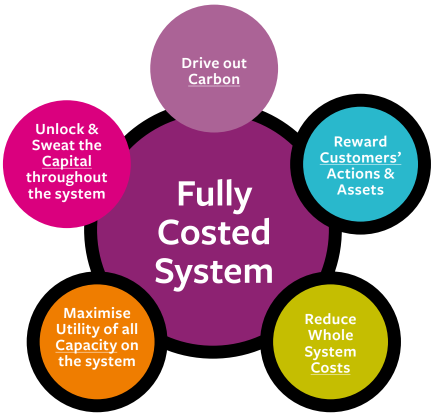
The Three New Service Agreements

Mechanism	Description	Whole System Benefits
Flexibility Purchase Agreements	Retailers, DNOs, ESO and generators buying and selling demand as they do supply	Unlocking demand assets, optimising the overall system costs and rewarding customers for their actions and assets
On Demand Purchase Agreements	Generators, storage operators and aggregators able to increase value through 'self-managing' imbalance and designing services that meet demand	Reducing imbalance costs, internalising risk and building stronger business models while enabling retailers to devolve imbalance risk
Commodity Purchase Agreements	Retailers with access to demand side actions and assets can access the commodity more cheaply, enabling greater value to flow to the management of demand and supply	Offering a very low price to those with more sophisticated business models who have greater understanding and ability to manage demand

From Commodities to Services



STOP PASSING THE BUCK:
From Spreading Risk to Owning Risk



Optimising the Five Cs of a Fully Costed System

AMBITION: Risk needs to be allocated to and owned by the businesses that create it and are best able to manage it, instead of passing through to consumers

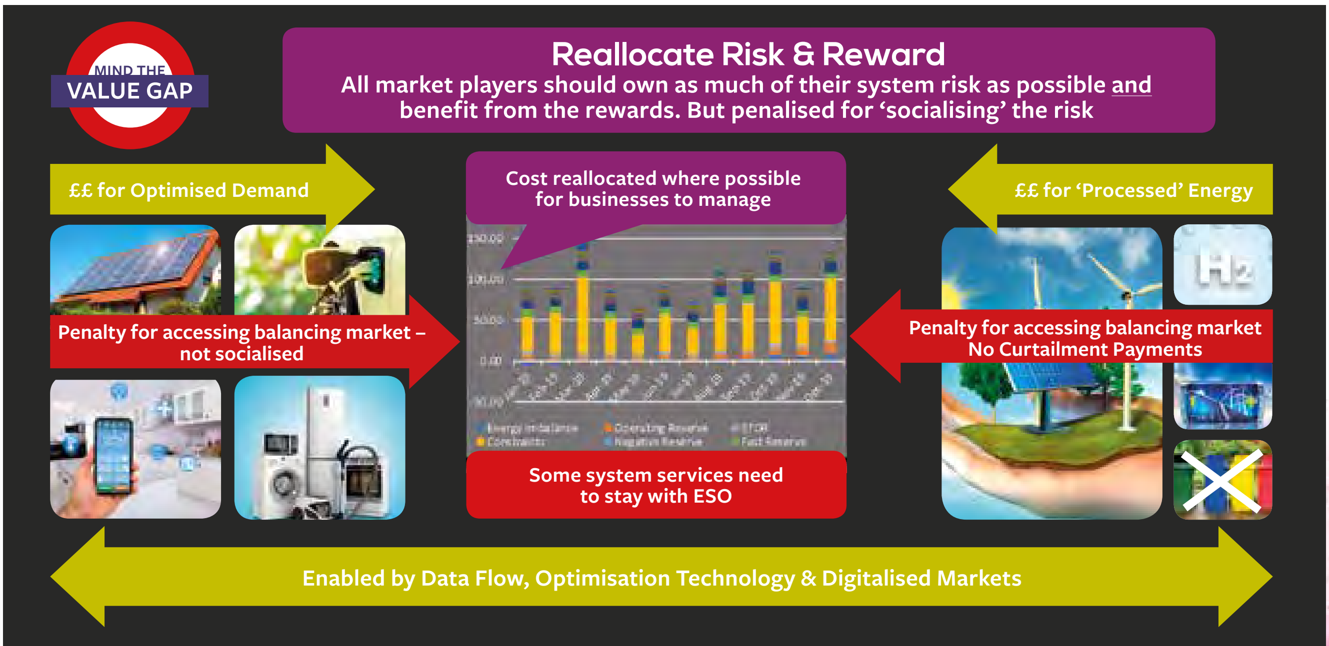
Far too many risks are passed on and smeared across all customers when risk should sit with businesses that create them and are best placed to manage and be rewarded for risk. Owning risk will assist building stronger business models that blend responses and assets.

Smearing and socialising risk with costs passed onto the consumer must be resisted as much as possible, particularly as they have no agency to mitigate that risk.

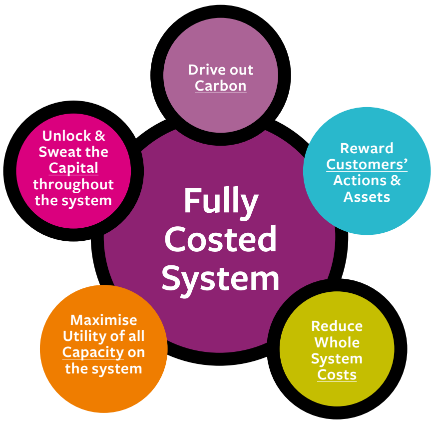
- **Increase Suppliers Information Imbalance Charge**
  Currently this is set at zero but should be increased to incentivise better demand/supply management and more optimisation and to unlock value in demand, storage, system management and smarter generation
- **The Risk of Supplier Failure Reviewed**
  Costs should be allocated to those who create them, not to consumers
- **Resist Capping Price Signals**
  While seen as pro-consumer, capping system charges and distorting real price signals will in the medium term reduce value in demand actions and assets and not provide customers with the ability to help shape the system to their longer-term cost and service advantage.

Insurance – the Missing Partner

- Insurance is a very powerful tool to assess, manage and mitigate risk, distancing costs from consumers and driving continual improvement, and is more efficient at assessing and predicting risk than the current regulatory capabilities
- Insurance should become a much more mainstream player in managing energy risk



MOVE TO MARKET SOLUTIONS:
From Subsidies to the Market



Optimising the Five Cs of a Fully Costed System

AMBITION: Boost investment in unsubsidised decarbonisation for mature technologies normalising the market and reducing the current subsidy distortions

Increase investment quickly into both mature and immature technologies, focusing on de-risking the capital not the commodity. Moving the mature technologies towards market solutions while pivoting support measures to immature technologies, demand and consumer assets

Equal policy and regulatory time and effort should be spent focusing on designing and supporting the unsubsidised market as it is on the subsidy mechanisms. Moving as many developers of mature renewables away from Contracts for Difference (CfD) will allow government support to invest in immature technologies and demand side assets.

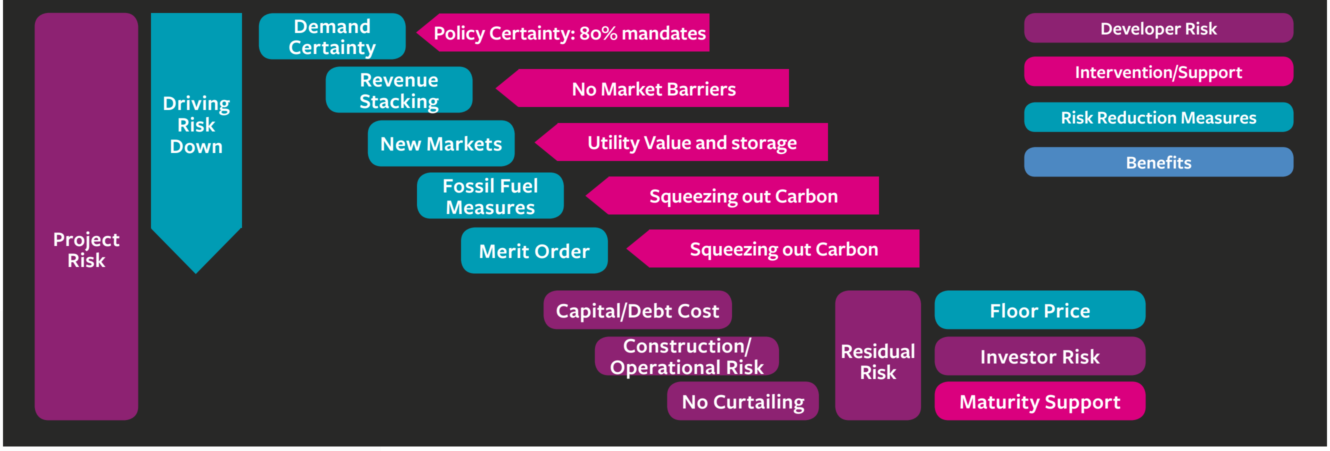
This requires focus on some significant risks in the merchant and PPA market, not least the credit-worthiness of the counterparties, which could only be managed through much higher cost of capital impacting the overall costs of the system.

- **Reducing Risk through Policy and Mandates:** This report's proposals on significantly reducing fossil fuel competition, new low carbon obligations for all markets, regulatory assets and support mechanisms, and with greater policy certainty, goes quite a long way to help de-risk the capital for mature renewables.

Public Goods In Food

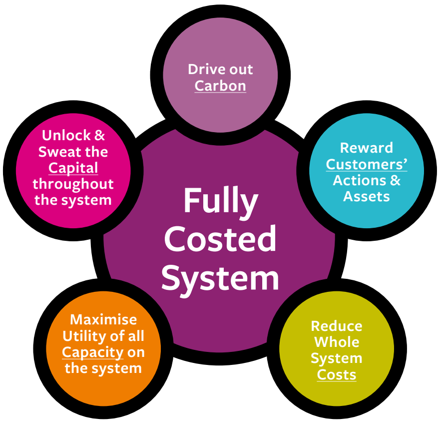
Even in a competitive sector like food there is a derisking component sitting with the farmer rewarding public goods. This support does not reward revenues but does de-risk embedded capital that delivers societal benefits

De-Risking the Capital through Policy Measures & Low Powered Floor Price



- **Low Powered Floor Price:** Due to weak counterparties further impacted by COVID-19 and to aim to capture the lowest cost of capital, there needs to be a decarbonisation "public good" to de-risk the capital but not designed to guarantee or underpin rewards. Ofgem's Offtaker of Last Resort, currently only accessible to those with CfDs, should be equally available to those without CfDs.
- **Commodity Purchase Agreements and On Demand Purchase Agreements:** Reflecting the new values between the commodity and the on demand service, government should promote the emergence of these differential contractual relationships.

START THE HEAVY LIFTING:
From Mature to Immature Technologies



Optimising the Five Cs of a Fully Costed System

AMBITION: Focus government support on immature technologies and customer assets to accelerate decarbonisation

Contracts for Difference (CfDs) have experienced significant mission creep, now becoming the default support for technologies that are mature and have reached parity with fossil fuels. In the medium term it needs to pivot back to its original design and do some very heavy lifting with technologies at the beginning of their cost parity journey such as hydrogen, CCUS, interseasonal storage and demand-side assets.

However there are some measures that should be taken immediately to reform current CfDs.

SHORT-TERM REFORMS: DELIVERING MORE FROM LESS

- **Sweat the Capital already Invested:** Enable revenues to be stacked, not least by enabling the Capacity Market to be accessed by assets receiving CfDs.
- **Mandate Storage:** Mandate procured or co-located storage capacity for generation over 500 MW to reduce wasted energy.
- **No more Waste:** Progressively reduce access to curtailment payments with none being paid beyond 2030.
- **Extending the Life of Assets:** Create an obligation for ongoing production post CfD term to revert to the market and be able to access the market floor price as above.

MEDIUM TERM: BITE THE BULLET AND SPREAD THE JOY

- **Increase the Pot significantly:** Government support is needed to go faster and further with the immature technologies crucial to decarbonisation.
- **Pivot to Immature Technologies and Non-generating Assets:** There needs to be a stronger focus on the immature technologies and "processing" assets not least long term storage assets that are not unlocked through current markets.
- **Spread the Joy:** Deliver customers with similar access to support mechanisms commensurate with their value to the system by miniaturising CfDs and the Capacity Market.
- **Citizens' Dividend:** As government increases its support across the decarbonsiation landscape, citizens should explicitly benefit from upsides through a profit share from those assets that they have de-risked creating a Citizen Transition Fund.

Attract New Investors

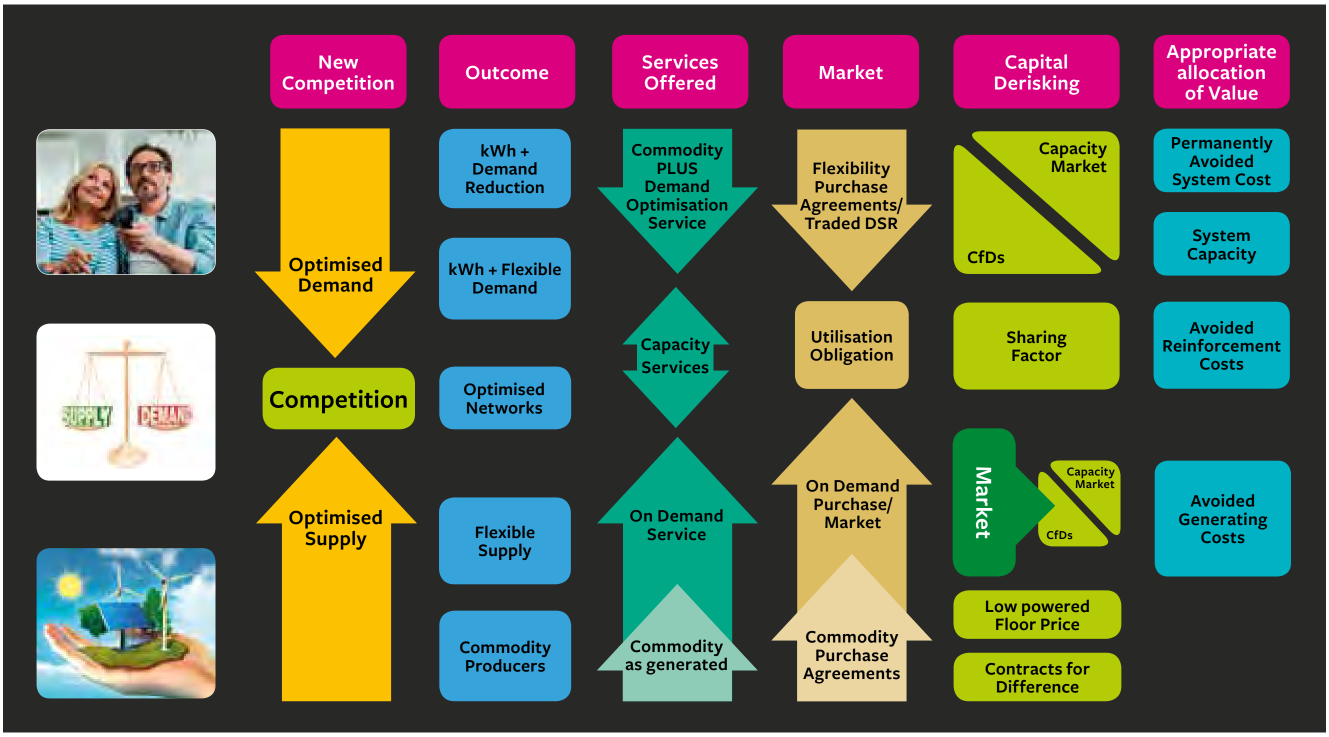
There is a growing interest from new investors who have a different appetite for risk and reward. While the "big stuff" might predominantly attract infrastructure investors, with growing confidence in how the market operates, mechanisms and new routes to investment must be investigated that are attractive to different types of investors.

- **Move the Mindset:** BEIS should establish a Financial Sandbox, allowing for diverse investors to examine and shape new routes to market and investment drawing in new expertise and new ideas.

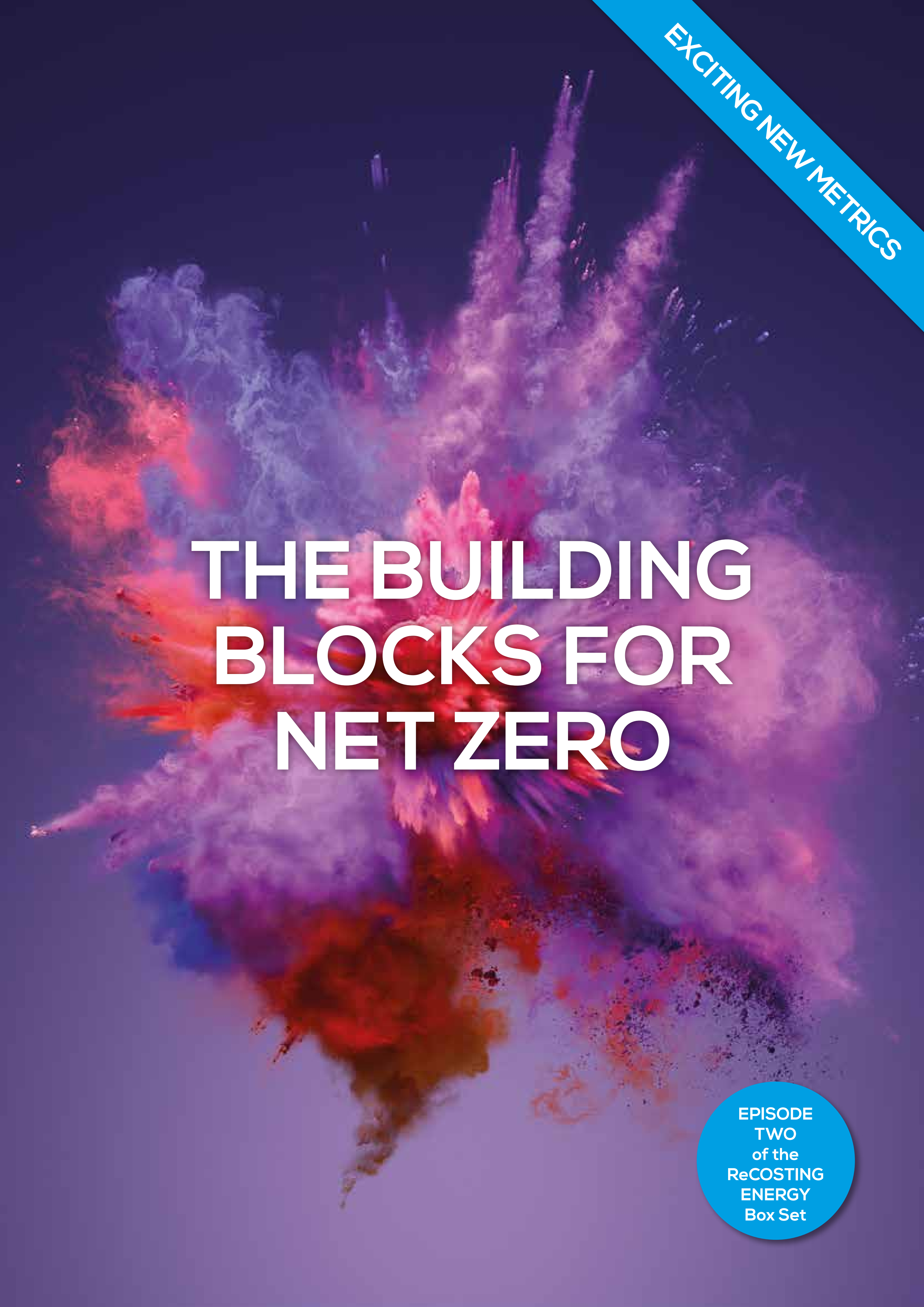
CONCLUSION

The key components of our recommendations require changes to the energy sector's mindset as much as large regulatory or policy changes.

- **New Focus on Carbon:** No longer any tolerance of fossil fuel bias
- **New Allocation of Value:** Whole system costs and values need to be at the heart of the transformation
- **New Important Actor:** Demand actions and assets are as important as generation
- **New Competitive Pressures:** Competitive tension between optimised demand and optimised supply
- **New Route to Market:** The prevalence of services unlocks the new "value" in the system
- **New Beneficiaries of Support:** Customers able to access markets, and support schemes commensurate to their value to the system
- **New Service Agreements:** Opening up new value and competition between the raw commodity, energy on demand and flexibility



SHAPING THE MARKET: In this new market design, Optimised Demand competes with Optimised Supply. It shows the new service arrangements and support mechanisms and, importantly, highlights the avoided costs of key choices.



THE BUILDING BLOCKS FOR NET ZERO

EXCITING NEW METRICS

EPISODE TWO of the ReCOSTING ENERGY Box Set

INTRODUCTION

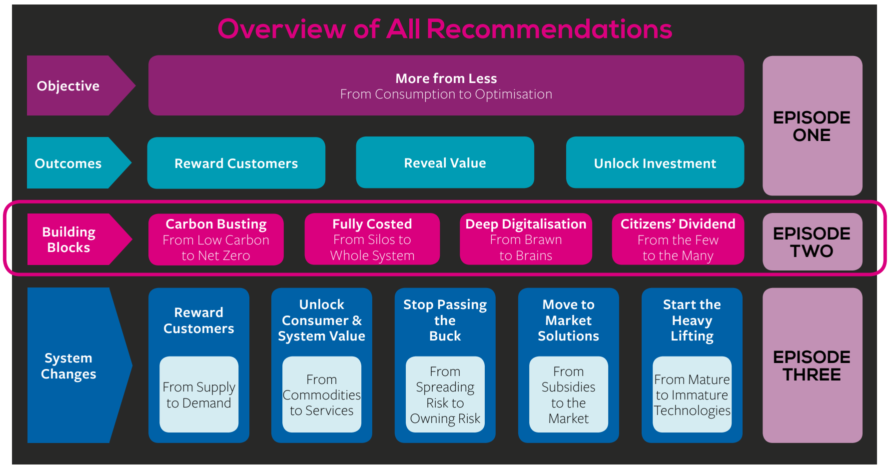
THE BUILDING BLOCKS

This episode of the ReCosting Energy box set aims to capture the building blocks that are needed to deeply decarbonise the energy sector. All our recommendations are shaped by the overall objective of optimising Carbon, Customers, Costs, Capacity and Capital throughout the system – all referenced against a fully costed system.

These recommendations focus on changes to policy and regulation with clear actions required around accelerating decarbonisation, whole system costings, digitalisation as a key enabler and an overriding outcome requiring a Citizens' Dividend integral to all we do.

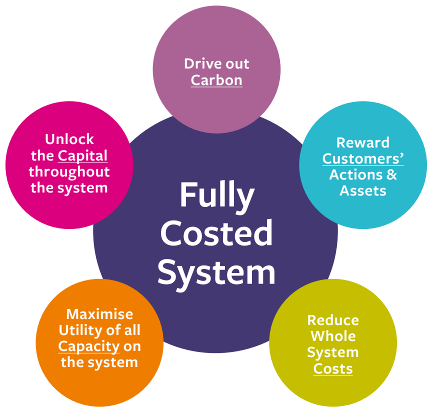
Developed before, but published after the Government's Energy White Paper of December 2020, this project supports all of its ambitions. In the Government's plans, we see some very strong themes that chime with our project – from moving faster on decarbonisation and the welcome focus on whole system costings and design, to digitalisation running through all the recommendations and consumer interests of first and foremost importance.

We hope ReCosting Energy can provide some input into these future strategies – pushing for further, faster and deeper action on some issues, proposing specific measures and methodologies on others, and introducing new concepts and potential actions to deliver Government's drive for a Net Zero Energy system.



We recognise that many of the recommendations have a different level of complexity to implement and have given a Red, Amber or Green rating to each of the recommendations, outlining the challenges that each poses.

Optimising the Five Cs: Carbon, Customers, Costs, Capacity & Capital



Optimising the Five Cs of a Fully Costed System

All regulatory and policy actions should be guided by optimising the Five Cs, measured against the Full System Costs

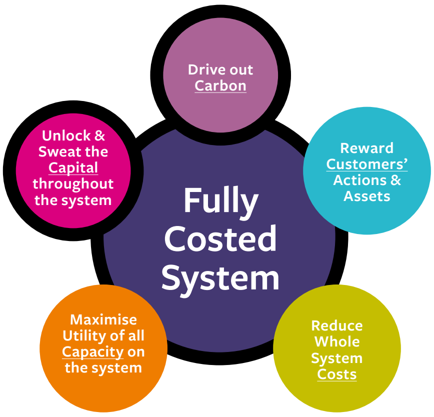
DIFFICULT

ACHIEVABLE

EASY

CARBON BUSTING

FROM FOSSIL TO LOW CARBON



Optimising the Five Cs of a Fully Costed System

AMBITION: Provide clear timeframes for decarbonising the different energy sectors, and reform all perverse regulations and market design rules that prioritise fossil fuels

Recommendations: From Fossil to Low Carbon

1. **Clear Destination:** Mandate suppliers to deliver 80% decarbonised electricity by 2030, with different but clear trajectories for other energy sectors.
2. **Whole System Cost to Decarbonise Energy:** Set an overall cost for the decarbonisation of a fully optimised system.
3. **Review all Policy and Regulatory Fossil Bias:** Government, Ofgem and other regulated bodies must urgently review all their actions to reduce any fossil fuel bias.
4. **Require Onerous Reporting of Fossil Choices:** Place bureaucratic burdens on all regulated actors who procure fossil fuels.
5. **Capacity Should Mean All Capacity:** Return Capacity Market to its origins to include all demand capacity such as domestic assets and energy efficiency.
6. **Tighten up the Renewable Energy Guarantees of Origin Scheme:** Ensure that REGOs are linked and related to UK-based renewable technologies.

Clear Destination: Certainty and Ambition

While policy and regulation will need to be flexible and adaptive through this period of dynamic change, to counterbalance this the greatest benefit that policy can deliver to the system today is certainty of destination.

Setting a time frame is key to investors, regulation, existing and new entrants across the energy sector – and beyond. As has been seen before, target dates accelerate action and investment.

Now is the time to be very clear about the staging posts along the journey.

No other part of the economy can achieve Net Zero before energy has decarbonised so energy must deliver long before 2050 to allow others to change business models and invest to meet Net Zero

Recommendation 1: Mandate 80% Decarbonisation Targets

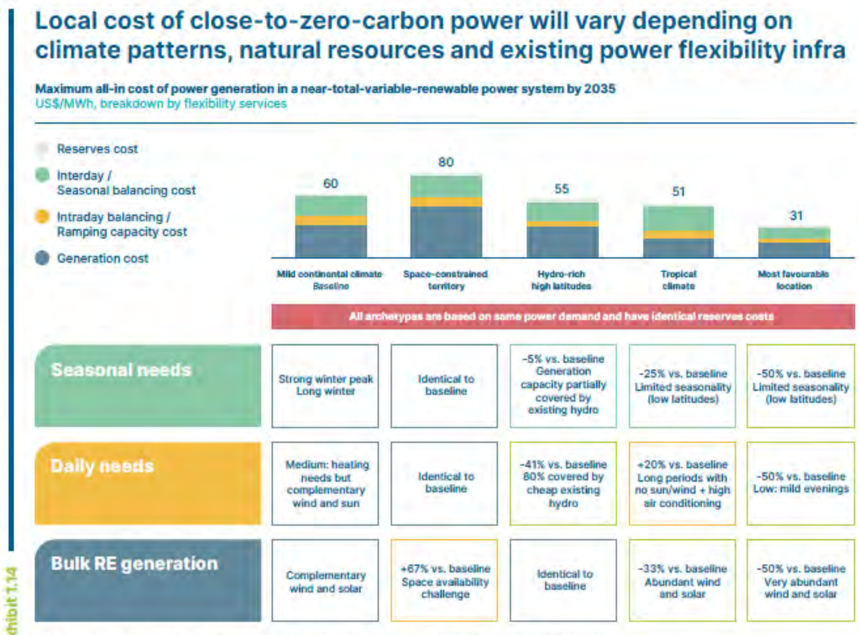
Energy suppliers should be mandated to deliver 80% decarbonised power by 2030 and 80% of heat and domestic transport by the mid 2030s. This would accelerate deployment of decarbonised assets, providing certainty to reduce the cost of capital, and create a strong market pull from suppliers to demand and procure decarbonised services. Regulation would also benefit from this level of clarity shaping all regulatory regimes to deliver this key outcome.

Other countries have set clear decarbonisation targets.

EASY
The mandate is simple and its impact significant. However, the whole supply chain needs to be effectively coordinated

Recommendation 2: Set Whole System Costs for Optimised Decarbonisation

We should set a target for the total cost of energy decarbonisation to drive greater utilisation of all assets on the system, increase efficiency and deliver cost reductions throughout the system. The Energy Transition Commission has calculated that a fully decarbonised system in a country with reasonable access to renewable assets should be able to achieve this for $60/MWh for whole system costs. While there are many assumptions included in these calculations, policy should aim to establish a range to drive innovation and greater supply chain pressures throughout the system.



SOURCE: Adapted from Climate Policy Initiative for the Energy Transitions Commission (2017), *Low-cost, low-carbon power systems*

www.energy-transitions.org/wp-content/uploads/2020/09/Making-Mission-Possible-Full-Report.pdf

This will require some very significant cost efficiencies across the sector driving smarter approaches, squeezing out some unnecessary functions of the old system, tackling waste and unlocking the value sitting between the silos. The methodology for the creation of this target cost must be clear and transparent, with the progress effectively audited.

DIFFICULT
Complex to establish the cost range but important to deliver efficiencies

Carbon Busting: ReStack the Deck

All players in the sector must be deterred from pivoting to fossil fuel options and should be encouraged and incentivised to choose low carbon options.

If we want to accelerate decarbonisation, we need to make the "green" option ALWAYS the default, with fossil fuels the difficult, expensive and bureaucratic option. There is a really important role for policy and regulation to become Net Zero compliant and reduce the significant distortions in the market that discriminate against low carbon energy and in some instances penalise it.

Far too many of the government or regulatory controlled mechanisms and markets are still dominated by "easy" fossil fuel assets. This is not just bad for our Net Zero ambitions but is also reducing investment in renewables, storage and system design with fossil fuels crowding out their routes to market.

ESO and DNO markets drawing on fossil fuel actors for balancing and flexibility and the Capacity Market is still handsomely rewarding fossil fuels.

Proportion of Fossil Fuel Generation

Table 1: Value, size and carbon intensity of electricity markets

Market	Value (2019)	Size (2019)	Carbon intensity
Balancing mechanism	£590m	Abs: 20,000 GWh Net: 630 GWh	Fossil fuels >99% of turn up
Short term operating reserve (excl spin gen)	£50m	2000 GWh	>99% fossil fuel contracts
Fast reserve	£90m	220 GWh	85% fossil fuel contracts
Firm Frequency Response	£40m	3250 GWh	20% fossil fuel contracts
Mandatory Frequency Response	£30m	2500 GWh	Large units only. Will be primarily fossil fuel generation
Capacity market (delivery 2021/22)	£500m	55 GW (de-rated)	70% fossil fuel contracts
DNO tenders	£1.5m	c. 850 MW (MWh unknown)	>80% fossil fuel contracts
Wholesale Market	£13,000m	219,000 GWh	~40% fossil fuel generation

Source: BEIS 'Carbon in Flexibility Markets' workshop, 14th October 2020, p. 10

Despite an increase in the number of low-carbon technologies, many **flexibility markets remain dominated by high carbon assets**.

We will need a significant increase in low-carbon electricity from a variety of sources in order to reduce carbon emissions intensity in the power sector in line with Net Zero

Recommendation 3: Change the Merit Order for all Markets and Mechanisms

Leadership must start with BEIS and Ofgem and they need to review their regulatory models, policies and schemes to ensure that they are Net Zero compliant.

Demand actions at zero carbon should top their merit order, with flexibility and low carbon generation second and fossil fuel options only as a last resort. The government has control of the Capacity Market and other support schemes, while regulation impacts significantly the decisions of the monopoly players. Government and Ofgem must urgently review all their schemes and markets to ensure that they minimise any fossil fuel bias.

ELECTRICITY DISTRIBUTION LICENCE: CONDITION 4
Needs to be changed to prioritise demand, low carbon and flexibility as currently it is not Net Zero compliant and requires technology neutrality

EASY TO IDENTIFY
An audit of all policies, schemes and regulation, with a rolling reform where requirements or behaviours are not Net Zero compliant

Recommendation 4: Accountable for Carbon: Require Fossil Fuel Reporting

It is not possible to stop the need for fossil fuel-based assets immediately in electricity. However this is not to say that fossil fuel choices should be "easy" or "pain free".

From 2022 all regulated actors should be required to provide public justification of why they had to resort to fossil solutions, outline other options they considered and why decarbonised solutions were not suitable. This process should become progressively more onerous and should be published and submitted to the House of Commons Environmental Audit Committee and the BEIS Committee.

EASY
Impose reporting requirements on all regulated actors and government schemes

Recommendation 5: Return the Capacity Market to its Original Design

The Capacity Market is far too dependent on fossil fuels, which undermines the renewable market and is certainly not Net Zero compliant.

While the Capacity Market still exists, it needs to revert to its very original concept reflecting the "name on the box" – Capacity. It needs to rebalance its portfolio to be Net Zero compliant and focus on inter-seasonal and inter-day storage, energy efficiency and demand-side action – increasing capacity in its widest sense.

In the 2019 T-4 Capacity Market auction, coal was awarded a greater allocation of capacity than demand side response[1]

SHORT-TERM COST IMPLICATION, LONG-TERM GAIN
By broadening its reach and reducing distortions to the market, the whole system – demand, storage and low carbon – will deliver lower carbon and total system costs

Total funding allocation for DSR, Storage and CCGT in Capacity Market Auctions between 2015-2019 (£m)

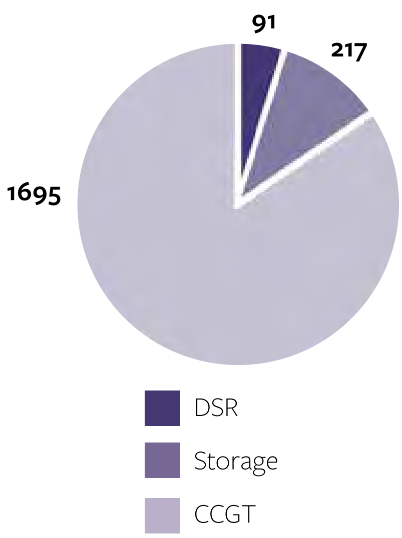


Figure 1 Source: https://www.emrdeliverybody.com/CM/Auction-Results-1.aspx

Recommendation 6: Tighten Up the Renewable Energy Guarantees of Origin Scheme (REGO)

EASY
Reforming the scheme is not very onerous but does need time and focus

REGOs have been misused and abused and need to be reformed to ensure that they are a robust mechanism and not a green washing exercise. They need to be tightly associated with the actual decarbonised generation, providing an additional investment signal for renewable technologies.

This can be achieved through the trading of REGOs alongside the renewable generation which produced them. Exploitation of the current loophole in regulation allows REGOs to be purchased from suppliers with an excess of these certificates, and therefore energy suppliers who procure generation from fossil fuels can claim to be 'renewable' by purchasing these excess certificates[1].

Public support for renewable technologies remains high[2] as does the demand for "green energy tariffs"[3]. It is very important that this is seen as a robust system that is delivering what consumers are paying for.

Table 1: Avoided FiT and CfD Costs by Supplier

Company	2018/19 Avoided Cost	2019/20 Avoided Cost
Axpo	£1,646,869	£1,001,508
British Gas	£26,145,487	£48,959,818
Bryt Energy	£2,133,506	£3,021,818
Dual Energy	£0	£615,125
E.ON	£308,009	£6,425,505
EDF Energy	£178,744	£6,843,370
Green Network Energy	£0	£758,243
Haven Power	£31,527,077	£18,878,799
Hudson Energy	£1,229,371	£3,899,737
Marble Power	£0	£480,407
Npower	£450,148	£680,181
Opus Energy	£5,783,383	£9,943,488
Orsted	£1,247,699	£4,154,695
Shell Energy	£787,772	£1,991,238
SmartestEnergy	£11,462,200	£14,663,879
SSE	£4,907,316	£3,784,884
Total	**£87,807,580**	**£126,102,694**

Source: https://www.goodenergy.co.uk/media/18730/renewable-certificates-in-europe-research-note.pdf

Conclusion

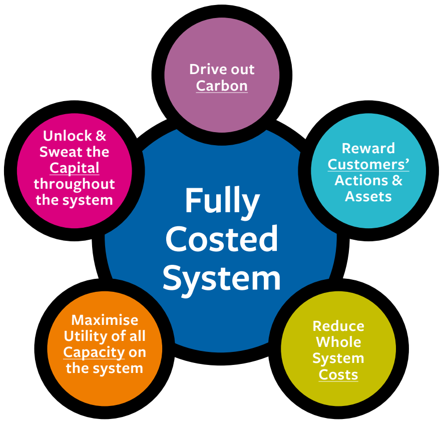
Carbon busting must be a priority for government to become Net Zero compliant. Our measures have few cost implications but aim to make regulation, policy and our existing schemes ensure that fossil fuel choices are difficult, burdensome and require public explanation and accountability.

These measures will unlock capital and reduce hurdle rates into the investment of flexible and low carbon technologies. A win-win!

1 Source: https://www.goodenergy.co.uk/blog/2017/08/15/green-tariffs-and-regos/
2 Support for renewables was at 82% in the latest BEIS public attitude tracker. Source: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/884028/BEIS_PAT_W33_-_Key_findings_Final_.pdf
3 Which found that over half of the 355 electricity tariffs reviewed in 2019 had renewable credentials. Source: https://www.which.co.uk/news/2019/09/how-green-is-your-energy-tariff/

FULLY COSTED SYSTEM

FROM SILOS TO WHOLE SYSTEM



Optimising the Five Cs of a Fully Costed System

AMBITION: Drive greater and more efficient optimisation of whole system costs, unlocking the value in demand and flexibility assets while delivering customer benefits through spreading the financial joy

TODAY: Silos still dominate with whole system costings rare. Cost impacts from one actor are passed onto others with few penalties or sanctions. Demand assets are still marginalised in terms of support, regulation and market design

Recommendations: From Silos to Whole System

1. **Fully Costed Decision Making:** Policy, regulation and market design must accommodate the full system impacts ensuring that costs or impacts are not passed from one silo to another
2. **Audit of Fully Costed System:** Whole System NAO Audit of policy, regulation and regulated assets
3. **Levelised Cost of Energy no longer Fit-for-Purpose:** LCOE is too blunt an instrument to be useful in valuing or costing the system
4. **Demand is Equal to Supply:** All policy and regulation and regulated assets must consider demand actions and assets equal to supply assets
5. **Capturing Value Avoided Costs:** By adopting whole system costings it is possible to make decisions and capture the real value of avoided costs
6. **More Data and Analysis:** The metrics in this report start analysing the value of whole system optimisation but our analysis has shown that there are still a lot of data gaps

Fully Costed and Fully Valued

With fragmented responsibilities, siloed regulation and technology-based policy making, the whole system costs and carbon are at best nodded to and at worst not accounted for at all.

For example:

- Despite the success of the CfD in unlocking investment, this scheme does not consider the balancing costs or network constraints.
- Generation assets are not being blended with storage assets.
- There are duplications of actions taken by different system actors within the system. In the future this will become much more prevalent if not addressed.

Full system metrics do exist but it is not evident that they are used throughout all policy and regulatory decision making.

ETI and Frontier Economics identified the variable components of whole system costings, revealing the costs but also the associated benefits that need to be considered, and this is the basis of our new metrics.

Normal supply chains in other sectors would be entirely abreast of and have visibility of total system costs and would be driving out costs across the system

The Components of Whole Electricity System Costs

Technology direct costs	▪ Capital and operational costs associated with the incremental technology.
Capacity adequacy impacts	▪ To the extent existing capacity can be retired, or new capacity forgone to ensure the same level of security of supply and carbon intensity as the counterfactual, there is a cost saving to the system.
Balancing costs	▪ If the incremental capacity impacts on the uncertainty of supply, it will affect how generators in the rest of the system are called on to help support system stability by altering their output. It will also affect the extent to which they need to be prepared to do so at short notice, potentiallyaffecting their staffing, fuel, and/or maintenance costs.
Network impacts	▪ The incremental technology may require investments to reinforce or extend the existing grid, and changes to power flow may increase or decrease power losses due to transmission and distribution. It is also possible that technologies can free up headroom on the grid, creating network benefits.
Displaced generation impacts	▪ Outputs from the incremental technology can displace higher marginal cost generation, producing variable cost savings, e.g. fuel, carbon. The scale of this is diminished if generators in the rest of the system operate less efficiently, or the incremental technology is curtailed. This category includes the impact on variable costs of ensuring that the same carbon intensity is maintained.

Source: Frontier

Recommendation 1: Fully Costed Decision Making

All policy, regulation and market development need to account for full system costs not least those that are picked up by consumers through misalignments in the design of the market. There are too many regulatory frameworks that do not require the actors to be responsible for the whole and total system costs and these need to be reviewed.

THE MODEL EXISTS
Whole system costings need to be introduced and incorporated across policy and regulation

Recommendation 2: Whole System NAO Audit and Assessment

The National Audit Office should be given responsibility to look at total system value every five years while Ofgem and BEIS should appoint a small but independent team to audit all decisions for their full system cost benefits.

PAINFUL BUT IMPORTANT
To change mindset and to drive new models to analyse whole system costs

New Metrics: The Missing Value of Demand

Demand and flexibility actions have not been effectively valued or costed within the system. This report has undertaken research that "crowds in" demand actions into the full cost and value of the system and unlocks a new competitive force within the sector – supply versus demand.

While there are many metrics available to understand the investment case for the deployment of specific producing technologies, there are few comparative metrics that measure the value that evaluate demand side "competitors". Procurement choices have competed different types of generation by focusing on the LCOE calculations. The generation of energy, however, is only one part of the cost and other system and distribution costs are rising with a greater impact on the overall system costs.

New Research Unlocking Whole System Cost and Saving

ReCosting Energy has commissioned new research, providing a methodology to compare the value of all actions on the system, while also explicitly valuing and comparing several different demand assets and actions.

If the energy system is designed in a way that allows all assets, both demand and supply side, to receive their full value to the system, this will help ensure the optimal mixture of technologies is deployed.

Drawing on the work that Frontier Economics, ETI and LCP have done already on the fully costed "supply" part of the market, we asked Frontier Economics, LCP and the BEIS Dynamic Dispatch Model (DDM) team to run their model with demand side actions, energy efficiency, and storage of all sizes, equally compared with traditional supply options.

Our research has shown that comparisons are possible and necessary and has focussed on quantifying the value of technologies per MWh of energy they produce or avoid.

Implications for Policy & Regulation

- **Reveals the value of demand side assets and storage**
- **Calls for policy, regulation and monopoly actors to give a new prominence to these assets and actions**
- **Indicates that we do not reward demand and flexibility assets and actions appropriately**
- **Creates a new value of "avoided cost" to the whole system**

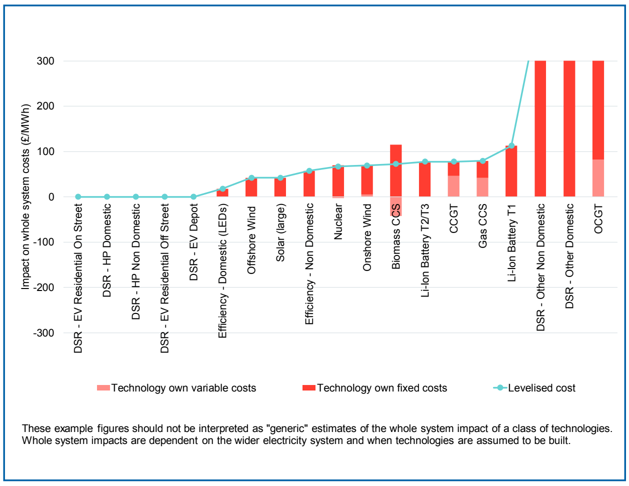
What the research has shown us

Many thanks to LCP, Frontier Economics and BEIS's DDM team for conducting what we think is the very first comparison between whole system analysis of demand assets and actions equally and equivalently compared with generation options.

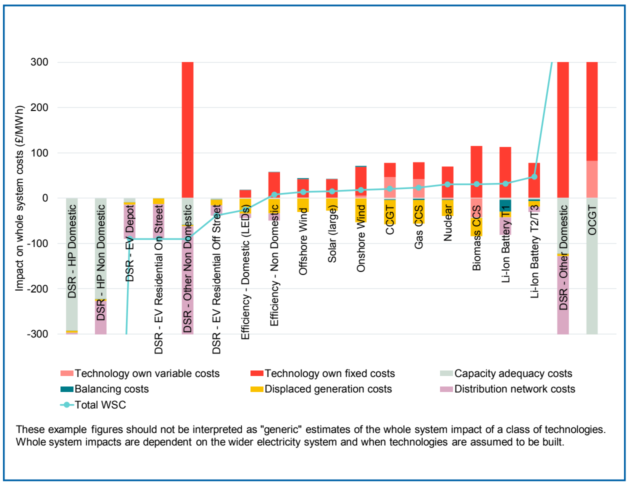
Frontier Economics' full analysis is in Annex One

Comparing the outcomes from a Levelised Cost of Electricity and a Whole Electricity System Cost analysis including for the first time demand assets equally compared to generation assets

TODAY: LEVELISED COST



TOMORROW: WHOLE SYSTEM COSTS



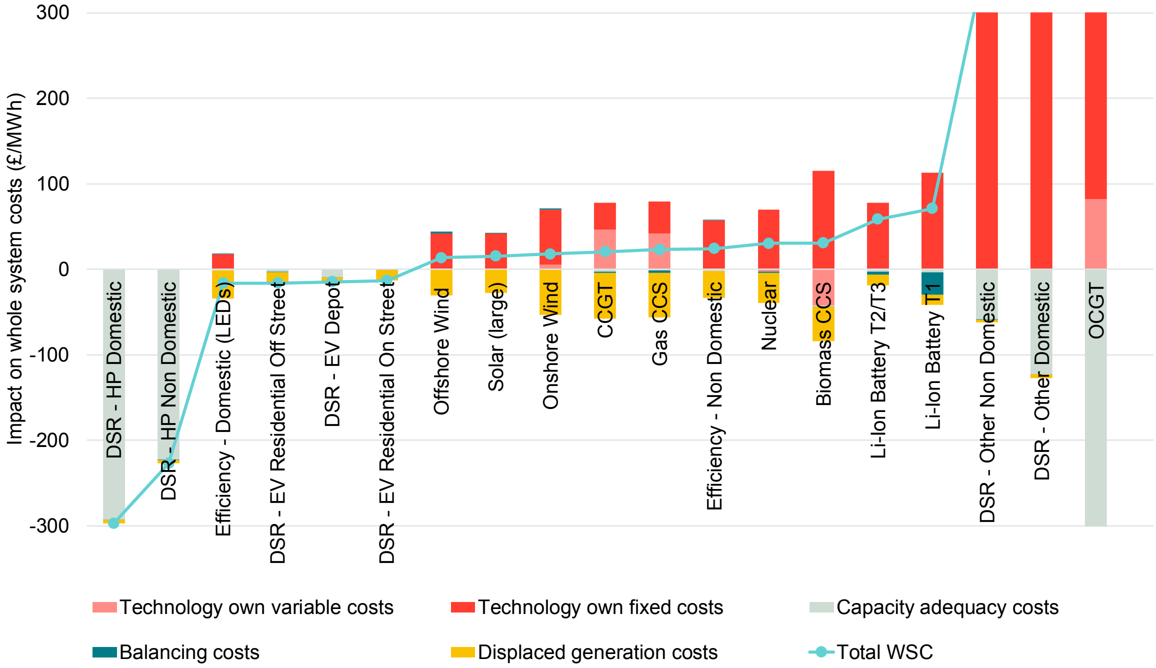
Revealing different outcomes for all forms of demand and flexibility assets and generation assets, showing LCOE is not able to reflect the overall value or cost to the system

Source: @Challenging Ideas: ReCosting Energy

Moving from LCOE to Whole Electricity System Cost

To go from LCOE to Whole Electricity System Cost (WESC) requires adding on the additional costs and benefits attributable to a technology on the wider system. The graph below shows the impact on total system costs of adding a sufficient amount of a technology that will produce or avoid the requirement for 1MWh of electricity. Negative values indicate a technology that, when added to the system, reduces costs.

Whole Electricity System Costs, excluding distribution network benefits

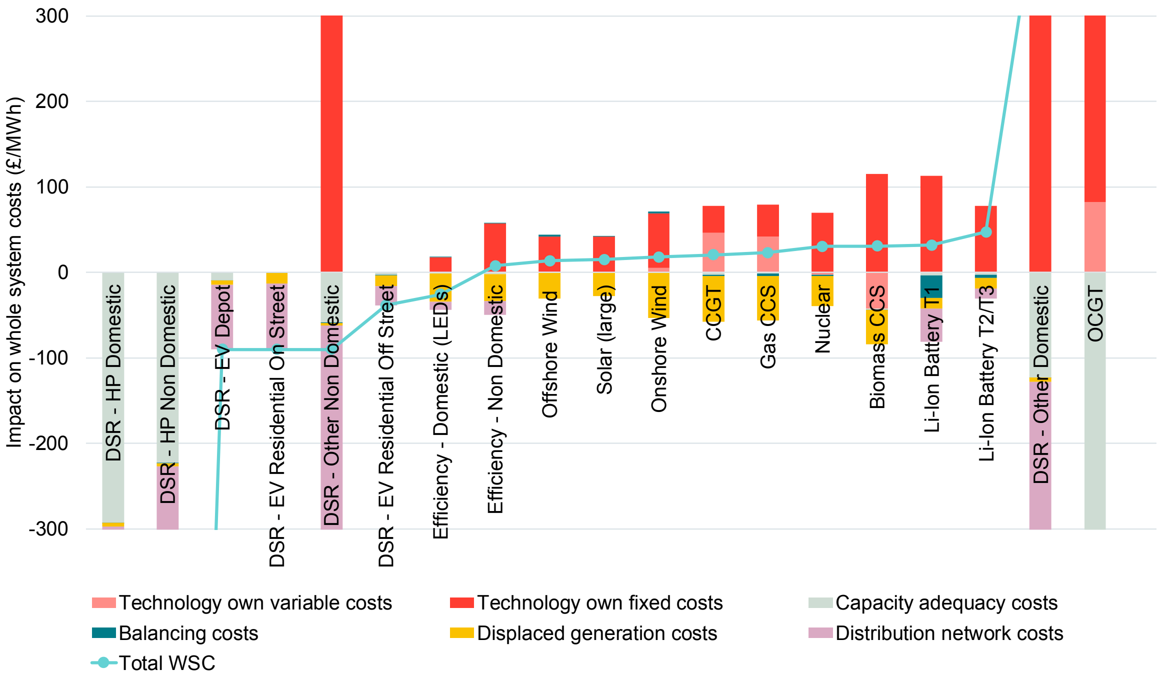


These example figures should not be interpreted as "generic" estimates of the whole system impact of a class of technologies. Whole system impacts are dependent on the wider electricity system and when technologies are assumed to be built.

Source: Frontier

The following graph includes an illustrative component for distribution network benefits. This accounts for the way that demand-side technologies may be able to reduce reinforcement costs on the networks.

Whole Electricity System Costs, including distribution network benefits



These example figures should not be interpreted as "generic" estimates of the whole system impact of a class of technologies. Whole system impacts are dependent on the wider electricity system and when technologies are assumed to be built.

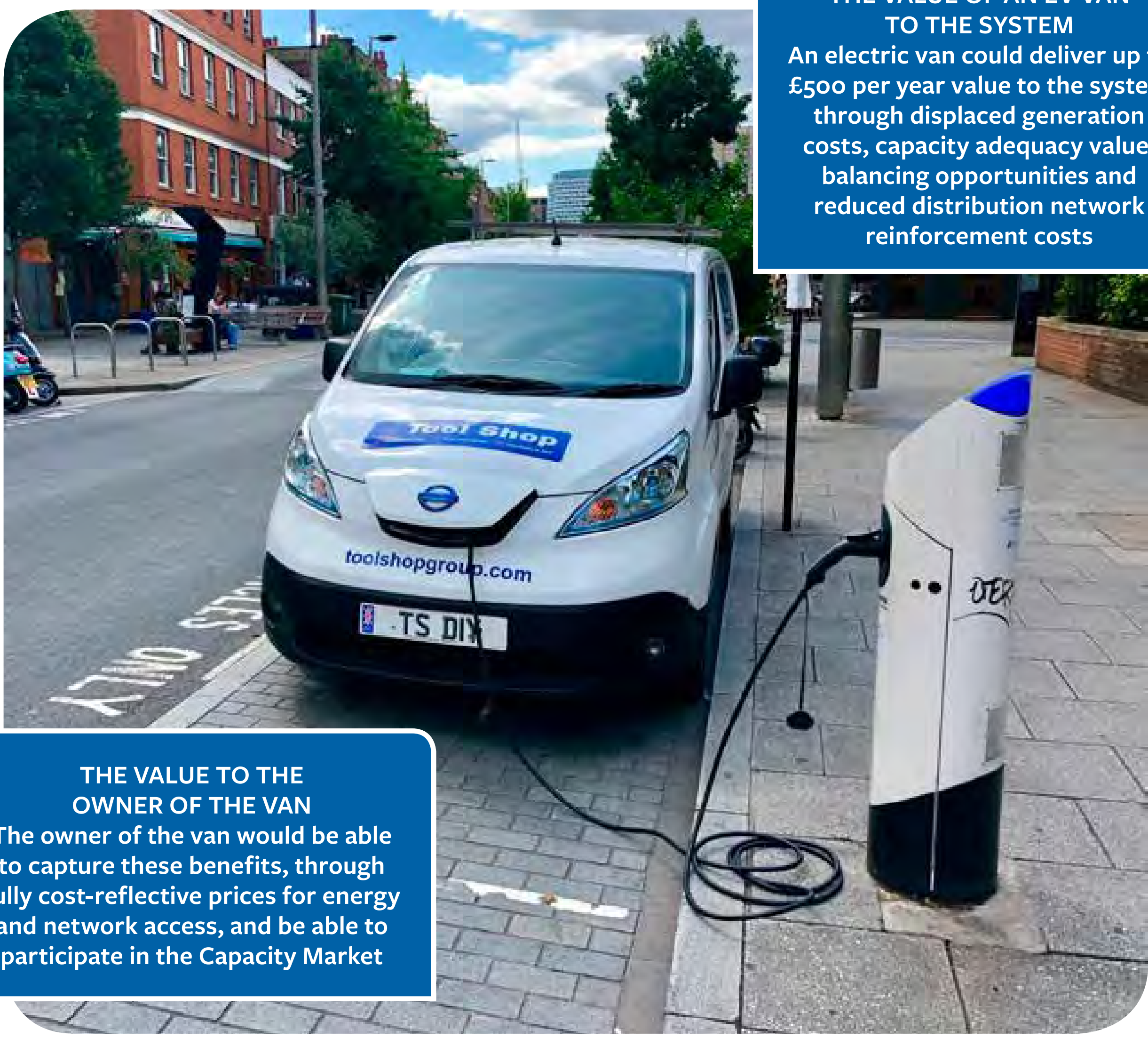
Key Findings: Whole System Value comparing Demand and Generation Assets

- **Value for Money:** Demand side measures can provide better value than generation technologies
- **Whole System Benefit:** More demand side measures can reduce overall system costs
- **Value of Renewable Generation and Storage:** Renewable generation and larger scale storage also show a reduction in whole system costs from an LCOE analysis
- **Network Benefits:** In areas of constrained capacity these demand side and storage technologies have an increased value
- **Avoided Costs:** Many of the actions and assets analysed show a real "avoided cost" which needs to be captured.

These findings and this analysis also reinforces the key recommendations in the section "From Socialising Risk to Owning Risk", that highlights the need for businesses to manage their own whole systems risks and associated costs.

An EV van example

THE VALUE OF AN EV VAN TO THE SYSTEM
An electric van could deliver up to £500 per year value to the system through displaced generation costs, capacity adequacy value, balancing opportunities and reduced distribution network reinforcement costs



THE VALUE TO THE OWNER OF THE VAN
The owner of the van would be able to capture these benefits, through fully cost-reflective prices for energy and network access, and be able to participate in the Capacity Market

Some of the assumptions of how demand assets could perform are conservative, and with greater automation, increased price signals and locational pricing the impact of demand assets will increase.

Technology	Description	Capital costs	Fixed O&M costs	Variable costs
DSR – EV residential on street	20% of demand in the period between 4pm and 10pm can be shifted later by up to 8 hours.	N/A – it is assumed that once an EV is purchased, there are no additional costs in enabling it to undertake DSR.	N/A – it is assumed that once an EV is purchased, there are no additional costs in using it to undertake DSR.	N/A. While there will be a cost associated with charging the battery at a later period, this will be modelled as part of the "displaced generation cost".
DSR – EV residential off street	70% of demand in the period between 4pm and 10pm can be shifted later by up to 8 hours.			
DSR – EV depot				
DSR – HP domestic	2% of peak demand can be shifted by up to 23 hours earlier (based on 20% of properties having heat storage).	N/A – it is assumed that once a HP is purchased, there are no additional costs in enabling it to undertake DSR.	N/A – it is assumed that once a HP is purchased, there are no additional costs in enabling it to undertake DSR.	N/A. While there will be a cost associated with running the heat pump earlier, this will be modelled as part of the "displaced generation cost".
DSR – HP non-domestic				
DSR – other domestic	Demand can be shifted backwards or forwards by up to 4 hours.	£514/kW.	N/A.	N/A – it is assumed that the DSR can be carried out in a way that does not inconvenience the consumer.
DSR – other non domestic	Demand can be shifted backwards or forwards by up to 2 hours.	£300/kW.		
Li-Ion battery DNO T1	DNO batteries with 1 hour duration.	£500/kW	£80/kW	N/A. While there will be a cost associated with charging the battery at a later period, this will be modelled as part of the "displaced generation cost".
Li-Ion battery DNO T2/T3	DNO batteries with 4 hour duration.	£1,170/kW	£190/kW	
Efficiency – domestic LEDs	Modelled as a percentage reduction in energy use.	£593/kW	N/A	N/A

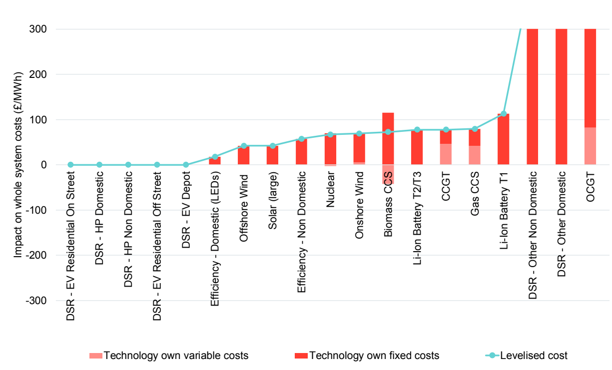
(1) DSR cost based on average of 'high' and 'low' 2030 scenarios from p74 of Carbon Trust and Imperial (2016), *An Analysis of electricity system flexibility for Great Britain*
(2) All figures for Li-Ion batteries are shown as a discounted cost per kW over the lifetime of the battery. For example, the capital costs will first have been annuitised at a hurdle rate, and then discounted back at the 3.5% social discount rate
(3) Based on an illustrative estimate of £15/MWh/year from BEIS. This was based on the use of LED bulbs. We converted this to £/kW using the load factor within the DDM. We have also scaled the cost up to account for the way that the DDM assumes that energy efficiency measures will last for 30 years, while the cost input is based on an intervention that only lasts 10 years.

Recommendations from the Research

Recommendation 3: Levelised Cost of Electricity is no Longer an Effective Metric of Cost or Value

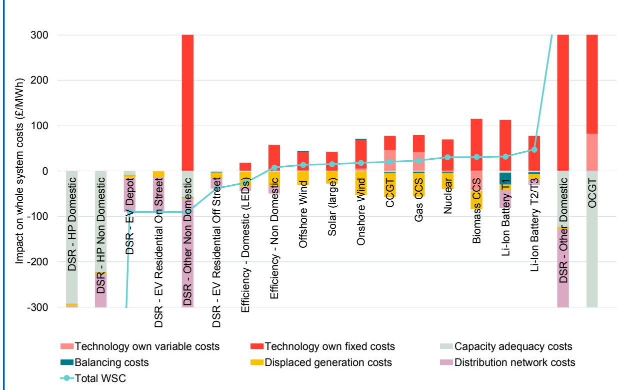
Levelised cost of electricity is no longer, or maybe never has ever been, an effective measure of valuing whole system costs and should not be utilised in decision making or as a metric of value for support mechanisms such as the Contracts for Difference. This mis-costing of the system is becoming more and more of a distortion as system costs rise and commodity costs reduce.

TODAY: LEVELISED COST



These example figures should not be interpreted as "generic" estimates of the whole system impact of a class of technologies. Whole system impacts are dependent on the wider electricity system and when technologies are assumed to be built.

TOMORROW: WHOLE SYSTEM COSTS



These example figures should not be interpreted as "generic" estimates of the whole system impact of a class of technologies. Whole system impacts are dependent on the wider electricity system and when technologies are assumed to be built.

Revealing different outcomes for all forms of demand and flexibility assets and generation assets, showing LCOE is not able to reflect the overall value or cost to the system

WHOLE SYSTEM COSTING METHODOLOGY EXISTS
It is now about deploying whole system methodology to inform decision making, where possible ensuring the incentives faced by market actors reflect the whole system costs and benefits. However, it does require more work on the nature and operational characteristics of different demand actions and assets, as well as how to compare the value of assets that primarily provide energy against those that primarily provide capacity.

Recommendation 4: All Assets and Options Must be Considered Equal

We believe that including demand side assets and actions as a mainstream actor is crucial in driving greater value from the system, informing choices, and designing support mechanisms. By creating equality it will open up investment in storage and generation blending, flexibility, customers assets and permanent demand reduction (energy efficiency).

Extraordinarily the Capacity Market "does not have rewarding flexibility"[1] as an objective, which seems like a big gap in its ability to reward the multiple routes to delivering capacity.

REQUIRES A ROLLING REVIEW OF POLICY, REGULATION AND MARKET DESIGN
We highlight recommendations throughout this report of how existing schemes, markets and regulation can ensure that demand is considered equally to generation options. As an added benefit, in many instances the value of these assets can flow to consumers, which is currently unattainable

Physics tells us that demand is of equal importance to supply

Recommendation 5: Value the Avoided Cost of Energy

This work creates a value for Avoided Cost of Energy – requiring less total energy, managing peak not meeting peak, sweating assets efficiently and delivering energy efficiency. The Avoided Cost of Energy needs to become much more central as we move forward if we are to avoid 'milk lakes', increased system costs and under-utilised assets.

We currently neither quantify nor pass on the value of avoided costs in the current system effectively. Through the comparative metrics developed, there is the opportunity to attribute the avoided cost of energy to those that assist the system to avoid increasing generation assets, balancing charges not incurred, distribution costs not required and overall capacity increased. We further develop the project's analysis to show how this value can be attributed effectively to reward assets and actions throughout the system.

This avoided cost is only realised through Whole System Modelling revealing that value often sits between the current silos. Costing the whole system and taking decisions on the basis of whole system efficiency is crucial if this "productivity" gain is to be captured.

The US Energy Information Department has been exploring the Levelised Avoided Cost of Energy (LACE)[2] and has created some metrics but this doesn't include demand side actions or assets[3].

THE COUNTERFACTUAL IS DIFFICULT
The energy system is not exposed to supply chain pressures or optimisation models that identify avoided costs – i.e. efficiencies. This value can only be realised through whole system costings and businesses being exposed to the risk and rewards of capturing these values.

Recommendation 6: More Data and Analysis Required

This project was only able to quantify and compare all technology options for the increase ina 1 MW of energy. However, there are several other value pots that need to be quantified and we recommend that this work is done as part of the wider BEIS and industry flexibility planning.

While this project has shown that demand side assets and actions deliver a value to the system, it has also revealed the very sparse knowledge and data around demand assets and actions costs and their characteristics.

RESEARCH AND MODELLING PROJECTS

There is a need for greater modelling of demand, measured against whole system costs. It might require, as we start this optimisation journey, giving different assets an allocated value so that we can initially standardise the "base case", developing into more nuanced values as we see how assets perform and what new assets come onto the system. This will also be accelerated by greater digitalisation of assets and much more granular information flows.

Conclusion

These metrics make the case that demand and generation should be compared equally and provide policy and regulation new tools to optimise the system more efficiently. It also requires focus on the interaction between demand and supply, moving customers from being on the side lines to being central to delivering an optimised, efficient and modern energy system – with value and benefits flowing in their direction.

This value will be further realised by half-hourly settlements and technology based services that will be in a position to capture the value and reward the actions and assets.

This is the start of fully optimising the system, driving more from less, and is at the heart of our overarching principle of optimisation not consumption.

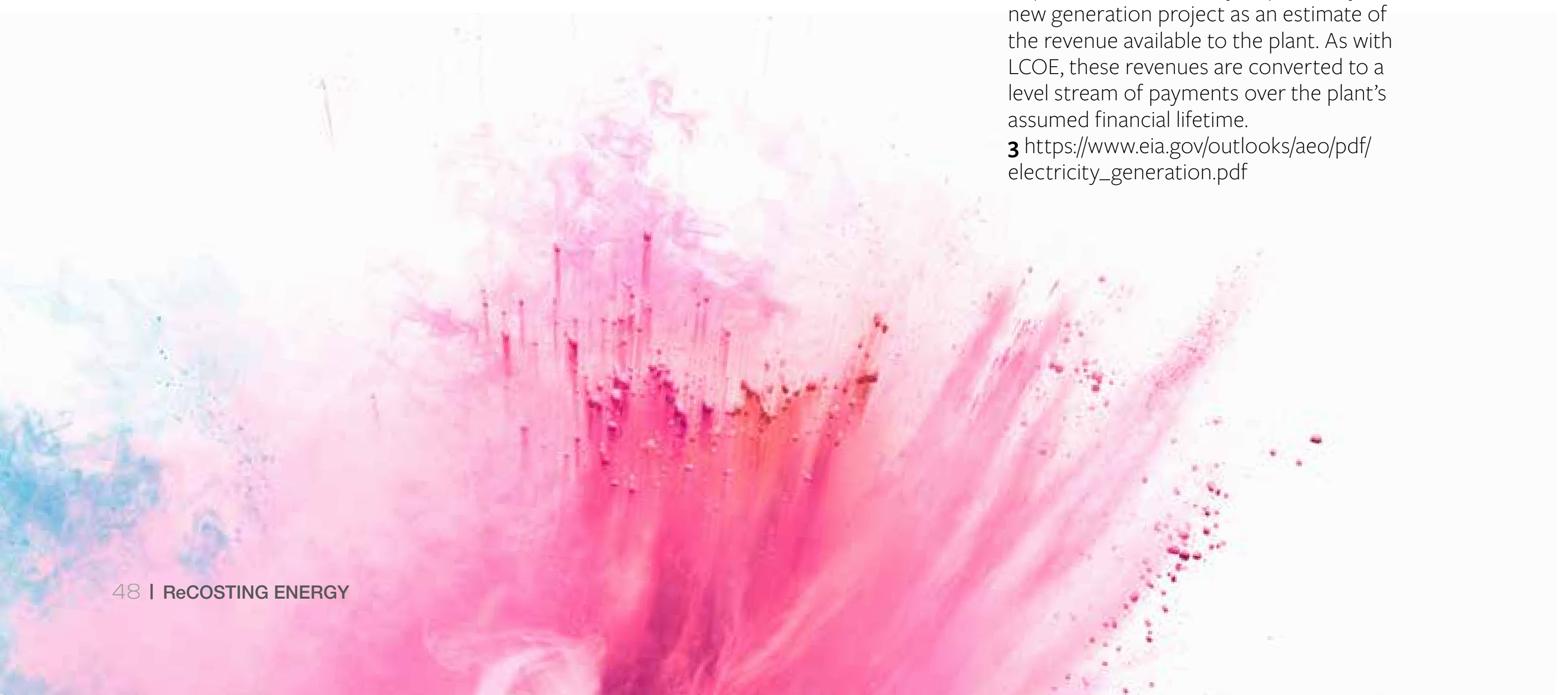
FRONTIER ECONOMICS SAYS

"This exercise has highlighted the relative paucity of data on the costs and benefits of demand-side measures... to consider demand-side measures alongside generation, a more systematic collation of this data along the lines of what is available for generation will be required."

1 https://www.gov.uk/government/consultations/capacity-market-new-technologies-2020/outcome/government-response-reply-to-stakeholders-on-new-technologies-in-the-capacity-market

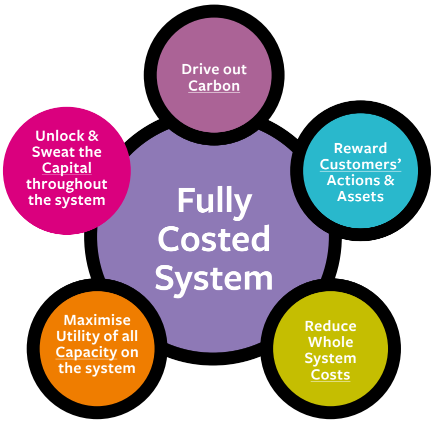
2 The Levelised Avoided Cost of Electricity (LACE) represents that power plant's value to the grid. A generator's avoided cost reflects the costs that would be incurred to provide the electricity displaced, by a new generation project as an estimate of the revenue available to the plant. As with LCOE, these revenues are converted to a level stream of payments over the plant's assumed financial lifetime.

3 https://www.eia.gov/outlooks/aeo/pdf/electricity_generation.pdf



DEEP DIGITALISATION

FROM BRAWN TO BRAINS



Optimising the Five Cs of a Fully Costed System

AMBITION: Develop a smart, responsive system, conflating energy and information to deliver more productive, stable and optimised infrastructure while releasing the value of potentially 50 million varied, diverse actors, assets and actions

TODAY: Despite significant progress, the energy sector needs to attract new skills, and increase investment in the transformative impacts of digitalisation

Recommendations: From Brawn to Brains

1. **Mandate all Energy Assets to be Digitally Enabled:** All energy assets from the home to the North Sea need to be interoperable and able to be connected and those supported by government need to be contractually required to share data
2. **Kick-Start Key Digital Tools:** There are some no-regrets and essential digital tools required to unlock the value and ensure stability of the system
3. **Opening Up Consumer Value:** A fundamental reform of how and what we enable consumers to do with their data while ensuring control, privacy and protections
4. **Digitalise Regulatory Priorities:** Focus more on softer assets and skills
5. **Build the Framework for Digitalisation Governance:** Establish the governance frameworks for managing and anticipating risks
6. **Skills Capabilities and Literacy:** Build a sector that is digitally literate and attractive to the brightest and best from the digital world

The system is moving from around 500 significant actors to the potential of 50 million actions and assets all "playing" in the system both drawing on and delivering energy

The Ambition

To unlock the innovation, value, cost reductions and optimisation that all actors can contribute to and benefit from, through effective coordination of the application of technology, and markets through deep digitalisation.

A Vision for a Digitalised Energy Internet

CUSTOMERS:

- **Auto-registration:** All assets from your fridge to your EV being automatically registered, with the characteristics and operational activity of those products and assets being shared with the system and markets, depending on customer consent
- **Auto-optimised:** Assets receive market and system signals that reward key actions and optimise utilisation of energy for the benefit of the owners and the systems
- **Personalised Services:** Ability to access tailored and good value propositions to optimise the needs and choices of consumers
- **Democratise Rewards:** Accessible markets will reward micro and macro actions and assets equally

RETAILERS:

- **Integrated Products and Services:** Retailers able to develop new business propositions providing a greater range of markets, customers and opportunities and easily build new B2B, B2C and B2B2C alliances and relationships
- **New Business Models:** Retailers offered transformative technology to change how and what they deliver to customers to unlock the value of their customers

NETWORK AND SYSTEM OPERATORS:

- **Automated System Design:** Significant automation of all systems and transformation of network and system management
- **Highly Calibrated Management**: Transformative planning, management, operational and maintenance tools
- **Multi-centred, Multi-vector System:** Energy will flow automatically from and to assets throughout the system optimising across electricity and gas networks, and blending grid edge, decentralised and centralised assets and actions

POLICY & REGULATORS:

- **New Level of Policy and Regulatory Oversight:** Dynamic modelling of the impact of policy and regulation interventions and their impact in the real market
- **Effective Risk Management:** Early warning of key market concerns, abuses and risks

MARKETS:

- **Open and Democratised Markets:** New varied tailored and accessible markets developed to unlock value throughout the supply chain

Future Challenges

REFORM OF FINANCIAL MARKETS
Numerous changes occurred simultaneously but perhaps the most important was the swift movement of securities trading away from the floor of the Exchange to a technology-based trading system open to a much wider set of players and heralding the democratisation of accessing financial markets. The key components were regulatory reform and technological advances and capabilities enabled by deep digitalisation of the underlying system.

The changes that the system will face are transformative in nature, scale and dynamism. Continuing with an analogue system will be expensive and not able to maintain energy security or system stability. At worst, energy services will collapse, require huge investment, further marginalise specific consumers, and not unlock the significant innovation and entrepreneurialism that the new system offers.

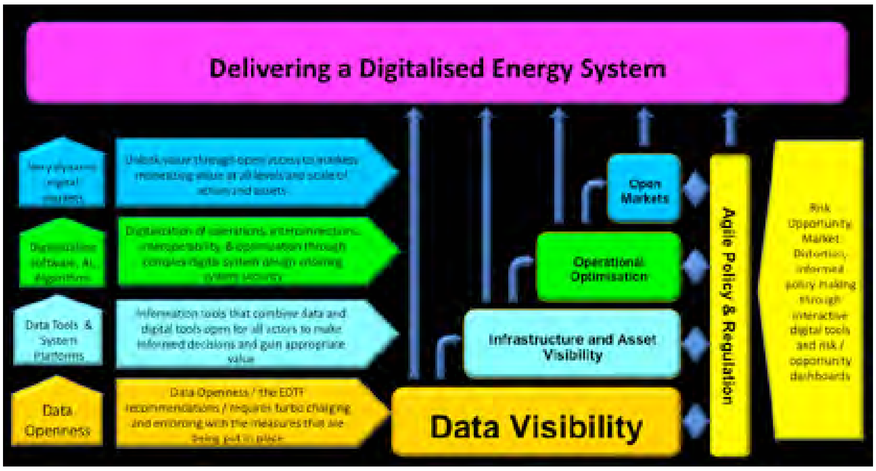
Consider the system challenges that are only solvable through deep digitalisation:

- **Quantity:** An exponential increase in the quantity of actions and transactions
- **Diversity:** Varied and multiple actors participating, with diverse asset capabilities and actions
- **Interaction:** The interaction of these diverse actors and their cumulative impact
- **Different:** The changing functions and characteristics of new products and new service propositions
- **Devolution:** The need to act and collaborate with a wider group of actors creating a matrix of decision makers
- **Dependency:** Greater inter-dependencies within the sector and beyond energy not least communications and transport.

Modern Digitalised Energy Infrastructure

The Energy Data Taskforce was very specifically focused on data and, following BEIS and Ofgem's adoption of the recommendations, the key elements of the report are being implemented not least through RIIO2 licence obligations and the Modernising Energy Data programme being run by BEIS, Ofgem and InnovateUK.

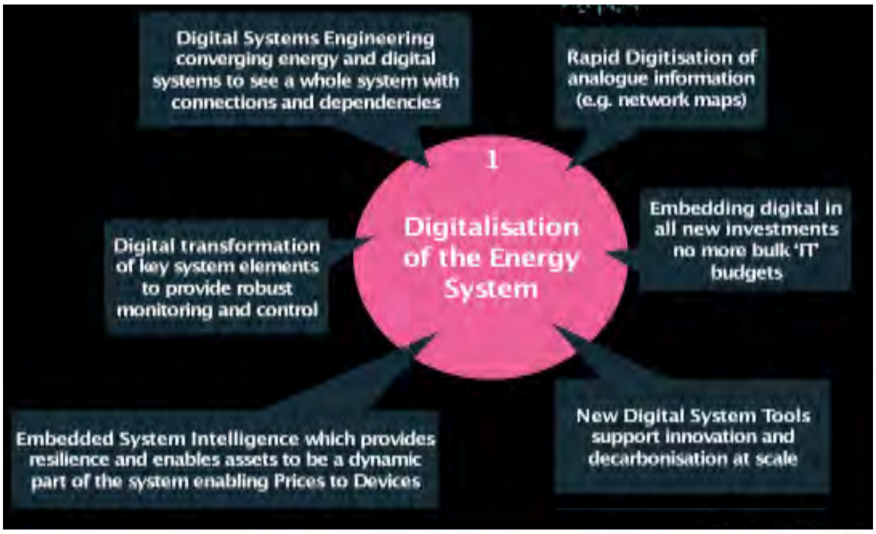
A Modern Digitalised Infrastructure needs to move from data to digitalisation. The outcomes could be realised through the four key steps for digitalisation as outlined in the Energy Data Taskforce report.[1]



This requires interoperation, practice-sharing and common governance, with many more players taking responsibility for system stability and managing energy through multi-lateral data flows, enabled through a deeply digitalised ecosystem of markets, services and exchanges.

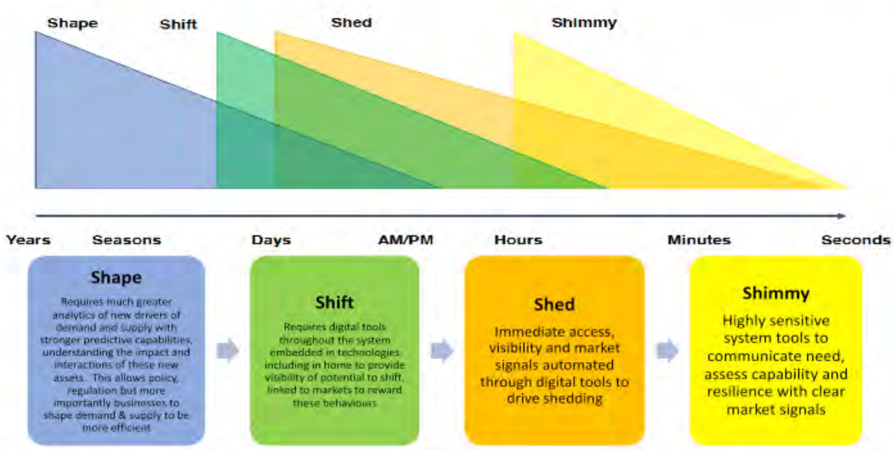
Changing Needs within our Infrastructure

This chart outlines the key digital infrastructure needs, all of which have been embedded in other sectors and so are tried and tested.



System Flexibility

Drawing on some of the key challenges from the Energy System Operator's Bridging the Gap project[2], the key system stability, security and value challenges and opportunities can be shaped around four core functions.[3]



To perform these functions across the quantity and diversity of new actors on the system requires new approaches to system management and stability, blending technology and markets through digitalised platforms and modelling.

Planning, Procurement, Regulatory and Design Tools

Strategic planning with 50 million potential assets and actions on the system will require some significant modelling tools that will need to identify, predict and analyse all the impacts of the growing number of moving parts.

Analytics that understand all drivers of optimisation will require much greater insights into the interaction between carbon, customers, capacity and cost, working at both national and local system planning levels.

This very much shapes a new energy system that is totally interrelated but also interdependent on communications and offers some really important opportunities and challenges to how we regard infrastructure into the future.

Recommendation 1: Mandate all Energy Assets Digitally Enabled

All government support mechanisms and access to markets should include contractual requirements for operational data sharing and interoperable digitalised capabilities to enable more effective system management, and greater asset visibility.

There are many new assets being added to the system at the grid's edge, even those receiving micro generation payments, that are not fully digitally enabled or if digitally enabled are not accessible to the energy system.

PRICES TO DEVICES: SMART PRODUCTS
All in-home and in-business energy using products should be "energy enabled" through integrating cheap "Wifi chips" to enable auto-discovery, self-registration and self-heal as is common elsewhere. This is particularly important and exciting for EVs on the move!

Simple amendments to Contracts for Difference, the Capacity Market and all ESO markets to require operational data sharing.

Energy enabled products would allow for auto-registration across the multiple registration platforms, provide visibility of assets and their capabilities, and enable owners to secure rewards and benefits for automated optimisation.

This would also allow for value to flow to assets through "prices to devices" that would further automate the benefit flow and democratise the system.

Mandate from 2023 new assets on the Microgeneration Certificate Scheme to be digitally enabled. Discussions with the manufacturers of grid edge equipment and in-home appliance to encourage their products to adopt Energy Enabled Standards.

Recommendation 2: Kick-Start Key Digital Tools

The teams at BEIS, Ofgem and InnovateUK are accelerating the development of key digital tools required to move towards a digitalised energy system. The journey has started, and excellent work is being undertaken to deliver these building blocks.

The key challenges that need to be addressed:

- **Digital Infrastructure:** Moving from greater asset visibility to building digital tools to manage, optimise and blend assets, enabling connectivity, monitoring, control and interoperability, all driving efficiency and resilience.
- **Turbocharge Interoperability:** Interoperability tools need to be extended from just system actors through to other sectors such as transport, local authorities and other service providers through open APIs and open data protocols.
- **Multi-actor System Stability:** Opening up system operation and enabling multi-level, coordinated optimisation at all levels within the system, helping to coordinate different actors and actions.
- **Market Development:** The markets need to develop digital infrastructure to open up to new actions and new actors across the system. The ESO and many of the DNOs are developing these market platforms and should learn from the stock market trading platforms that have multiple customer interfaces but interoperate with the real time stock market data.

These digital tools are in play across many other sectors and learning from these other sectors will allow the energy system to adopt, adapt and implement these tools quickly and effectively.

Establish a BEIS Energy Digital Tools task and finish group, importantly adopting tried and tested standards and protocols from other sectors.

UK lead on a global energy connectivity standard, learning from the Global System for Mobile (GSM) Success

Finland took the lead in creating global standards for mobile connectivity. Within three years GSM was established as the global standard. The UK is well positioned to own this equivalent and mimic many of the protocols from GSM and Wifi protocols for a fully "connected" energy system.

Recommendation 3: Opening Up Consumer Value

There is rightful concern about the privacy of consumer data. However the regime around consumer data is very out of date, fashioned in the 2000s with no visibility of what consumers might want or be able to benefit from in a truly digitalised energy system. Allowing for greater data sharing needs to be seen as an empowerment of consumers, placing power, consent and control in their hands for their benefit.

Estonian Model: Estfeed

Estonia has developed a consumer-centric methodology by which consumers not only have control of their data but have great ease in sharing it with all parties that might offer them value, reversing the consent from government knows best, to putting the power in the hands of the people. This makes for a much more dynamic and consumer-centric design and as an EU member is totally GDPR compliant.[4]

Government should commission a feasibility study of the Estonian model to establish what can migrate to the UK market. In addition, there are several platforms and security and privacy protocols that have been developed by the Estonian government that should provide the governance required.

Commission Elering, Estonia's transmission operator, to work with BEIS to identify the elements of their model that can be employed in the UK. Adopt the Public Interest Principle to enable sharing of smart meter data.

The Smart Meter Energy Data Public Interest Advisory Group (PIAG)[5] and Citizens Advice Midata

There has been some important work done on how we might open up consumer data to the system and for consumers' benefit.

Their key recommendations include:

- **Importance of Smart Meter Data (PIAG):** Access to smart meter data for public policy purposes is essential to avoid policy makers and industry actors "flying blind" into the energy transition
- **The Public Interest Principle exists in other sectors (PIAG):** Government should draw on existing arrangements used in other sectors to enable access to smart meter data for a public interest purpose while protecting privacy
- **Consumer Consent (Citizens Advice):** Customers own their data and must give explicit individual consent for access but in the act of obtaining consent innovators and market actors will beneficially engage consumers in demand-side actions.

Blending the recommendations and principles from PIAG and Citizens Advice with the methodology and technology adopted by Estonia to empower consumers

Recommendation 4: Digitalise Regulatory Priorities

Ofgem is embracing greater regulatory focus on digitalisation, as shown by the RIIO2 requirements for digitalisation strategies from the networks. However, there is still an unequal focus on the big infrastructure investment with less priority on the development of the "softer" assets and most importantly the investment in people to drive greater digitalisation throughout the network and system management functions.

This is particularly the case for the Electricity System Operator and networks whose investment in smart technology is crucial to enable the rest of the system to digitalise.

Ofgem requires a digital vision of what the future infrastructure needs to look like and what needs coordination to deliver lower costs into the future. In addition, it requires Ofgem and Ofcom to understand their interrelationships as their sectors are becoming progressively intertwined and inseparable.

Recommendation 5: Build Framework for Digitalisation Governance

Digitalisation is not risk free despite all its benefits. It comes with new regulatory challenges and new system risks, not least its reliance on stable and secure communications infrastructure.

However, the nature of digitalised system design and innovation must be recognised, and governance must neither crush nor disincentivise experimentation or unintentional mistakes. This requires a different approach to regulation that needs to adopt more adaptive and supportive regulatory mechanisms.

The key areas for focus need to be:

- Recommend mandates for core standards for interoperability
- Accredit the safety and efficacy of system wide data and digitalisation tools
- Anticipate the "interoperability and interaction" risks and opportunities
- Assure for cyber and security risks
- Assess the efficacy, ethical and distributional implications of AI, algorithms and emerging digital tools
- Anticipate the longer-term opportunities, needs and risk – planning for the transformative nature of digitalisation
- Prohibit any misuse of data or digital tools and develop appropriate redress

This is likely to form part of wider governance requirements across the sector but it is crucial that those with the responsibility for governance are independent of any operational body and able to independently assess and regulate this new world.

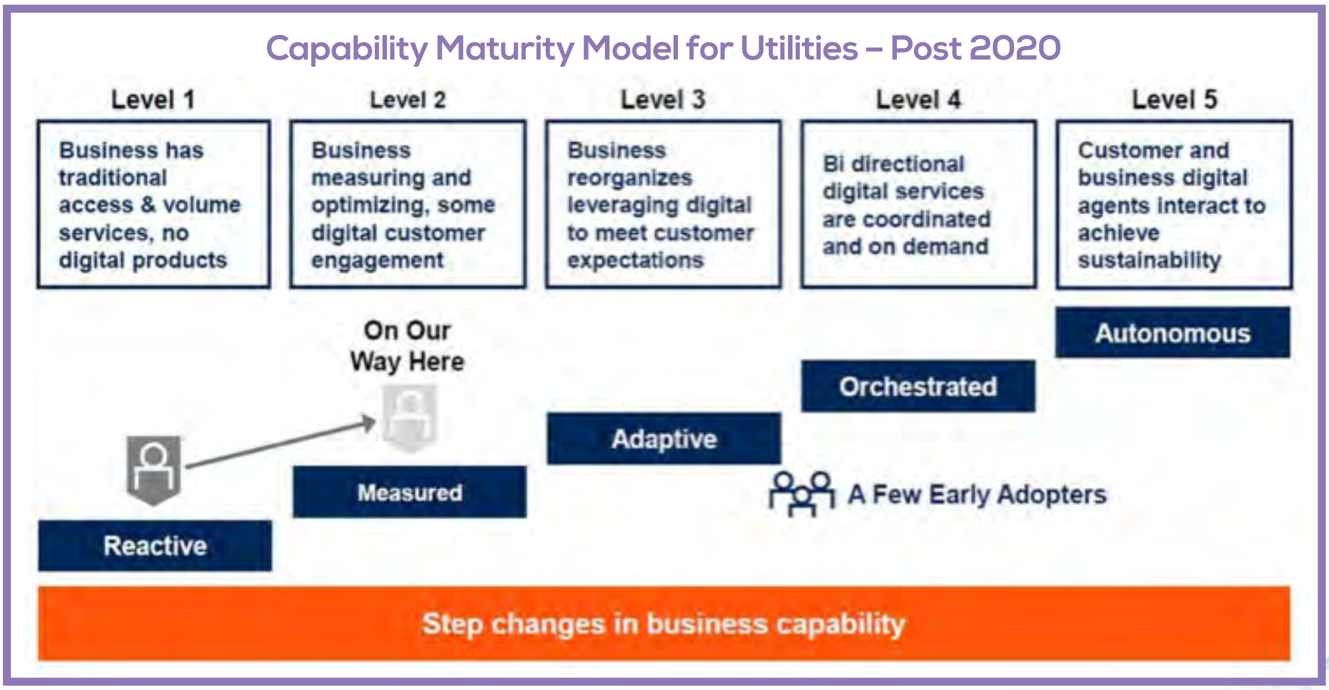
Recommendation 6: Skills Capabilities and Literacy

Lack of skills, capabilities and literacy are some of the biggest gaps facing the sector and there needs to be a concerted effort from all players to ensure that energy is seen as attractive, exciting and ambitious to attract the right people.

These gaps lie throughout energy organisations and companies and require not just the recruitment of the right digital personnel but also greater management literacy around the potentials of more data and digitalised business models.

Gartner produced this maturity map for the utility sector that reveals that we have a long way to go to develop truly transformational outcomes.

Digital Skills PLUS
Digital skills are not enough and need to be blended with understanding and expertise in consumer behaviour, digital business models, whole system engineering, energy, security, environment, planning and communications.



Conclusion

The Energy Internet is a unique opportunity that the UK is well placed to pioneer and for UK customers to benefit from. There is a need for an increased ambition to accelerate the new transformative business models. It also needs to be recognised that a very new and crucial alliance is emerging between the communications and the energy sectors as their mutual reliance and interconnectivity is at the heart of the new energy system.

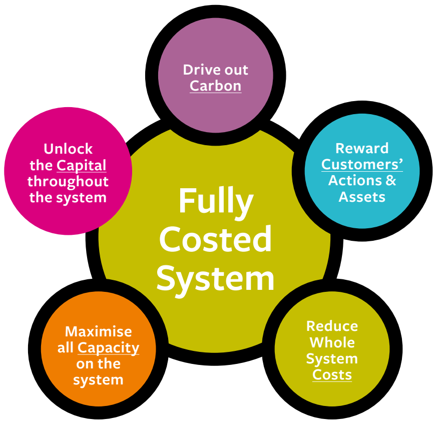
Digitalising the energy system is not just nice to have but essential – essential for customers to get the most from energy services, crucial for system stability and important to drive greater efficiencies throughout the system.

Consumers won't tolerate an analogue service for much longer when the rest of their world is optimised on their behalf, consumer-centric and responsive to their needs

1 http://www.challenging-ideas.com/wp-content/uploads/2019/07/EDTF-A-Strategy-for-a-Modern-Digitalised-Energy-System.pdf
2 https://www.nationalgrideso.com/future-energy/future-energy-scenarios/bridging-the-gap-to-net-zero
3 https://eta-publications.lbl.gov/sites/default/files/lbnl-2001113.pdf
4 https://www.estfeed.eu/en/home
5 https://www.smartenergydatapiag.org.uk

THE CITIZENS' DIVIDEND

FROM THE FEW TO THE MANY



Optimising the Five Cs of a Fully Costed System

AMBITION: A system designed for and by citizens, offering them opportunities and rewards as equal partners in building a decarbonised system. Focusing on delivering the most friction-free and cost-effective journey to a decarbonised future for all

TODAY: Customers are not seen as instrumental in shaping the new system and benefits to them often appear as secondary to the system's needs. Policies need to be designed to ensure citizens feel they are beneficiaries of the investment

Citizens do have a veto on Net Zero and will be the judge and jury on whether we have shaped our energy system with customers at its heart. A just transition is crucial to the sustainability of the decarbonisation journey and cannot be seen as an add-on but intrinsically embedded in all that the sector does.

This report places customers and citizens at the centre of the decarbonisation journey by respecting their crucial role and rewarding them accordingly.

There is a lot required to rebalance the system from the few players today to the many customers whose actions, assets and behaviours will have such a significant impact on decarbonisation. This power imbalance is significant today (see page 8 of Episode One), but when embarking on the next stages of decarbonisation – heat and transport – we are going to have to ask so much more of customers.

Consider the "asks" of customers going forward:
- invest in a new car
- change their heating equipment
- insulate their homes

The cost of these could total between £30,000 and £50,000.

While we know that these changes are essential to decarbonise, we have to establish not the what but HOW to enable, support and accelerate deployment of all these very expensive interventions that we need customers to make.

We have aimed to shape recommendations to unlock the value and the accessibility of all our assets to the many, not just those with capital sitting in their bank account.

The Opportunity

- To ensure large capital assets are available and accessible to the many
- To reward customers' actions and assets equally to those of generation
- To maintain strong citizen support in decarbonisation

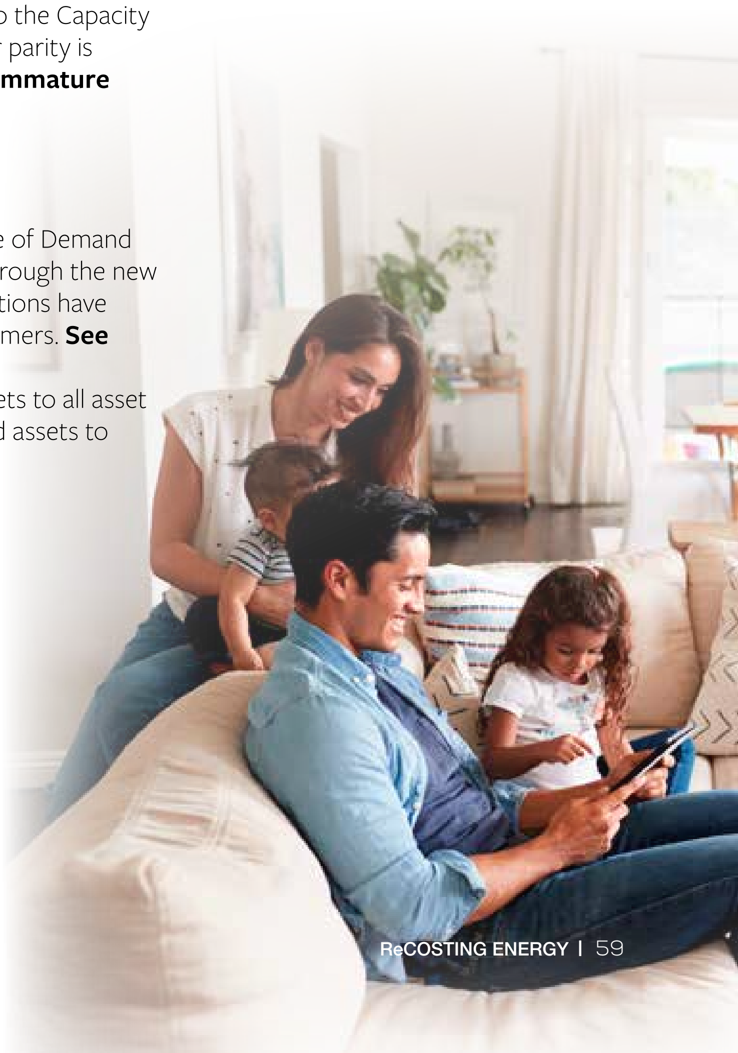
Reducing Financial Barriers to Accessing these new Assets

For an average customer, changing their heating system is as big a financial ask – if not bigger – as for a large infrastructure fund requiring support to build an offshore wind farm.

- **Rewarding Energy Efficiency:** Permanent demand reduction has a significant value that is not captured in any support mechanism or market mechanism. Energy efficiency must play a more central role in the Capacity Market and even through Contracts for Difference – the difference between energy generation and energy savings costs. **See From Supply to Demand – Episode Three**.
- **Making Capital Investments Accessible for All:** It is virtually impossible for the majority of people to invest in EVs, new heating equipment or energy efficiency off the basis of a volatile commodity price. We need to pass the capital investment on to the retailers while enabling the customers to gain the benefits through product-based services. This is so common in other consumer areas, such as car leasing, mobile phone packages and office equipment leasing. **See From Commodities to Services – Episode Three**.
- **Supporting Retailers, Housing Associations and Local Authorities too:** Deployers of these assets should have equal access to all support mechanisms. As shown in our new metrics, demand assets deliver whole system value and capacity and therefore should have access to the Capacity Market and Contracts for Difference mechanisms until greater parity is reached. **See From Supply to Demand & From Mature to Immature Technologies – Episode Three**.

Rewards Flowing to Customers

- **Whole System Value:** By measuring the Whole System Value of Demand Assets we can reward customers for their assets. As shown through the new metrics developed for this report, customers' demand side actions have significant value and this value needs to flow through to customers. **See From Silos to Whole System – Episode Two**.
- **Democratising Access to all Markets:** Opening up all markets to all asset classes and sizes will further allow for demand side actions and assets to attract fair rewards for their participation.
  See From Supply to Demand – Episode Three.



A Fairer Deal for Customers

- **Reduce the Socialising of Risk and the Cost to Consumers:** There is too much risk placed on consumers and this requires a review of how regulation allows for companies to pass risk from one player to another. Where possible, risk that is created by a business needs to be owned and managed by that company. **See From Spreading to Owning Risk – Episode Three**.

A Stake for Citizens

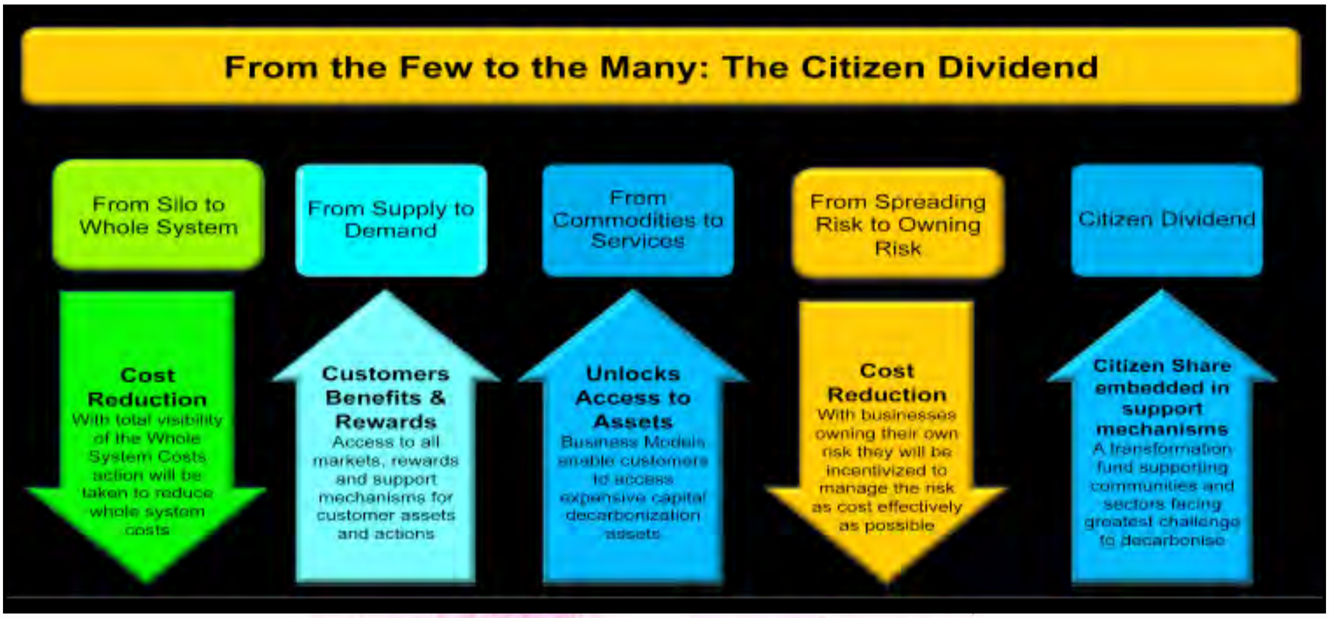
- **A Citizens' Share:** Government should design its support schemes to include a Citizens' Share. It is important that customers have a stake in the investment that government is making on their behalf. Revenues from this "Citizens' Share" should be allocated to a Citizens' Adaptation and Transformation Fund directed at the challenges that communities and citizens are likely to face on the journey to decarbonise.

Conclusion

The theme of Citizens' Dividend runs throughout this report and is crucial to the transformation of the sector. At the heart is that the future system becomes demand led. This redesign is one that many other sectors have experienced from food through to data and transport. We need to start now!

The cumulative impact of the measures outlined above but further developed in other sections should deliver a significant change in power, resources and access to assets to the benefit of consumers. While the cost reductions are very important, changing the design of the system around demand not generation is key for the future of regulation, policy and business practice.

Each of the recommendations throughout this report aim to fulfil our stated obligation to deliver this Citizens' Dividend and are covered in other sections.



MODELLING WHOLE SYSTEM COSTS OF DEMAND-SIDE TECHNOLOGIES

Analysis carried out for the ReCosting Energy project

27 November 2020

CONTENTS

EXECUTIVE SUMMARY

The ReCosting Energy project has been examining how the GB energy sector may need to be transformed to meet the opportunities and challenges of net zero. This requires an understanding of the extent to which demand-side activities could add value to the system and whether the regulatory and market landscape needs to be changed to unlock this value.

Generation technologies are often compared on the basis of the “Levelised Cost of Electricity” (LCOE), a metric that summarises the lifetime cost per MWh generated. This can be extended to a “Whole Electricity System Cost” (WESC), which incorporates the wider impacts of a generator on the electricity system. The WESC can enable comparisons of the value that different types of generation add to the system (although no single metric can fully capture the optimal *mixture* of different technologies).[1]

We were therefore commissioned to calculate a set of example WESCs for demand-side technologies. This exercise is worthwhile since:

- it can determine whether it is possible to compare demand-side technologies to generation technologies using these types of metric, and what issues may need to be overcome; and
- the figures, while intended as examples which will not reflect all types of demand-side technologies or all future energy system scenarios, can show whether there is the potential for demand-side measures to be more cost effective than supply-side investment, and identify the circumstances where this would be more likely.

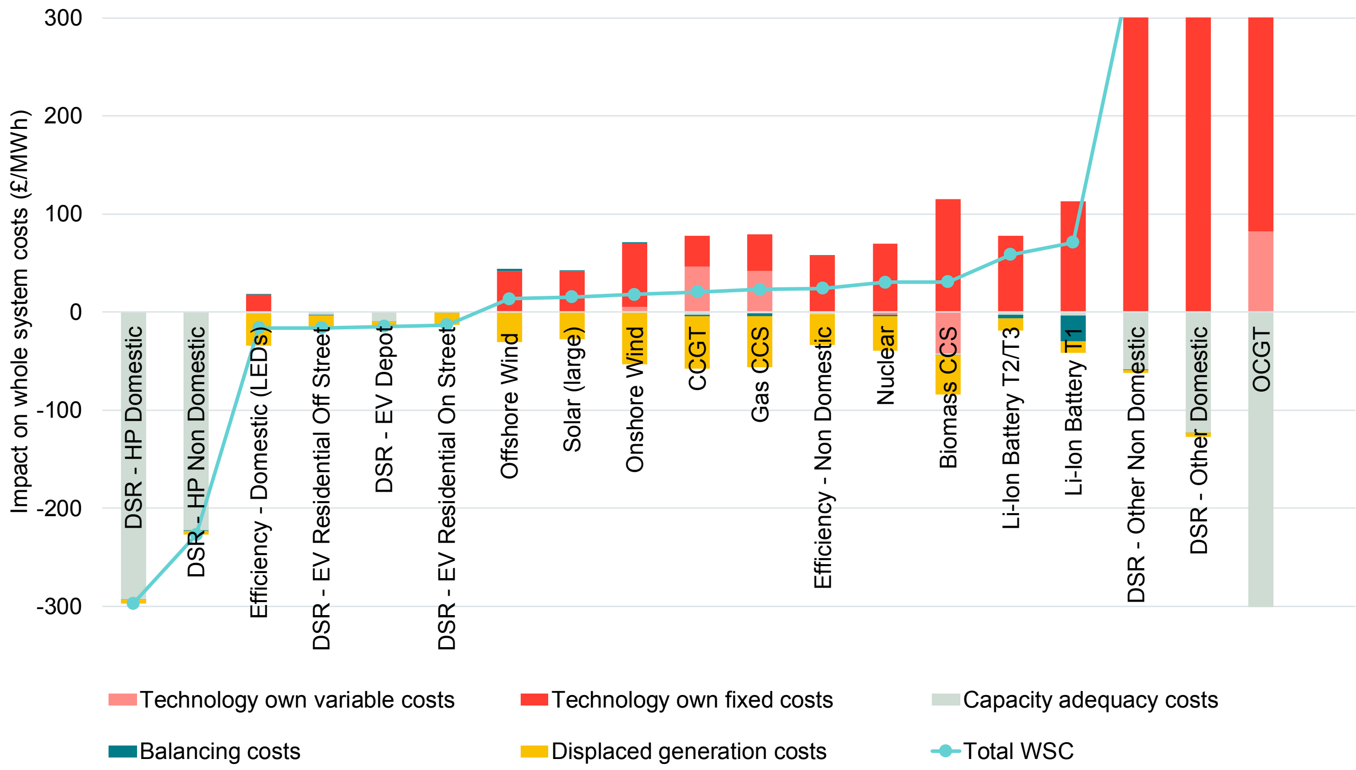
We carried out modelling to estimate the WESC for a variety of representative demand-side technologies, as well as various forms of generation.

Figure 1 summarises the results: The blue line indicates how much additional cost would be incurred on the electricity system if a sufficient amount of each technology was built to produce[2] 1MWh over its lifetime. Negative values indicate a technology that, when added to the system, reduces costs. These figures relate to technologies added to the system in 2025.

[1] Such an exercise requires optimising the least-cost way of building and dispatching plants to meet demand. While outside the scope of this work, the types of data required for the WESC metric shown here are also the key inputs for such an optimisation.

[2] For DSR and storage technologies, this refers to the gross electrical energy output or avoided while shifting or discharging, and does not include the associated energy requirement for “catching up” on demand shifting or charging storage.

Figure 1 Example WESC, excluding distribution network benefits



These example figures should not be interpreted as "generic" estimates of the whole system impact of a class of technologies. Whole system impacts are dependent on the wider electricity system and when technologies are assumed to be built.

Source: Frontier

Our analysis shows that it is possible to compare demand-side and generation technologies alongside one another. Some of the examples of demand-side technologies we have modelled provide a greater benefit to the system per MWh than generation. This is primarily driven by their investment costs: We have assumed a zero or low cost for some forms of DSR and domestic energy efficiency measures, and as a result they constitute a lower cost form of "generation" than even low-cost plants such as wind and solar. If the potential benefits to local distribution networks are accounted for, even more forms of demand-side action may become cost-effective for the system as a whole.

The benefits to the system can be material. For example, the whole system benefits of carrying out DSR to shift the charging of an electric van might be worth up to £500 per van per year if the van is in a location requiring distribution network reinforcement.[3] If such benefits flowed through to consumers, they could incentivise such demand-side actions. In some cases this may require regulatory changes (such as widespread half-hourly settlement).

This exercise has also highlighted the relative paucity of data on the costs and benefits of demand-side measures. If policymakers are to consider demand-side measures alongside generation, then a more systematic collation of this data (along the lines of what is available for generation) will be required.

[3] The benefit would be around £84 without such gains on the distribution network.

1 INTRODUCTION

The ReCosting Energy project has been examining how the GB energy sector may need to be transformed to meet the opportunities and challenges of net zero. This requires an understanding of the extent to which demand-side activities could add value to the system and whether the regulatory and market landscape needs to be changed to unlock this value. To do this, it is first necessary to compare demand-side activities, such as DSR, storage, and energy efficiency, on a like-for-like basis with generation assets.

Different electricity generation technologies are frequently compared in terms of the Levelised Cost of Electricity (LCOE), a simple metric focussing on the costs of building and running an asset. Whole Electricity System Costs (WESCs) have also been developed to extend the LCOE to cover the wider impacts of generation technologies on the whole system. The project therefore commissioned Frontier to calculate a set of example WESCs for demand-side technologies. This exercise is useful since:

- it can determine whether it is possible to compare demand-side technologies to generation technologies using these types of metric, and what issues may need to be overcome; and
- the figures, while intended as examples which will not reflect all types of demand-side technologies or all future energy system scenarios, can show whether there is the potential for demand-side measures to be more cost effective than supply-side investment, and identify the circumstances where this would be more likely.

The rest of this annex is structured as follows.

- First, we describe the way in which the LCOE is calculated for generation technologies. We explain how it can be extended to a more WESC metric, and how this should be interpreted.
- We then set out the methodology used to model whole system impacts alongside some of the main assumptions made for the demand-side technologies we are modelling.
- The results section presents both levelised costs and whole system costs for demand-side technologies, alongside generation technologies.
- We present two worked examples that show how the figures can be interpreted.
- Finally, we set out the main conclusions from this analysis.

2 WHAT ARE WHOLE SYSTEM IMPACTS AND HOW CAN THEY BE INTERPRETED

In this section we briefly describe the Levelised Cost of Electricity (LCOE) metric, and how this can be extended to estimate a Whole Electricity System Cost (WESC).

2.1 Levelised costs

Electricity generation technologies have widely varying cost structures, with a different mixture of initial capital costs, fixed running costs, and variable running costs (such as fuel), which depend on the electrical energy produced. For example:

- an open-cycle gas turbine (OCGT) has relatively low construction and maintenance costs, but since it consumes a large amount of fuel (and emits a large amount of carbon) it has high variable costs;
- a wind turbine has no fuel costs, but a high capital expenditure; and
- a nuclear power plant has relatively high capex and fixed costs, low variable costs and a significant decommissioning cost at the end of the plant's lifetime.

The **Levelised Cost of Electricity** (LCOE) metric summarises all of these different costs on a simple £/MWh basis. It is calculated as the discounted sum of all lifetime costs of a generator, divided by the discounted sum of electrical energy generated over its lifetime.

BEIS regularly publishes LCOE cost estimates of various generation technologies, and its latest report describes in more detail how they are calculated.[4] However, as that report states, "*…the simplicity of the measure means that there are factors which are not considered, including a technology's impact on the wider system given the timing, location and other characteristics of its generation.*"

"Whole system cost" metrics have therefore been developed to take account of some of these other factors, and allow the cost-effectiveness of different technologies to be compared on a more like-for-like basis.

2.2 Whole system costs

Technologies with the same LCOE have the same "direct" costs, but may have very different impacts on the power system. For example, consider two generators that have the same LCOE, but where one can be dispatched flexibly, and one produces electricity intermittently. All else equal, the flexible generator may add more value to the system (i.e. lead to a greater reduction in the costs of operating the system) since:

- if it can be relied upon to produce electricity during the system peak, it can reduce the amount of capacity that needs to be kept on standby;

[4] BEIS (2020), *Electricity Generation Costs 2020*

- if its output can be rapidly increased or decreased it may reduce the costs of balancing the system (i.e. keeping electrical demand and supply equal to one another); and
- if it can be dispatched when electricity prices are highest, it will displace forms of generation with higher variable costs.

A **Whole Electricity System Cost** (WESC) metric takes these wider impacts on the power system[5] into account.

One way of calculating such a metric is to simulate the operation of the electricity system, both without and with a quantity of the generation technology under consideration. Once the generator is added, the system is allowed to re-optimise (for example, a small amount of another type of generation may be able to be retired). The change in total system costs for each year can then be calculated, discounted, and divided by the discounted output of the generator that is being assessed.

The WESC metric is therefore equal to the LCOE, plus a variety of whole system impacts. One way of categorising these costs, described in our previous work for DECC[6] and the Energy Technologies Institute,[7] is described in Figure 2. BEIS has adopted this type of framework to calculate what it terms “enhanced levelised costs”.[8]

5 The WESC does not consider impacts beyond this (e.g. on the transport, gas, or heating systems). For example, it is possible that the use of DSR could reduce ownership costs of heat pumps and electric vehicles, leading to greater take-up of these assets and benefits elsewhere in the system. As this impact is beyond the power system, it is not quantified as part of the WESC.

6 Frontier (2016), *Whole power system impacts of electricity generation technologies*

7 Frontier (2018), A framework for assessing the value for money of electricity technologies

8 BEIS (2020)

Figure 2 The components of Whole Electricity System Costs

Technology direct costs	▪ Capital and operational costs associated with the incremental technology.
Capacity adequacy impacts	▪ To the extent existing capacity can be retired, or new capacity forgone to ensure the same level of security of supply and carbon intensity as the counterfactual, there is a cost saving to the system.
Balancing costs	▪ If the incremental capacity impacts on the uncertainty of supply, it will affect how generators in the rest of the system are called on to help support system stability by altering their output. It will also affect the extent to which they need to be prepared to do so at short notice, potentiallyaffecting their staffing, fuel, and/or maintenance costs.
Network impacts	▪ The incremental technology may require investments to reinforce or extend the existing grid, and changes to power flow may increase or decrease power losses due to transmission and distribution. It is also possible that technologies can free up headroom on the grid, creating network benefits.
Displaced generation impacts	▪ Outputs from the incremental technology can displace higher marginal cost generation, producing variable cost savings, e.g. fuel, carbon. The scale of this is diminished if generators in the rest of the system operate less efficiently, or the incremental technology is curtailed. This category includes the impact on variable costs of ensuring that the same carbon intensity is maintained.

Source: Frontier

The additional categories of cost described in Figure 2 are not directly incurred by the owners of generators. This may suggest that they are externalities (i.e. costs and benefits not faced by the producer). However this is not necessarily the case. For example, at least some generators may be able to obtain revenue streams corresponding to:

- capacity adequacy costs from the capacity market;
- balancing costs from the balancing services market;
- network costs from a combination of avoiding network charges such as TNUoS; and
- displaced generation costs from the wholesale energy market.

The WESC metric takes into account some of the factors overlooked by the LCOE, and in that sense allows different technologies to be compared on a more “level playing field”. However, reducing the many different characteristics of generators down to a single metric will inevitably lose much detail. The following section describes how WESCs can be interpreted.

2.3 Interpreting whole system costs

The results of any WESC analysis will be highly dependent on the baseline system under consideration. For example, if a system already has a large amount of flexibility, adding intermittent generation may appear more beneficial compared with a situation where there was a lower amount of flexibility.

For a given system, the metric estimates the impact on whole system costs of an investment in additional generation. **The sign of the metric can therefore show whether or not investment in a particular technology is beneficial from the point of view of the system as a whole.**

As set out in Frontier (2016): *If all externalities were appropriately priced (e.g. carbon) into the costs of building and running the power system, and therefore included in the estimation of the various impacts, then generation capacity with a positive whole system impact would increase the costs of the system overall and, consequently, ought not to be built, on the basis of power system costs alone. Conversely, where the whole system impact implies a net reduction in total costs, the associated capacity ought to be built.*

Therefore, from the point of view of the specific system under consideration, technologies with negative WESCs are more beneficial than those with positive WESCs. However, great care must be taken when comparing technologies where the WESCs are of the same sign: **A technology with a lower WESC is not necessarily better value for money than a technology with a higher WESC of the same sign**.

The WESC is constructed as a cost per MWh and therefore answers a specific question: *If a generator has to be built that can produce 1MWh of output over its lifetime, what is the least costly option?* However there are other equally valid questions that could be asked. For example: *If a generator has to be built which can supply 1kW of firm capacity during the system peak, what is the least costly option?* That question could be answered with a variant of the WESC which divides the total system cost by the derated capacity provided by the generator, rather than its energy.[9]

Both of these are valid questions for a system planner to answer. However, the generator that is most cost-effective at providing 1MWh of energy may not be the most cost-effective at providing capacity. For example, a solar plant may be able to provide cheap energy, but adds very little (if anything) to capacity adequacy. It cannot therefore be said that the generator with the lowest WESC is the “best” type of generation overall.

We could try to avoid these issues by asking: *Per pound invested, which technology provides the greatest value to the system?* However this is only useful for the very specific case where there is a strict limit on the amount of money that can be invested. Such a metric will tend to favour technologies with low initial investment costs, even if they have high running costs, and may not be optimal for the system as a whole in the long run.

[9] The same issue applies to the LCOE. This is explained in BEIS (2020): a pound per derated kW measure is a more suitable way of comparing the costs of peaking plant than the LCOE.

In general, there is no single least cost type of generation, and a well-functioning system will require a mixture of complementary technologies. For example, intermittent generation on its own cannot meet peak demand in a cost-effective way, but can when combined with flexible sources of generation or storage. **A single metric such as the WESC cannot take account of such relationships**. Instead, a more complex model is required that optimises the overall least-cost mixture of technologies subject to various constraints (such as meeting demand in every hour).[10]

Despite these complexities, we consider that the WESC is still a useful metric since:

- the sign of the WESC indicates whether, for the scenario under consideration, a technology will add or reduce costs; and
- a comparison of WESCs may be valid between technologies that all have a relatively high load factor (where their role in providing energy is important).

[10] One example of such a model is the Energy Systems Catapult's ESME model. This is a whole-system optimisation model which goes beyond the power sector to include markets such as heat and transport. ESME is capable of trading-off investment in generation against activities such as energy efficiency.

3 MODELLING METHODOLOGY AND ASSUMPTIONS

In this section, we first describe the model that has been used to estimate example WESCs for generation and demand-side technologies. We then set out the key inputs, including those that relate to the specific demand-side technologies that have been assessed.

3.1 Model methodology

As we described above, WESCs can be estimated by simulating the cost of running the power system both with and without an extra generator (or demand-side technology) added.

The modelling we report in this Annex has been carried out using BEIS's Dynamic Dispatch Model (DDM). This power system model is capable of simulating the GB electricity system, including the behaviour of investors, and the dispatch of generation to meet demand. It also includes functionality to calculate the different components of WESC.

For this work, the DDM was set up with a scenario[11] that represents a reasonable view of how the GB power system may evolve in the future, to act as a baseline for the estimation of whole system costs. However it is not intended to act as a forecast of the future power system, and so is not reported here.

The DDM simulates whole system impact on a marginal basis (i.e. it considers the impact of a very small additional unit of generation). The £/MWh results produced from the model therefore cannot be applied to very large increments of capacity. In general, as more and more of a particular technology is added to the system, each additional unit will reduce system costs by less (or increase them by more). This is because different forms of generation are complementary to one another, and there will be fewer gains from adding a technology that is already very widely adopted.[12]

It is necessary to specify the year when the additional capacity is added. We used 2025 – this is consistent with our earlier work for the ETI, and is reflective of when investments that are committed now may come onto the system.

We have built a very simple model to extract these figures from the DDM and calculate a WESC. This is a simplified version of the calculations used for our 2018 work for the ETI.[13] The main simplifications are as follows.

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[11] The scenarios provided to us included variants with different levels of demand and flexibility. For the purpose of this report, we only present results for one scenario (with "central" flexibility and "high" demand). This is since the other scenarios available to us represent a relatively narrow range of possible configurations of the system, and might suggest (misleadingly) that the WESC results are not sensitive to the assumed baseline system.

[12] For example, if there is a very high amount of wind generation on the system, there will be less value to adding more. This is since the output of the wind generators will be correlated, and will increasingly need to be curtailed in periods when it is too high.

[13] Frontier (2018), A framework for assessing the value for money of electricity technologies

- The DDM uses hurdle rates to calculate the financing costs of different technologies.[14] A technology that is seen as more risky will have a higher hurdle rate, will attract higher financing costs and will (all else equal) have a higher levelised cost and whole system cost. However the risk faced by a technology depends on both its intrinsic risk as well as the regulatory framework. For example, generators eligible for CfDs will face a lower level of risk than those exposed to the wholesale market, and will therefore have a lower hurdle rate. In our 2018 modelling, we carried out an adjustment to hurdle rates to try to better reflect the intrinsic properties of each technology (rather than the policy regime that applied to them) to place them on a level playing field. This adjustment has not been carried out for the modelling presented here.
- When a technology is added that can reliably provide 1MW of power during the peak hours of the year, it will allow 1MW of another technology to be retired (or not built) while maintaining the same security of supply. The DDM captures this as a "capacity adequacy" benefit. However while this includes the avoided technology-own costs, the DDM does not presently capture the "second-round" effects of removing that technology (such as changes in balancing or network cost). We have not calculated the impact of this effect on WESC.

The WESC, like the LCOE, is expressed on a pounds per MWh generated basis. There is therefore a need to define what we mean by "generation" for DSR, storage and energy efficiency.

- For energy efficiency, this "generation" represents the overall reduction in electrical energy consumption caused by the efficiency measures. This concept is frequently referred to as "negawatts".
- For storage, it represents the gross electrical energy provided to the system during periods when the batteries are discharged.
  - The batteries will also need to be charged, consuming additional electrical energy from the wider system. We treat this as a cost of the gross electrical energy provided, which in the model is reflected by a positive contribution to the "displaced generation" cost figure.
  - The battery will tend to discharge when power prices are high, and charge when they are low. This difference in power prices leads to the battery having a negative displaced generation cost overall: The value of electricity released will be higher than the value of electricity consumed.
- For DSR, "generation" refers to the gross reduction in energy when demand is reduced or shifted. If demand is shifted to other hours, this increase will be costed in the same way as a battery charging.

For the purposes of this modelling, we have not presented the transmission network reinforcement costs provided by the DDM. These costs will be very specific to where on the network the additional generation is added, and the DDM has not been populated with locations for the DSR, storage and energy efficiency technologies.

[14] We do not have such rates for the DSR and energy efficiency technologies and so assume that any capital costs are paid up-front.

As the DSR, storage and energy efficiency technologies will be embedded on the distribution networks, there may be additional benefits from using them to reduce the need for reinforcement on those networks. These benefits will also be extremely localised. On areas of the distribution network where there are no constraints there may be no such benefits, while in areas where the use of DSR, storage or energy efficiency can avert reinforcement, the benefits could be very high. To illustrate the possible magnitude of these benefits, we have used a benefit of £17 per kW per year[15] for technologies that have the potential to reduce peak demand on the distribution networks.

3.2 Model inputs

The DDM has been populated with examples of different demand-side technologies (DSR, energy efficiency, and storage). Figure 3 below provides a high-level summary of their nature and costs.

There are many different forms of DSR, energy efficiency, and storage, each with their own characteristics and costs. The examples used in this modelling should not be interpreted as being representative of all forms of demand-side technologies.[16] For DSR these costs relate to the *incremental* costs of carrying out DSR using an existing asset (such as a heat pump or electric vehicle) rather than the cost of the asset itself. A consumer purchasing a vehicle will do so primarily due to the benefits in terms of increased mobility, safety, comfort etc. Similarly, a consumer purchasing a heat pump will do so for reasons unconnected to the use of the heat pump for DSR. The whole system impacts we are modelling relate to the electricity system, but not the wider markets for transport, heat etc. Therefore we include neither the costs nor the benefits of the underlying assets themselves.

[15] This was the indicative ceiling price for DSR calculated as part of Norther PowerGrid's Customer-Led Network Revolution Project – see CLNR (2015),*Customer-Led Network Revolution Project Closedown Report* p14

[16] As an example of the uncertainty in these costs, the source we use for domestic DSR costs has a range from £43/kW to £984/kW – the inputs below use the middle of this range.

Figure 3 Summary of DSR, storage and energy efficiency technologies

Technology	Description	Capital costs	Fixed O&M costs	Variable costs
DSR – EV residential on street	20% of demand in the period between 4pm and 10pm can be shifted later by up to 8 hours.	N/A – it is assumed that once an EV is purchased, there are no additional costs in enabling it to undertake DSR.	N/A – it is assumed that once an EV is purchased, there are no additional costs in using it to undertake DSR.	N/A. While there will be a cost associated with charging the battery at a later period, this will be modelled as part of the "displaced generation cost".
DSR – EV residential off street	70% of demand in the period between 4pm and 10pm can be shifted later by up to 8 hours.			
DSR – EV depot				
DSR – HP domestic	2% of peak demand can be shifted by up to 23 hours earlier (based on 20% of properties having heat storage).	N/A – it is assumed that once a HP is purchased, there are no additional costs in enabling it to undertake DSR.	N/A – it is assumed that once a HP is purchased, there are no additional costs in enabling it to undertake DSR.	N/A. While there will be a cost associated with running the heat pump earlier, this will be modelled as part of the "displaced generation cost".
DSR – HP non-domestic				
DSR – other domestic	Demand can be shifted backwards or forwards by up to 4 hours.	£514/kW.[17]	N/A.	N/A – it is assumed that the DSR can be carried out in a way that does not inconvenience the consumer.
DSR – other non domestic	Demand can be shifted backwards or forwards by up to 2 hours.	£300/kW.		
Li-Ion battery DNO T1	DNO batteries with 1 hour duration.	£500/kW[18]	£80/kW	N/A. While there will be a cost associated with charging the battery at a later period, this will be modelled as part of the "displaced generation cost".
Li-Ion battery DNO T2/T3	DNO batteries with 4 hour duration.	£1,170/kW	£190/kW	
Efficiency – domestic LEDs	Modelled as a percentage reduction in energy use.	£593/kW[19]	N/A	N/A

17 DSR costs based on average of "high" and "low" 2030 scenarios from p74 of Carbon Trust and Imperial (2016), *An analysis of electricity system flexibility for Great Britain*

18 All figures for Li-Ion batteries are shown as a discounted cost per kW over the lifetime of the battery. For example, the capital costs will first have been annuitized at a hurdle rate, and then discounted back at the 3.5% social discount rate.

19 Based on an illustrative estimate of £15/MWh/year from BEIS. This was based on the use of LED bulbs. We converted this to £/kW using the load factor within the DDM. We have also scaled the cost up to account for the way that the DDM assumes that energy efficiency measures will last for 30 years, while the cost input is based on an intervention that only lasts 10 years.

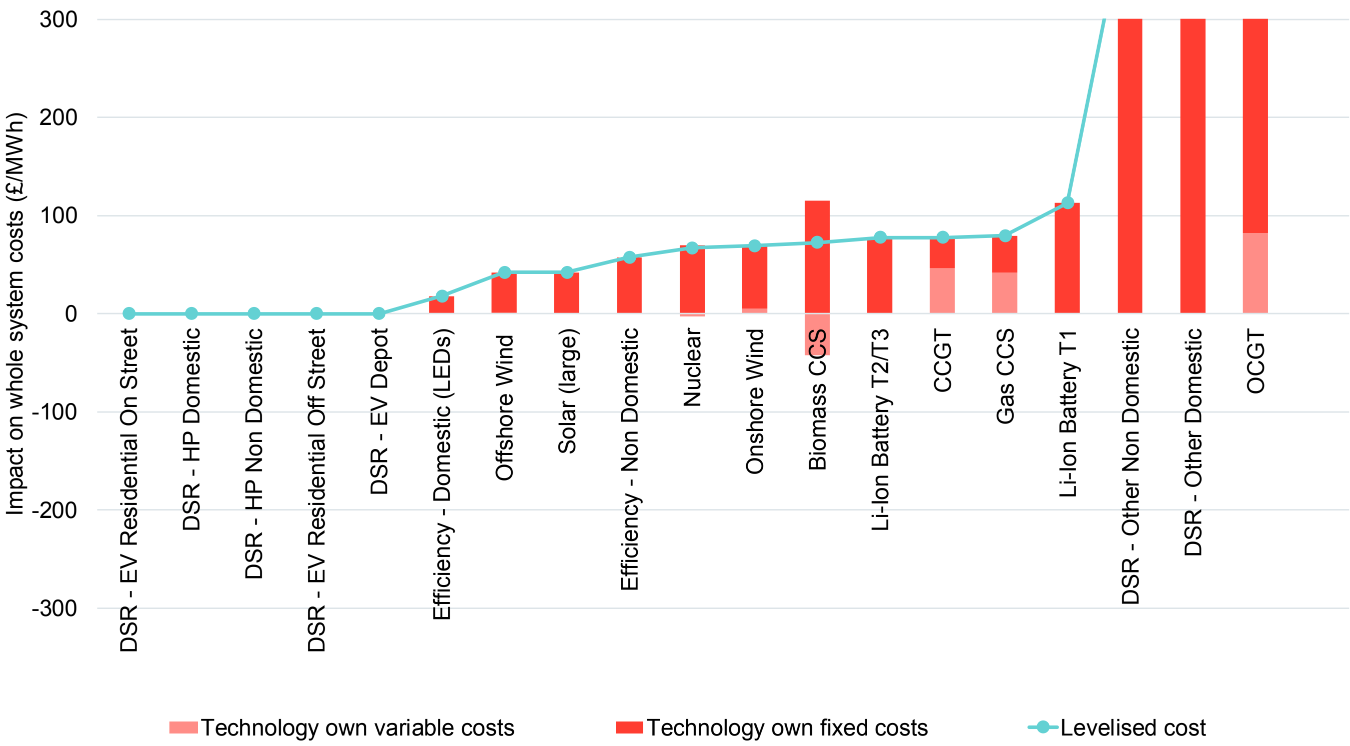
4 MODEL RESULTS

Since the WESC is an extension of the LCOE, we first calculate the LCOE for each modelled technology, before adding on the other components of WESC.

4.1 Example LCOE estimates

Figure 4 presents the LCOE estimates, and splits them into fixed costs (including both capex and fixed operating costs) and variable costs. Figures above £300/MWh (for technologies with extremely low load factors) have been truncated.

Figure 4 Example LCOE



These example figures should not be interpreted as "generic" estimates of the whole system impact of a class of technologies. Whole system impacts are dependent on the wider electricity system and when technologies are assumed to be built.

Source: Frontier

The purpose of this analysis has not been to produce a set of generation LCOE figures. The figures above will be particular to the specific scenario we have assessed,[20] and should not be used as the source for other analysis. However they are broadly in line with the costs reported in BEIS (2020) for plants commissioning in 2025.

[20] Unlike many LCOE estimates, this modelling uses simulated load factors for flexible technologies, rather than the maximum potential generation net of availability. The LCOE estimates above will therefore be particularly sensitive to how frequently each type of plant is simulated as being dispatched.

When comparing the LCOE of the demand-side technologies to the generation technologies, four groups of technologies stand out:

- **DSR for heat pumps and electric vehicles**. As described in Figure 3, the assumptions used for this modelling include no costs for enabling or carrying out DSR for these assets. These technologies therefore have a levelised cost of zero.
- **Energy efficiency measures**. The domestic and non-domestic energy efficiency measures are assumed to have some fixed costs. However, on a simple £/MWh basis, these costs are lower than the forms of generation technologies considered.
- **Li-Ion batteries.** The batteries have levelised costs at the high end of the generation technologies. This is also before the cost of the energy used to charge the batteries is accounted for (which in the model is considered as part of displaced generation costs).
- **"Other" forms of DSR**. The "other" DSR measures have levelised costs that are above all generation technologies except OCGTs. This reflects the extremely low load factor modelled for these measures (which is equivalent to DSR being carried out for around 20 hours in the year).

4.2 Example WESC estimates

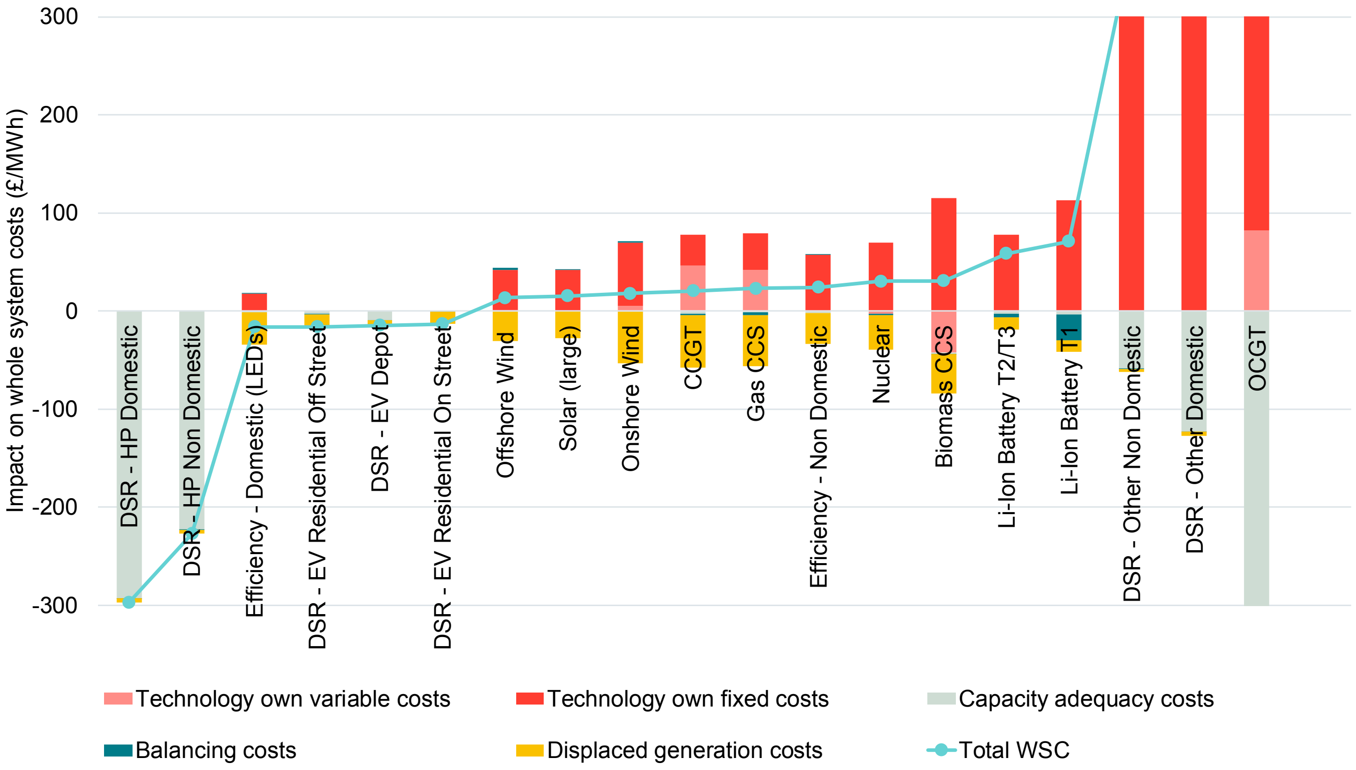
The simple levelised cost measure does not include the wider system impact of the technologies. For example, although the "other" DSR does not release a large amount of energy onto the system, if it does so during times of peak demand then it may have a disproportionately high capacity adequacy benefit. We have therefore added on the other components of WESC.

Figure 5 plots the resulting WESC estimates. Each component of the whole system impact is shown as a separate bar. The sum of these is the overall whole system impact, which is shown by the light blue line. These can be interpreted as the change in total electricity system cost if a sufficient amount of a technology is added to produce a lifetime output of 1MWh (and the rest of the system is allowed to adjust in response).

This graph does not include any potential distribution network benefits as these are likely to be highly localised and will not apply in all areas (they are quantified in Figure 6 below).

Technologies have been ordered by this whole system impact. Technologies with lower figures will add fewer costs (or greater benefits) to the system for each MWh of energy they produce.

Figure 5 Example WESC, excluding distribution network benefits



These example figures should not be interpreted as "generic" estimates of the whole system impact of a class of technologies. Whole system impacts are dependent on the wider electricity system and when technologies are assumed to be built.

Source: Frontier

While the addition of the other WESC components has changed the position of some technologies, they are still broadly in the same order: The low WESC of some of the demand-side technologies is therefore driven primarily by their low investment cost per MWh.

The majority of technologies under consideration, including all types of generation, have a positive WESC (i.e. adding them to the simulated system leads to an increase in total costs). This suggests that the scenario that is being simulated already has sufficient or excess capacity, and so adding more will lead to additional costs.

Two types of demand-side technologies do have a negative WESC, indicating that whole system costs can be reduced if they are added to the system.

- **The heat pump and EV DSR measures** all have extremely low (negative) whole system impacts. This is to be expected – as noted above, we have modelled these without any incremental costs, but they are still able to displace costs of generation and capacity elsewhere in the system. If costs were required to enable DSR and incentivise load-shifting, these would need to be taken into account.

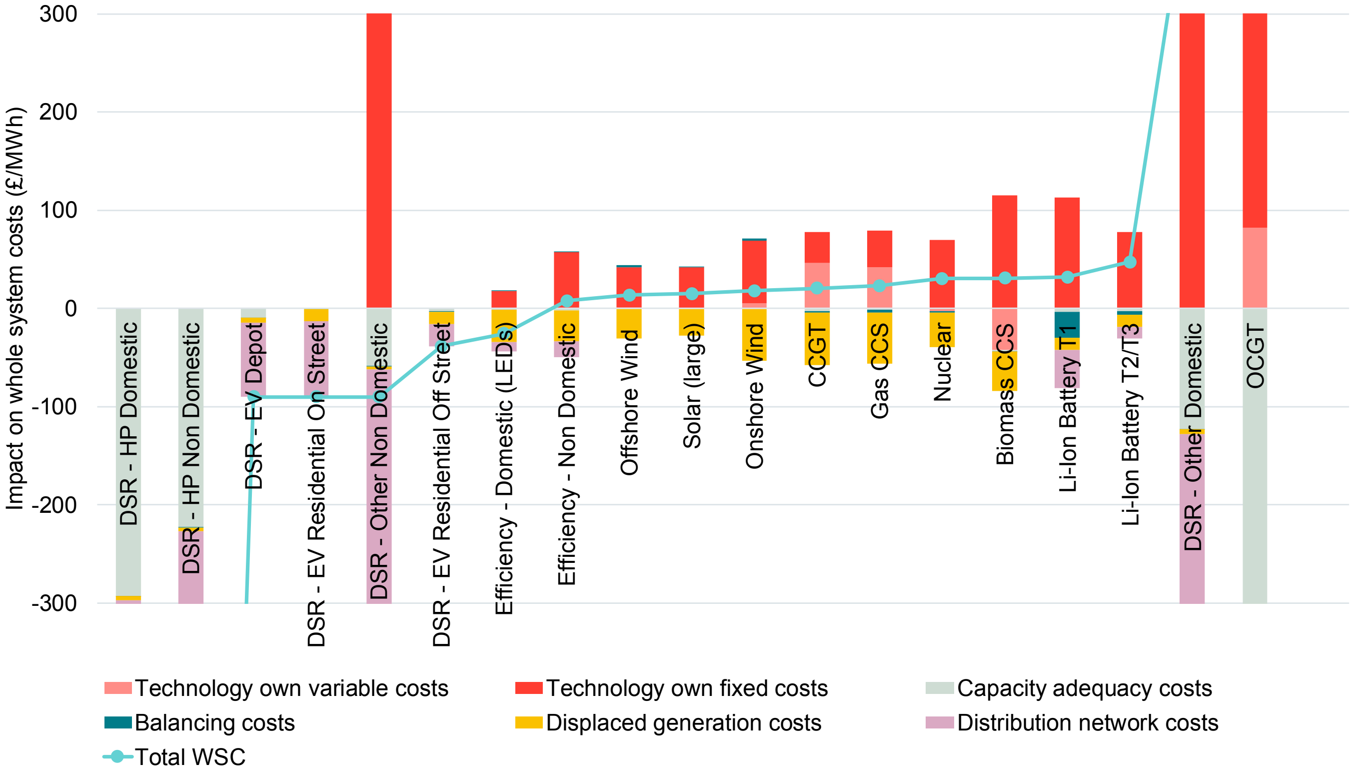
- Despite being associated with capital costs, **domestic energy efficiency measures** (represented here by the conversion of lighting to LED bulbs) reduce whole system costs.

As noted in section 2.3, comparing the value of this metric across different technologies with positive WESCs must be carried out with caution. This is because the use of a £/MWh metric only makes sense for technologies that are primarily being built to provide energy, rather than capacity. Since the “other” forms of DSR and OCGTs both have an extremely low factor, comparisons between these technologies and the others in the graph are unlikely to be valid.

Non-domestic energy efficiency and Li-Ion batteries also have relatively low load factors (between 5% and 20%), although these are in a more similar range to some generation technologies (solar, onshore wind, and CCGTs) and so may be more comparable. On this basis, the batteries and non-domestic energy efficiency measures we model do appear to be more expensive per MWh than many forms of generation. However, the results do not include the benefits from “stacking” these benefits alongside reduced distribution network reinforcement costs, which may be particularly significant for batteries.

The graph below adds in an illustrative size of these distribution network benefits. This assumes that the DSR, storage and energy efficiency technologies can be added to a section of the network that would otherwise require reinforcement to meet peak demand. These figures would not apply to installations of these technologies in areas where the network did not require reinforcement.

Figure 6 Example WESC, including illustrative distribution network benefits



These example figures should not be interpreted as "generic" estimates of the whole system impact of a class of technologies. Whole system impacts are dependent on the wider electricity system and when technologies are assumed to be built.

Source: Frontier

The addition of these benefits leads to an improvement for whole system impacts for all the DSR, storage and energy efficiency technologies, given that they are all on the distribution network. "Other non-domestic" DSR, is now shown as having a negative WESC (whereas without these benefits it adds costs to the system).

5 WORKED EXAMPLES

The £/MWh figures produced by the LCOE and WESC calculations allow different technologies to be compared on a like-for-like basis. However the concept of a MWh of DSR, storage, or energy efficiency can seem rather abstract. For example, it is not immediately clear from the graphs above what these results mean in terms of individual households or firms carrying out actions on the demand-side.

To make these figures more concrete, we have produced two simplified examples.

- The first considers what the £/MWh figures for depot-based EVs would mean for the owner of such an EV.
- The second uses the £/MWh figures to compare the impact of energy efficiency and new build CCGTs on the system.

5.1 Depot-based electric vehicles

Figure 7 summarises the components of WESC estimated by the model for depot-based electric vehicles (EVs).

Figure 7 WESC components for depot-based electric vehicles

WESC component	Value per MWh
Technology own variable costs	£0/MWh
Technology own fixed costs	£0/MWh
Capacity adequacy costs	-£10/MWh
Balancing costs	-£0.01/MWh
Displaced generation costs	-£5/MWh
Distribution network costs	£75/MWh

Source: Frontier

To translate these figures into more intuitive terms we need to make a number of assumptions regarding the EV.[21]

- We assume that the vehicle is an electric van with a 37kWh battery,[22] which is charged using a 22kW fast charger at the depot. The vehicle will therefore take roughly an hour and a half to fully charge.
- The van is assumed to be fully recharged (from empty to full) for five days a week, for 30 weeks of the year. [23] Without any DSR, we assume that the van would be charged after working hours, at a time that would coincide with the system peak.
- The DSR acts to postpone the charging of the vehicle until after the system peak (for example to later at night).

[21] These assumptions are illustrative and may not correspond exactly to the type of vehicle that is being modelled in the DDM.

[22] Based on a VW Transporter electric - https://www.parkers.co.uk/vans-pickups/volkswagen/transporter/2020-e-transporter-review/

[23] The figures in this example have been chosen to be realistic, while also providing the same load factor as used in our modelling.

The amount of energy that such DSR could shift is 37kWh per charge, or around 5.6MWh over the year (3.7kWh multiplied by 5 days and 30 weeks). The peak amount of power which the DSR could shift is 22kW, based on the capacity of the charger.

We can also use the assumptions to calculate that the load factor[24] for the EV is approximately 3%. This is lower than all generation technologies in the model except OCGTs and illustrates how this form of DSR provides a relatively high peak power reduction, compared to the overall amount of energy it can shift.

Since we have estimated that a single EV can shift 5.6MWh per year, we can convert the WESC into a value per van that is enable per DSR:

Figure 8 WESC components for depot-based electric vehicles

WESC component	Value per MWh	Value per van per year
Technology own variable costs	£0/MWh	£0
Technology own fixed costs	£0/MWh	£0
Capacity adequacy costs	-£10/MWh	-£56
Balancing costs	-£0.01/MWh	-£0.06
Displaced generation costs	-£5/MWh	-£28
Distribution network costs	£75/MWh	-£420
Total WESC	**£90/MWh**	**£504**

Source: Frontier

Overall, the use of DSR for the van shows a whole system benefit of approximately £500 per year, assuming it is an area requiring distribution network reinforcement (without these benefits, the value would be around £84).

As the modelling considers the *marginal* impact of a small addition of capacity, these figures are also unsuitable for considering the impact of a large addition of capacity on the system. For example, we cannot state that the application of DSR to 1m vans would reduce whole system costs by £500m. Once a large number of vans have had DSR enabled, the marginal benefit of additional DSR may be lower.[25]

We now look in more detail at the breakdown of the WESC.

5.1.1 Technology own costs: £0 per van

As described in Figure 3, we assumed that there are no material costs involved in carrying out this type of DSR and so the owner of the van does not incur any such costs.

[24] A load factor is the amount of energy that can be shifted, as a proportion of the energy that would be shifted if the technology operated at its maximum power throughout the year.

[25] For example, a single van shifting its demand at peak will almost certainly reduce peak demand by a full 22kW. However if a million vans shift demand, peak demand may not shift by 22GW, as a different hour will likely become the peak.

5.1.2 Capacity adequacy benefits: £56 per van per year

By postponing the charging of the van during the system peak, overall peak demand on the system is reduced by 22kW. This means that 22kW of standby generation could be retired from the system (or not built in the first place), reducing overall costs.

In practice, 22kW is an extremely small amount of capacity compared to the size of a typical power plant (many hundreds of megawatts or more) and so it is unlikely that exactly 22kW of capacity could be retired – this figure simply represents the average expected reduction in capacity requirements.

The results of the modelling suggest that this cost saving is approximately £56 per year.

This benefit accrues to the whole system, but may not necessarily "flow down" to the owner of the van. For that to happen, there either needs to be a component of non-domestic bills that accurately reflects the capacity adequacy costs, or the van owner will need to be able to participate in the capacity market (e.g. through an aggregator).

5.1.3 Balancing benefits: 6p per van per year

The DSR carried out by the EV could in principle be used by the system operator to help balance supply and demand.

However, in our model results, the value of this benefit is very low. This may reflect the way in which the DSR is assumed to be carried out for a relatively small proportion of hours in the day, and will not be available to carry out balancing actions most of the time. This value might be higher for more flexible forms of DSR (such as the use of vehicle-to-grid).

5.1.4 Displaced generation benefits: £28 per van per year

Despite providing DSR, the van is still consuming the same amount of electrical energy per year that it did. However this will now be during times when demand is lower, and so when forms of generation with lower variable costs are operating. There will therefore be a net reduction in the variable costs of generation.

This cost saving is approximately £28 per year.

The van owner will obtain these benefits directly if they are billed for their energy usage in a way that reflects the varying wholesale cost of electricity across the day. This would require them to have both half-hourly settlement (which is currently mandatory only for larger consumers) and a tariff that reflects wholesale prices.

5.1.5 Distribution network reinforcement costs: £420 per van per year

If the local distribution network was near its maximum capacity, then the EV could provide a significant amount of additional value. This could take the form of a contract to regularly carry out DSR to reduce peak loads, or an agreement to carry out DSR in the event of a fault on the network that reduces its capacity.

The value of such benefits will vary tremendously depending on the status of the local network (and may be zero if the network has ample capacity). We have assumed that the DSR is happening in an area where the network is near its maximum capacity, which, given our assumptions about its value, results in savings to the network operator of £420 per year.

For the van owner to obtain these benefits, they would either need to:

- face a fully cost-reflective distribution network use of system charge, which passes on the benefits of a local reduction in demand to their bills; or
- enter in to a contract with the DNO to provide these services directly.

5.2 Non-domestic energy efficiency and solar

As we have emphasised throughout this annex, even with a measure like WESC it is difficult to compare technologies that provide very different services to the system. For example the same metric cannot be used to compare an OCGT (which primarily provides peak capacity) and a nuclear plant (which primarily provides baseload energy).

Such comparisons become more meaningful when technologies have a similar load factor. Within our model, non-domestic energy efficiency has a load factor of 12%,[26] which is comparable to the load factor of solar (10%). Solar is a particularly cheap form of generation on a £/MWh basis, and like energy efficiency has high fixed costs and low variable costs. It is therefore informative to compare the two, as in Figure 9.

Figure 9 WESC components for solar and non-domestic efficiency

WESC component	Large solar	Non-domestic efficiency
Technology own variable costs	£0.0	£0.0
Technology own fixed costs	£42.2	£34.0
Capacity adequacy costs	-£0.2	-£2.1
Balancing costs	£0.8	£0.0
Displaced generation costs	-£27.6	-£31.5
Total WESC	**£15.3**	**£0.4**

Source: Frontier

Although both technologies would add costs to the system, “producing” 1MWh of electricity from non-domestic energy efficiency is estimated as being around £15 cheaper than from solar. This is due to a combination of factors.

- **Fixed costs**: Under the assumptions set out in Figure 3, the amount of non-domestic energy efficiency interventions required to save 1MWh are around £8 cheaper than building an equivalent amount of solar plant.

[26] The “load factor” of energy efficiency is defined here as the total MWh reduction across the year, divided by the total reduction that would occur if the highest peak reduction was replicated across every hour of the year.

- **Capacity adequacy costs**: An amount of non-domestic energy efficiency interventions that saves 1MWh can reduce capacity adequacy costs by around £2, while solar is associated with very little saving. This is unsurprising: The efficiency savings will tend to reduce consumption whenever non-domestic customers are consuming electricity (which will include some consumption during the peak, which will be during winter evenings). By contrast, solar will produce very little power during the peak.
- **Balancing costs**: Non-domestic energy efficiency produces a predictable reduction in electricity requirements. It therefore does not contribute to imbalances. As it is inflexible, it can also not help mitigate imbalances caused by other technologies. By contrast, solar generation is intermittent, and in the model leads to higher imbalance costs.
- **Displaced generation costs**: Both solar and energy efficiency displace other forms of generation. However, solar will tend to displace most generation during summer days, when demand is lower and the marginal cost of generation higher. By contrast, the energy efficiency measures will reduce demand in a way which is more correlated to overall system demand. The generation displaced is therefore more costly.

6 CONCLUSIONS

We set out to answer two key questions with this analysis:

- First, whether it is possible at all to compare demand-side technologies on a like-for-like basis with generation; and
- second, whether demand-side technologies may (at least in some circumstances) be able to add more value to the system than generation technologies?

In both cases, the results have been positive.

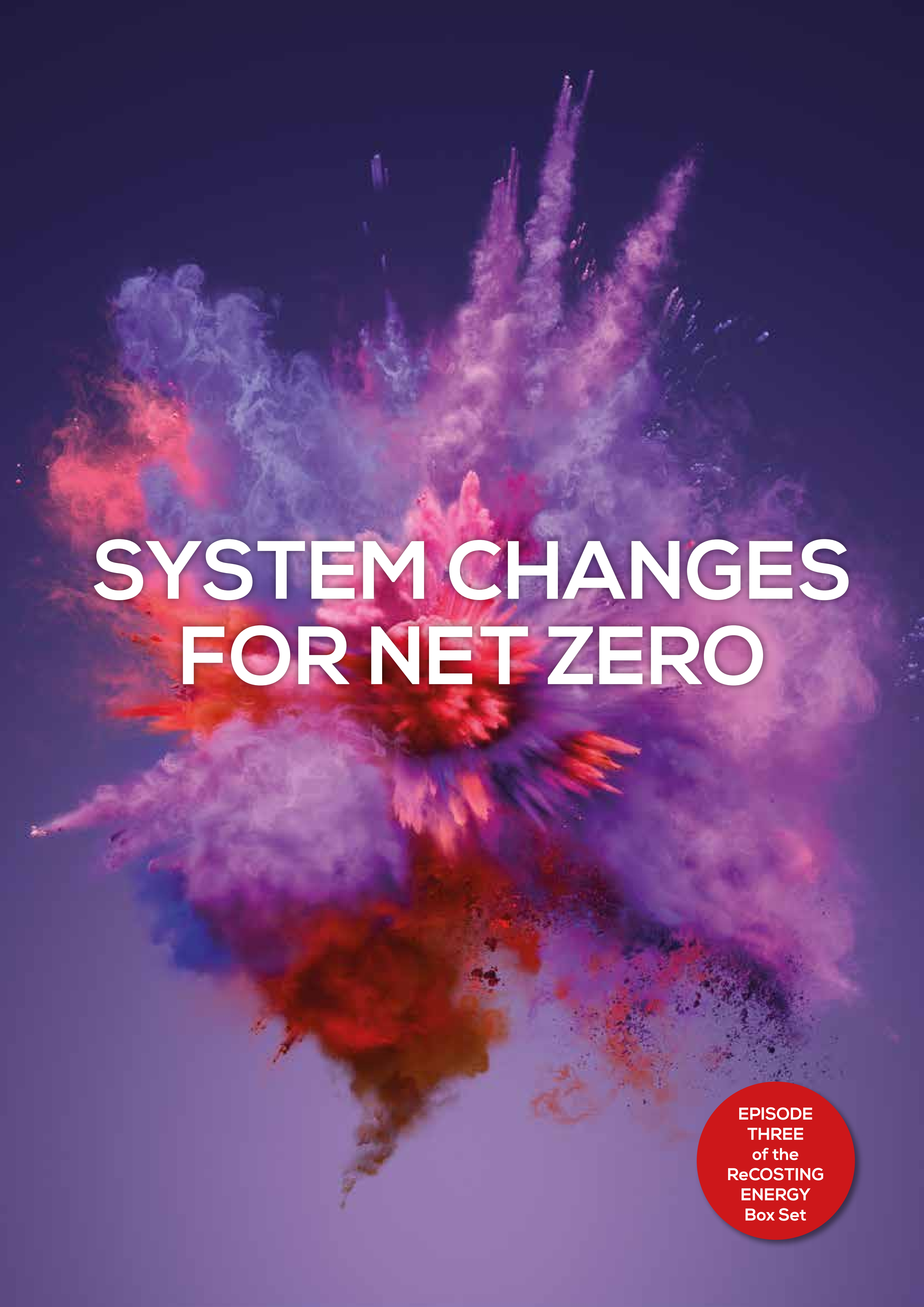
This work has shown that it is possible to compare demand-side and generation technologies alongside one another. The WESC metric provides a useful benchmark with which to compare the contribution of different types of technologies, and can be applied as easily to demand-side actions as to more conventional generation technologies. No single metric can fully capture the complementary nature of different technologies – for example, how peaking and baseload technologies can work together as part of the system. However the £/MWh metric is particularly useful for comparing technologies with broadly similar roles providing energy to the system – as shown in the example comparing energy efficiency and solar generation.

Some of the examples of demand-side technologies we have modelled provide a greater benefit to the system per MWh than generation. This is primarily driven by their investment costs: We have assumed a zero or low cost for some forms of DSR and domestic energy efficiency measures, and as a result they constitute a lower cost form of "generation" than even low-cost plants such as wind and solar. If the potential benefits to local distribution networks are accounted for, even more forms of demand-side action may become cost-effective for the system as a whole.

However, this work has also highlighted barriers to unlocking this value.

Some forms of demand-side action may have significant benefits at the level of an individual asset. For example, we demonstrated how the whole system benefits of carrying out DSR to shift the charging of an electric van might be worth up to £500 per van per year. If these benefits flowed through to consumers, they could incentivise such demand-side actions to take place. **However in some cases this may require regulatory changes** (such as widespread half-hourly settlement) so consumers face the true costs and benefits of their actions on the system.

In addition, **this exercise has highlighted the relative paucity of data on the costs and benefits of demand-side measures**. Data on the costs of generation technologies is readily available – for example through BEIS's regularly updated generation cost assumptions. Information on the costs of demand-side measures is generally harder to find in such a summarised form. This is understandable, as there is such a huge variety of demand-side measures, with very different characteristics. However, without this data, it will be difficult for policymakers and others to consider demand-side measures alongside generation (for example when running models to assess how the optimal energy system may look in the future).



SYSTEM CHANGES FOR NET ZERO

EPISODE THREE of the ReCOSTING ENERGY Box Set

INTRODUCTION

SYSTEM CHANGES

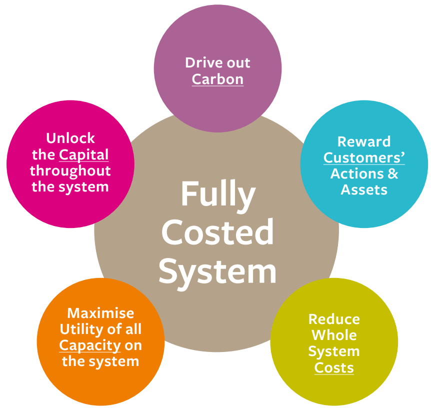
If we are to deliver Net Zero with a fully optimised energy system we have to change the basis of the cost, value and price of the system. The current "truths" were designed in the 1980s and 1990s around the fossil fuel system where customers were "recipients" of the system rather than participants, where the big step was the change from a nationalised system to a privatised system, and where there were few big and important players.

This section aims to address some of those fundamental system changes required to deliver decarbonisation.

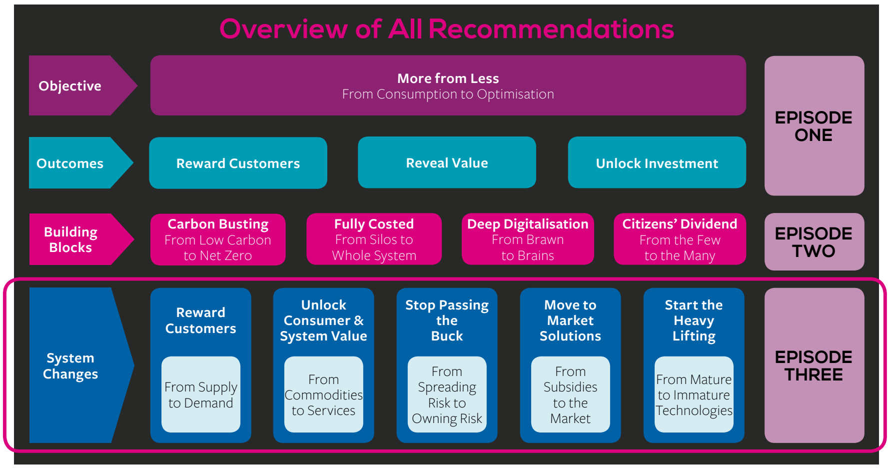
Key recommendations include:

- **Consumers Equal Access to Support:** Consumer assets to be included in all support and market mechanisms.
- **Services Unlocking Added Value:** Offer consumers services not just commodities.
- **Reward Flexibility Fairly:** Introduce a Flexibility Service Agreement similar to a Power Purchase Agreement (PPA).
- **Reallocate System Risk and Cost:** Risk needs to move from consumers to those that create the risk.
- **Underpin the Market:** Create a low-powered floor price for the merchant and PPA markets.
- **Focus support on the Heavy Lifting:** Focus support and resources on immature technologies, not least consumer assets.

Optimising the Five Cs: Carbon, Customers, Costs, Capacity & Capital



Optimising the Five Cs of a Fully Costed System



All regulatory and policy actions should be guided by optimising the Five Cs, measured against the Full System Costs

We recognise that many of the recommendations have a different level of complexity to implement and have given a Red, Amber or Green rating to each of the recommendations, outlining the challenges that each poses.

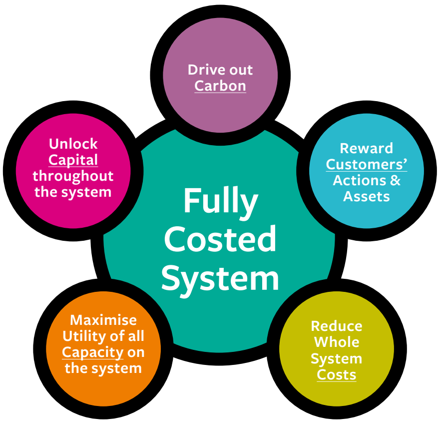
DIFFICULT

ACHIEVABLE

EASY

REWARD CUSTOMERS

FROM SUPPLY TO DEMAND



Optimising the Five Cs of a Fully Costed System

AMBITION: A system designed around optimising customer demand actions and assets, recognising their value to the whole system. Fair and equal access for consumers to funds, markets and investment for demand assets and actions

Recommendations: From Supply to Demand

1. **Optimise Demand First:** Policy and regulation needs to prioritise optimising the customer demand to ensure that the system is "sized" appropriately.
2. **Make Supply and Demand Equal:** Recognise that the competitive tension is between optimised demand and optimised supply.
3. **Give Equal Access to all Support Mechanisms and Markets:** Open up all support mechanisms and markets to demand side actions and assets.
4. **Promote a Flexibility Purchase Agreement:** Policy and regulation to support the development of a common framework for a flexibility purchase agreement.
5. **Allocate Significant Value to Energy Efficiency:** As shown by the new metrics, energy efficiency is highly valuable and needs to be central to system design – not an afterthought.
6. **Launch a Demand First Taskforce:** Establish a Demand First Taskforce to drive through reform across policy, regulation and business practice.

Demand is Equal to Supply

Until now, our energy system has been structured to prioritise supply of energy. While there is a need for significant investment in the supply side, we must introduce the competitive tension of customer actions and assets into the market and provide them with a level playing field. Despite the benefits of unlocking demand and flexibility, there is uncertainty, misunderstanding and lack of confidence in the ability of demand actions and assets to play an important role.

While demand assets and the flexibility that they deliver are crucial to the future efficiency of the system there are several challenges:

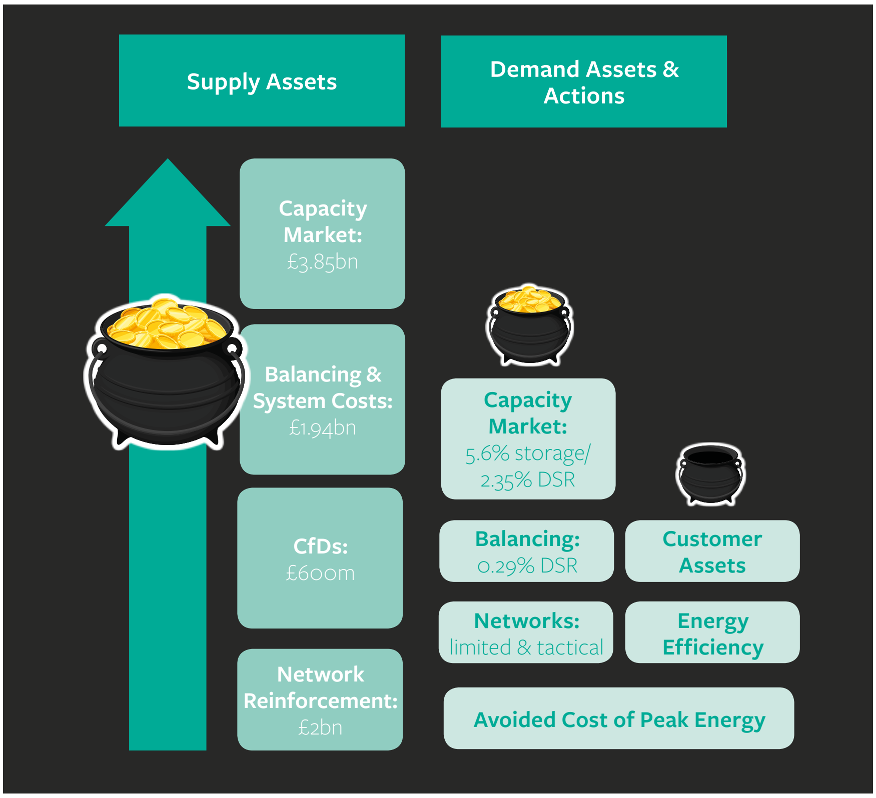
- **Limited Current Revenue Opportunities:** Few effective routes to market for all sizes of demand side assets
- **Capital Not Released through Existing Markets:** Upfront capital is difficult to unlock against a volatile commodity price
- **Chicken and Egg:** Only a significant penetration of these demand actions and assets will have a meaningful impact on the system
- **Limited Focus or Price Point:** The value of demand side actions and assets are not appropriately prioritised or rewarded

For too long we have been looking at the system from one end of the supply chain rather than recognising what physics tells us – that demand is of equal importance to supply.

DISTRUST OF DEMAND SIDE ACTIONS
It is always amusing to listen to those that don't trust the reliability of demand actions. This is a false fear. The system already has to predict and manage the weather – which is a lot more unpredictable than consumers – whose behaviour patterns are pretty well set and much more predictable than the sun, wind and rain. The distrust really stems from from a lack of understanding or knowledge about customers.

Power Up Customers & Spread the Joy

Demand actions and assets are very unequally rewarded, and demand-side assets and actions have been short-changed. There have been some developments in 2020, but in 2019 value and resources flowing to demand actions through the Capacity Market and the Balancing Mechanism amounted to less than 10%.



While the sector has come a long way, the current system design is still primarily shaped around "What can you do for us?" rather than "What do you need from us?"

Fundamentally, energy in its centralised form has always started from the wrong end of the "pipe", starting with security of supply rather than sizing the system around optimising and making demand most efficient.

This absolutely does not mean any threat of the lights going out or heat not being delivered when it is needed. But it does mean there needs to be what most other sectors have already undertaken – a process re-engineering around demand, not supply.

The significant opportunity is to power up the demand side, not least through consumers' assets and actions. This section aims to indicate how best this can be achieved and builds on the new metrics in From Silos to Whole System.

Optimising Demand is at the heart of Net Zero ambitions

Optimised demand is at the heart of the economy-wide Net Zero ambition – to achieve more from less, ideally coupled with an enhanced service at lower cost.

To optimise demand in a decarbonised system requires strong focus on how consumers can more efficiently use energy at the lowest cost with the greatest contribution to the system. At the customer end it requires optimising their overall need for energy and reducing their "call" on the energy system. Fundamentally, the incentives throughout the system are driven by "more is more" not "less is more" as all revenues are derived through quantity not quality of outcome.

Incentives lie in selling as much commodity as possible, with no rewards for optimising demand or driving efficiency. The market design needs to move from a commodity "play" to services where optimisation is rewarded – See From Commodities to Services

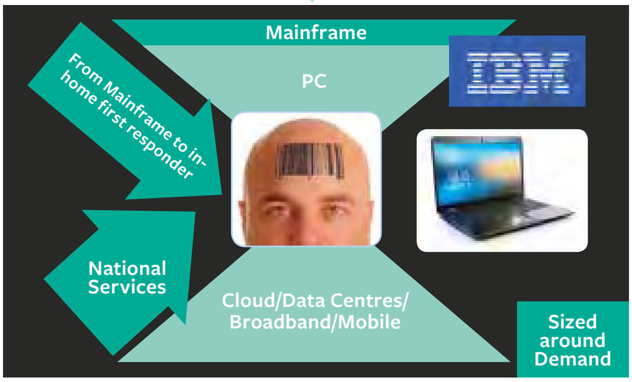
Data, Food, Transport & Health: Examples of sectorsworking to shape their systems through the actions and assets of their customers

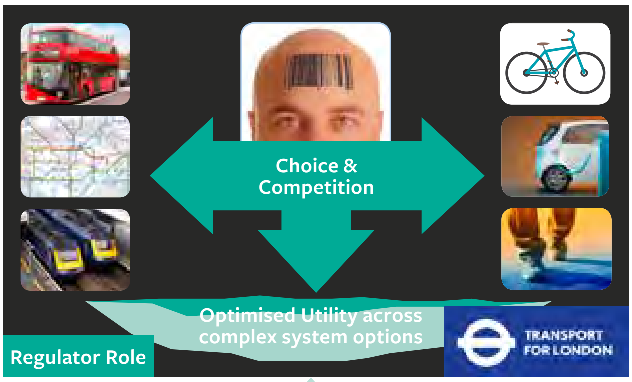
Most other sectors "optimise" demand and shape their business models by considering their customers' capabilities, using customers' assets and actions to drive down cost and drive up efficiencies throughout the supply chain.

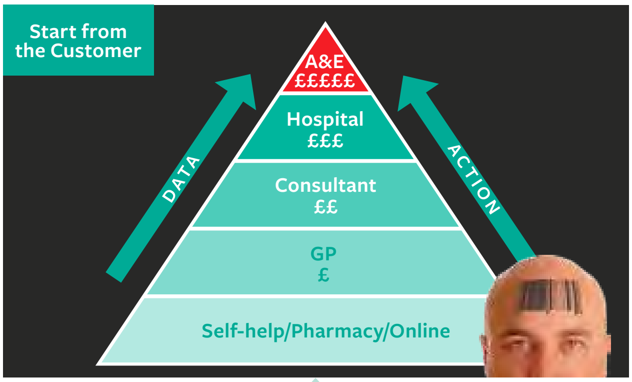
What is Optimised Demand?

From Mainframe to PC
Data provision has moved from a central mainframe system to one designed around the storage capacity of the PC and consumer-facing Cloud services, drawing on national and local services to meet and provide additional services against "optimised demand"

Customer-centric Food
Customers have wide choice blending supermarkets with specialist providers, local markets and eating out. Crucially fridges are integral to the food system. Without fridges in homes, supermarkets would need to be three times the size – fridges are energy's equivalent of distributed "storage"







Transport
Transport for London is a regulator that provides wide choice to travellers, with varied and blended options competing on convenience, price and capacity

Health Care
The hierarchy of provision provides for self-help from the chemist moving through to GPs with optionality to go to A&E in extremis. This design aims to serve at the most localised level first

There are of course differences between energy and other sectors but the key learnings for designing and sizing service around demand include:

- **Customer-first Hierarchy:** The design is shaped around a demand-led hierarchy
- **Optimise the Customer:** Customer actions, assets and services are key to designing the supply chain
- **Choice in the hands of the Customer:** Differential choice and blended options create real competition and improve standards

Recommendation 1: Optimise Demand First

The system needs up-ending, starting with customers.

Customers of all types should be able to reduce their consumption, access decarbonisation assets, perform new actions and be appropriately rewarded for optimising the system. This requires a change in how energy is sold and is enabled by access to tools and assets. Markets, regulation and policy need to be reorientated towards demand actions, to open up the opportunities of new technologies to automate customers' assets and actions such as "Prices to Devices"[1] and to access new products and services tailored to a wide range of consumer preferences.

While change will be evolutionary it is important that the destination of an optimal and customer-centric decarbonisation system is articulated.

There are four key design features that need "turning on their head".

- Designed around Optimised Demand not Supply
- Demand has REAL value and should be rewarded
- Shaped around a new competition between Supply and Demand
- Equitable access to demand assets and actions

Recommendation 2: Make Supply and Demand Equal

Demand needs to become a much greater focus for regulation, markets and policy as a component of the energy system that is equal to supply. This is a true representation of whole systems thinking and costing.

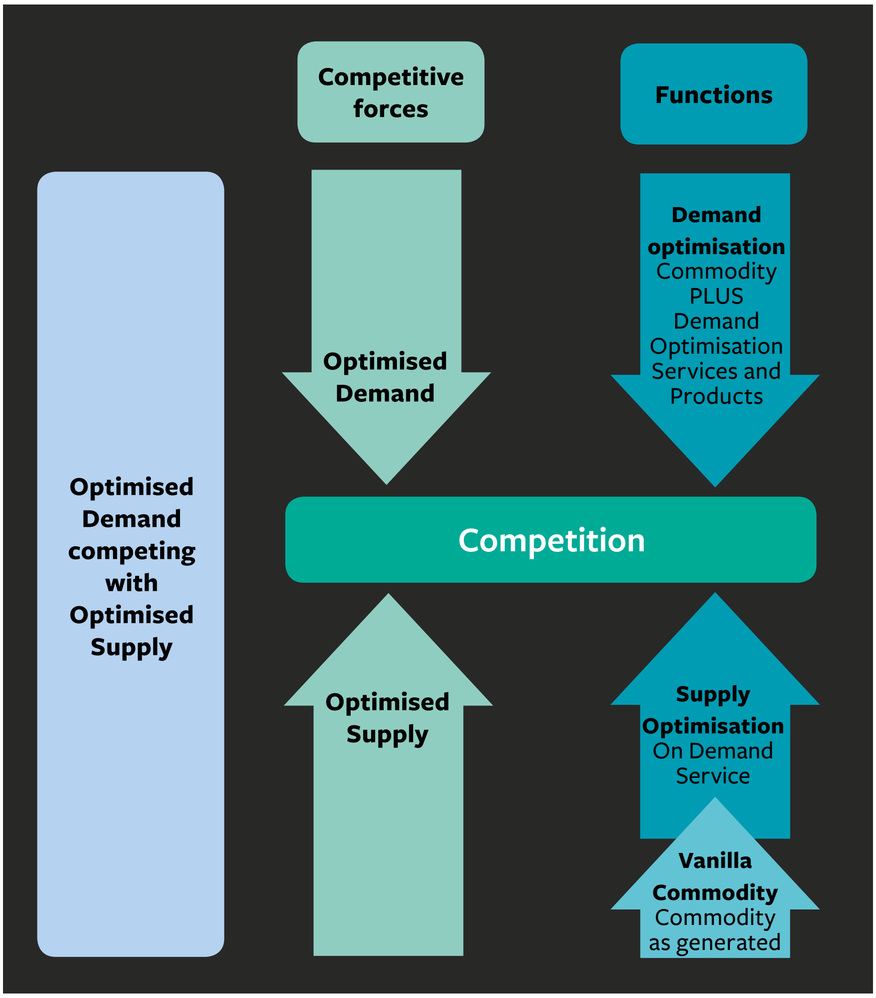
This is not to say that demand assets and actions are similar in scale to generation needs. However, demand is of growing importance and needs to be considered as the key "competitor" to generation going forward. ReCosting Energy's new metrics illustrate that all mechanisms and markets can measure the value of demand actions and assets equally to supply options and provide the opportunity to create equality for support mechanisms, markets and sector choices. See Fully Costed: From Silos to Whole System[2].

ReDesigning Regulation Recommendations

Re-engineer the market design: The sector should undertake business process re-engineering (BPR) to reshape the market design starting with the consumer, redesigning the relationships within the supply chain reflecting the new value opportunities of the new system.

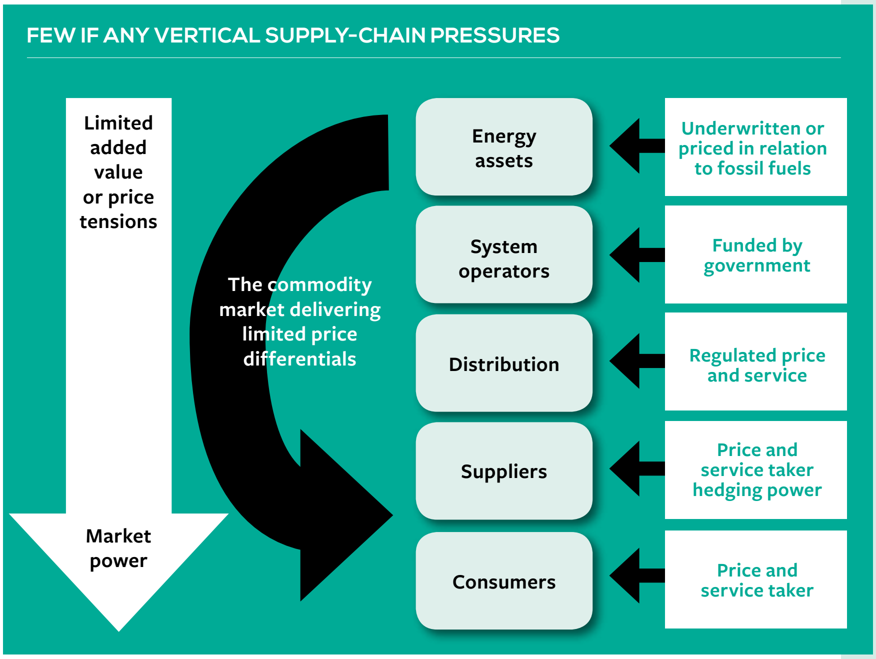
EASY
Reorientating policy is not difficult, but but embedding this outcome will take time. There might be legislative hurdles that preclude the implementation of a fully Demand First market design that need to be addressed

The New Competitive Pressure: Supply v Demand



With demand being equal to supply, a new competitive pressure emerges that unlocks so much more value and opportunity. Optimised Supply, the delivery of "processed" energy, needs to compete with Optimised Demand with both driving for greater efficiency and productivity through new products, services, technology and business models.

This addresses a crucial problem with the current system which is currently shaped around a linear pass-through system that creates virtually no supply chain pressures and leaves most of the cost and risk with the consumers. ReDesigning Regulation[3] highlighted this core issue that is inhibiting better price discovery and a more efficient system.



LIMITED SUPPLY-CHAIN PRESSURES

One of the key components of competition – that of supply-chain pressure – is almost non-existent. The barriers to competitive behaviour include the levels of uncontested pass-through costs and restrictive licences that frequently preclude significant differentiations in price, service or corporate behaviour.

Each part of the supply chain has been priced as if it was a standalone asset or service rather than part of a dynamic and integrated supply chain – or system. A normally functioning supply chain would drive efficiencies, cost reductions and service enhancements between vertical functions, not just within the currently horizontally siloed parts of the system.

Fully Value Demand

With demand and supply being equal, all support schemes, regulatory measures, markets and policy actions need to compare and compete demand-side actions and assets with supply assets.

750,000 V2G EVs optimised at times of peak dispatch, would represent 15GWh of storage that could displace the capacity of 4 CCGT plants.

EASY AND DIFFICULT

Focusing policy to regard demand as equal to supply is not so difficult, but the implications are more significant changes for market design, regulatory frameworks and implementation.

Recommendation 3: Give Equal Access to all Support Mechanisms and Markets

If demand were equal to supply, it should then receive equal access to markets and support, regulatory focus and policy attention.

The December 2020 Net Zero Review Interim Report from HM Treasury makes the point that access to capital is the most significant barrier: "Liquidity constraints occur where people are willing to make an investment that is cost saving but do not have access to the capital to pay for it. If they could borrow money to fund the investment, they would do so. This may be an issue throughout the transition due to the large amount of new capital investment required, for both households and businesses."[5]

We therefore have to open up the markets available to generation assets to demand-side assets, not least for consumers and SMEs.

FAIR ACCESS FOR CONSUMERS

We must recognise that for a householder or SME to be able to invest in a decarbonisation asset is as large an "ask" as for a large investor to build a windfarm. These financial barriers need to be treated equally.

Broadening and Miniaturising the Capacity Market:
The Capacity Market needs to be mandated to regard demand equal to supply and compare the full capacity value of both. While its mandate is "capacity", today it only supports increasing supply not increasing capacity through permanently reducing demand (energy efficiency), or more effectively shaping peak, delivering inter-seasonal capacity peaks, optimising generation or increasing network utilisation. It has no remit to even consider promoting flexibility.

In addition, the Capacity Market has no responsibility to consider the whole system costs of its actions, which should guide its cost-effectiveness calculations.

The Capacity Market needs to change to unlock the new value of demand and take very careful consideration of whole system costs.

QUITE EASY
The Capacity Market is changing and is considering including EVs in its regime. However this change needs to go further to include and equally compare demand and supply options.

Miniaturising the Contracts for Difference:
Currently focused on generation assets, CfDs could be shaped to include demand and flexibility assets. Offering CfDs to small, distributed and behind-the-meter assets would unlock, through retailer counterparties, much greater access to local storage, self-supply (such as PV deployment) and DSR assets (such as EVs).

BEIS's recent consultation on co-locating storage with CfD projects is a welcome start, yet further progress in this area is required. See more in Unlocking Investment: From Subsidies to the Market.

MORE COMPLEX
To create a regime that values cost reduction to the whole system is more complex as it requires a value of avoided costs but would be a global first with the UK pioneering this trend.

Balancing and Ancillary Markets:
The Energy System Operator (ESO) should prioritise demand. As the system becomes more digitalised the ability for the ESO to draw on demand actions should increase and we recommend that an ongoing "shadow" system is created to start measuring the reliability of different demand actions to provide confidence in demand side actions' reliability and predictability.

QUITE EASY
The ESO has robust plans to open its markets to all players. This needs to go faster and requires greater knowledge sharing with product manufacturers and behaviour change experts to calibrate the exact reliability and variability of customers.

Distribution Network Markets:

ELECTRICITY DISTRIBUTION LICENCE: CONDITION 4
Needs to be changed to prioritise demand, low carbon and flexibility as currently it is not Net Zero compliant and requires technology neutrality.

There are a multitude of emerging markets developed by DNOs that are bringing on flexibility but, as shown, far too many of them are accessing fossil fuel responses. This is mainly because the demand side market is not as developed. However, there does need to be a change in regulation for DNOs to access the most optimal response in a low carbon world, not always the cheapest option.

DNOs need to adopt a Flexibility Purchase Agreement regime that creates a standardised mechanism by which demand side actions can be accessed.

EASY
Simple change to RIIO2 regime to change the merit order, reduce fossil fuel dependence and support a growing demand side market.

Recommendation 4: Launch Flexibility Purchase Agreements

There are limited standardised mechanisms by which flexibility can be bought and sold. Currently, as outlined in the Energy White Paper, there are far too many approaches to buying flexibility and most of them are quite inaccessible and designed around the needs of the procurer rather than open and demand-led. This diverse and, in some instances, messy approach has reduced liquidity in flexibility marketplaces and creates barriers to new and innovative means to providing flexibility.

Flexibility Purchase Agreements could be developed with similar principles to Power Purchase Agreements and would be able to be accessed by a much wider range of actors. From research with many of the providers and advisors in the PPA market, developing a Flexibility Purchase Agreement would be reasonably simple – but requires government and regulatory leadership.

The sellers and purchasers of these Flexibility Purchase Agreements would range from suppliers who have active customers; DNOs who are looking for flexibility; the ESO for maintaining system stability; and generators to optimise the value of their production.

See more in From Commodities to Services.

EASY
This is not for Government to develop but to urge the sector to develop these products in a standardised manner to drive greater liquidity and uptake of flexibility options. Changes in regulation would also stimulate the need for these new arrangements.

Recommendation 5: Allocate significant Value to Energy Efficiency

The largest impact on energy efficiency over the last 15 years has been the improved energy efficiency of in-home products and appliances, nothing to do with the energy sector itself.

Energy efficiency has always been seen as a crucial player but has not been equated with the costs of supply before. It has also been regarded as a social issue and not valued as an intrinsic tool in the energy sector. With the new metrics developed in Episode Two, we recommend that energy efficiency should be a priority for funding through Contracts for Difference (the difference between the whole system cost and the cost of the efficiency measure), and through the Capacity Market.

The value of permanently reducing the need for energy has an impact beyond demand-side response – it changes the shape of our energy needs, not for "just in time" markets but permanently reduces investment required and on-going system costs.

Deep energy efficiency is estimated to reduce consumption by 25% by 2035 – the equivalent of the annual output of 6 Hinkley Point Cs[6]. Recent figures estimate that investment in energy efficient heating, insulation, lighting, controls and appliances could deliver a £7.5 billion net benefit to the UK economy.[7]

There are increasing technologies and system designs that are now able to calibrate the value of energy efficiency designed around services and product-led propositions. See From Commodities to Services.

QUITE EASY
There are new metrics and measurement tools calibrating the value of energy efficiency such as developed by EnergyPro. However, to date savings have only measured the savings of the cost of the commodity and not fully valued the whole system savings.

Conclusion: Refocusing Money, Policy and Regulation

To maximise and optimise the system, while also spreading the benefits of the transition, we need to treat demand equal to supply and facilitate access to the assets and services that can truly provide a win-win to consumers and the system. Markets and mechanisms must judge the whole system cost and value and regard demand as an active and highly desirable tool.

We have the existing support mechanisms and markets – it is just that they have to be equally available to demand actions and assets. The biggest blocker to access to demand assets is, however, the energy retail sector and its constraints through being focused on a commodity not a service.

Through opening up demand-side action more aggressively, the real competitive market – between demand and supply – can have real impacts on cost and efficiency. Without recognising this new competitive tension, we will never move from a linear, inefficient and old-fashioned system.

For the Many not the Few

The exciting opportunity is to deliver a system that is not controlled by the few but unlocks greater contribution and control by the many. In theory every household, every car owner, every business has the potential to "participate" in optimising the energy system. While feeling quite far-fetched today, most other sectors use the power and actions of their consumers to manage their systems' capacity and needs.

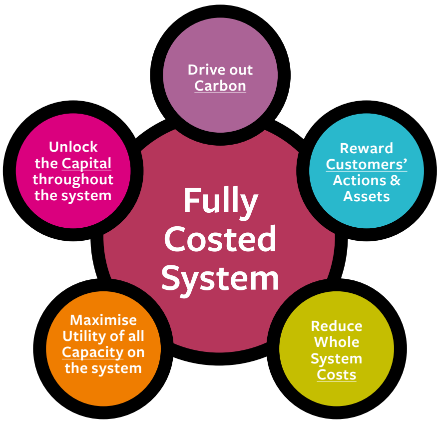
With the full value of demand actions fairly rewarded, access, affordability and desirability of assets and actions can be unlocked to benefit homeowners, SMEs and larger energy consumers. Through aggregators and innovative retailers much of the value to consumers will be unlocked through working the demand value on behalf of the consumer. The cumulative value of the energy demand market should allow for car companies, white goods suppliers and home management companies to provide reduced product prices to consumers, discounting the product value against the energy system value.

However, there does need to be some significant changes to the retail market to enable more service-driven propositions to be offered to consumers, including longer-term financial service products for EVs, PVs and behind-the-meter assets. See From Commodities to Services.

1 Deep Digitalisation: ReCosting Energy page 51
2 ReCosting Energy page 37
3 http://www.challenging-ideas.com/wp-content/uploads/2018/12/ReDESIGNING_REGULATION-final-report.pdf page 10
4 ReCosting Energy Fully Costed: From Silos to Whole System – page 40
5 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/945266/Net_Zero_Review_interim_report.pdf – page 87
6 https://publications.parliament.uk/pa/cm201719/cmselect/cmbeis/1730/1730.pdf
7 https://www.sciencedirect.com/science/article/pii/S030142151830421X and https://ukerc.ac.uk/news/unlocking-britains-first-fuel/

UNLOCK CONSUMER & SYSTEM VALUE

FROM COMMODITIES TO SERVICES



Optimising the Five Cs of a Fully Costed System

AMBITION: Move from sellling commodities to selling services, to unlock access to the capital assets needed for decarbonisation, optimise services and deliver simpler and predictable purchases for consumers. Businesses will absorb complexity and risk and create a strong supply chain pressure

Recommendations

- **Open up the Market to Consumer Services:** Ofgem needs to accelerate, deepen and broaden its review of the current retail licence model and promote the development of services.
- **Undertake Consumer Protection Assessment:** Drawing on learnings from other sectors, Ofgem needs to develop appropriate consumer protection measures addressing longer term product and financial service based contracts.
- **Promote New Service Agreements:** Policy and regulation should promote the development of a new suite of services across the supply chain from consumers through to generation.

Why Services and not Commodities?

The changing nature of the system from an opex to a capex system requires a new form of contractual relationship to unlock the capital, utilise that capital most efficiently and allocate value to longer-term investments and reliable actions that the commodity-based system cannot effectively release. The current market rewards quantity not quality with all incentives based around the amount of commodity (such as kWh of electricity) sold to consumers. It places limited incentives for doing more with less, with few rewards for "adding value" and "processing" energy. The focus on an incomprehensible kWh inhibits energy suppliers from investing in customers, or unlocking important decarbonisation assets and creates precarious business models. The intensive focus on switching aims to deal with the symptom of the current regime and is not a sustainable approach to really introducing effective and meaningful competition.

We believe that moving from a commodity "sell and buy" to a service-based system is crucial for the new decarbonised system. Selling a commodity is a very old fashioned model that is becoming less and less prevalent across other consumer-facing sectors.

Decarbonisation Demands a New Business Model

ReCosting Energy's underlying premise is that we are moving from a commodity costed system to a capital costed system and this requires a change in business models throughout the system.

Commodity selling is no longer delivering value to the customers, will never facilitate fair access to the new products and assets consumers need, creates increased risk to investors and does not serve retailers whose business models are becoming more and more shaky.

The current commodity market is not reflecting the full system "cost", which is moving from the commodity to the cost of capital and system management. The "value" is increasingly being created through the management and optimisation of the demand profile, efficient system operation, capacity utilisation, time, location and weather, not the production of the commodity.

It is very likely that the value of the commodity will mirror the cost journey of data, from valuable to ubiquitous. Action is needed to pre-empt the reduction in the cost of electrons otherwise the overall market and its investability will be significantly reduced.

"25 years from now, the bulk of the energy you use to heat your home and run your appliances, power your business, drive your vehicle, and operate every part of the global economy will be nearly free."
Jeremy Rifkind, *The Zero Marginal Cost Society*

THE DATA JOURNEY
In 1967 1 Megabyte cost $1 million to send, whereas today the estimated cost of sending a 1 Megabyte file is $0.001.

Services Drive out Cost and Optimise Systems

Services on the whole are driven by optimising the cost and use of the service and this is not a consumption model. Through longer term contractual arrangements, and risk being owned by the service provider, costs throughout the supply chain can be more efficiently driven out. The margins will be made through actually delivering less for equal service experience. It will drive investment in technology, system redesign, innovation and optimisation throughout as the core financial incentive will be less, not more.

This is not to say that there isn't a need for a "just-in-time" market to provide price discovery for managing peaks and troughs. However, the current commodity markets have little relation to the real costs of the system.

Servicing, processing, delivering, optimising and utilisation of capital assets are all better managed around a Service Economy rather than a commodity market.

Delighting Consumers and Shielding them from Volatility and Complexity

The opportunity to provide services should incentivise the service provider to support customers to optimise their use of energy while allowing the consumer to be distanced from the volatility of the commodity and the growing complexity of the new system.

There are great models in other sectors driven by service, subscription and asset-based propositions that take the optimisation responsibility away from the consumer and manage the risks and costs within the businesses themselves. In addition, the delivery of new and innovative services and products delights their customers, adding value and satisfaction.

Service packages have emerged in the mobile sector and moved away from selling minutes and texts to packages with capital assets embedded into their propositions.

Fair Access to Decarbonisation Assets, Demand Actions and their Rewards

A move to a service economy is not just a nice to have but an essential component of ensuring that we democratise the benefits of the system. We need business models that allow wide access to the equipment, assets and actions required to ensure that we don't have a two-tiered energy system – the EV/PV owner benefiting from accessing markets and those without picking up the full system costs.

From a customer perspective a fixed service contract with products embedded in the service agreement would provide much greater access to the decarbonisation assets so needed across the population.

Policy and regulation should spend as much time developing new frameworks for really "delightful" services that deliver fair access to the system of the future as they do trying to address the switching regime.

Less is Certainly More

Businesses would not be rewarded for the amount of energy but the utility of the energy in line with the customers' needs and expectations. Therefore, the service model would drive the businesses to manage their consumers' consumption, offering exciting new methods of demand shifting, helping shape their demand to reduce the need for energy. In addition, service contracts can be designed around energy efficiency measures unlocking the longer-term benefits of reduced consumption.

Internalising Volatility, Complexity and Risk

Through service packages, retailers will need to take on the complexities of the system, managing their customers' consumption rather than turning customers into electricity or heating engineers.

Service and subscriptions models would further drive the supply chain pressures to optimise all that it does, in order to reduce their costs. This is in big contrast to today where costs are just passed on to the consumer – socialising the costs rather than managing the risk themselves.

Through services it will be possible to distance customers from the volatility of the commodity and move to energy becoming a component of other products rather than a purchase in its own right, potentially changing the business model from a consumer product to a business-to-business service. See From Spreading Risk to Owning Risk.

CONSUMER PROTECTION

This is not to say that service models do not have their own set of challenges, not least enforcing contractual obligations and different consumer detriment. However, while these risks are different from the challenges of today, they are not more complex than the current set of arrangements in other consumer facing sectors.

Retailers Becoming Product Providers and Demand Optimisers

Retailers should be able to share the benefit from their customers' demand value to the overall system.

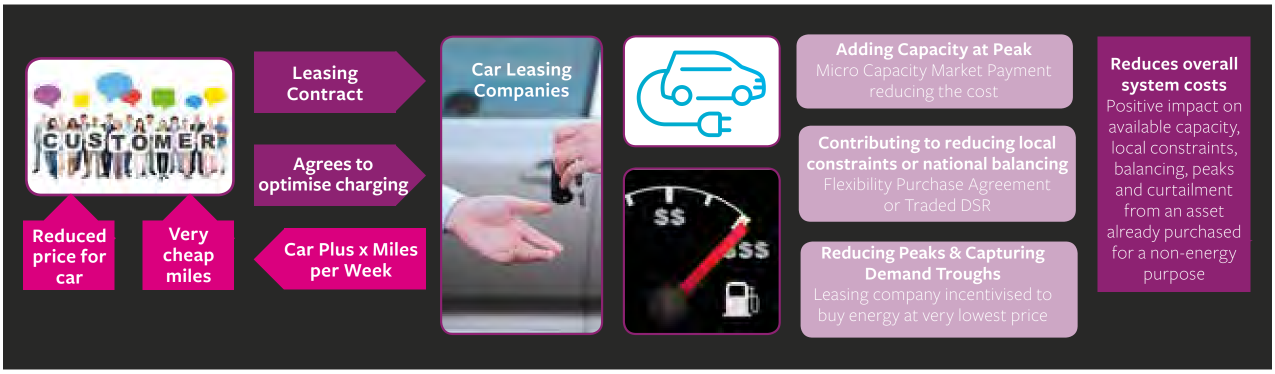
Being able to blend the commodity with services will, and should, build stronger business models, more tailored to varying customer needs, and unlock the capital required for customers to optimise their consumption. Retailers would be able to diversify their offers and through the access to "miniaturised" support mechanisms that will derisk investment in customer assets, assist with the overall system optimisation. See From Supply to Demand.

Services rather than a commodity proposition must also open up the market to a much greater diversity of providers creating new competition for traditional suppliers of energy and deliver a much greater diversity and innovation in consumer-facing businesses.

How a Service-based System could Work for Customers

This model is based on the mobile phone model. It includes access to support mechanisms (see From Supply to Demand), and shows that there are several different revenue streams available to reduce the up-front costs of the asset. In addition, an automated service to optimise the energy system, and access the cheapest energy has wider efficiency benefits for the whole system.

An EV Service Agreement – a Model based on Mobile Phones



- Customers are offered a leasing arrangement for a car with a service agreement including x miles per week, similar to a mobile phone contract.
- The leasing company optimises the charging of the car through automated services reducing the cost of the energy.
- The leasing company is able to reduce the capital costs through accessing the Capacity Market.
- The leasing company is also able to sell a flexibility purchase agreement to key players, providing greater certainty to those exposed to imbalance risks.
- The customer is delivered a cheaper cost for the asset, lower running costs and reduced volatility. The system benefits from the increased capacity and flexibility resources that assist all within the system to reduce costs.

The Customer Journey

Customer Needs
For customers to play their role and add value to the energy system they require innovative propositions, tailored to their lifestyles and needs but also products that unlock their value. hese range from EVs and PV to smart controls, smart white goods and – most importantly – energy efficiency measures. However, the barrier to mass deployment and access to these assets is the capital cost.

Customer Choice
The customer is offered a wide range of products and services through service contracts that allow for the capital asset value to be amortised across a longer period of time, with the energy embedded into the agreement. This would be accompanied with a service-level agreement allowing consumers to decide on their service levels and the amount of control in relation to energy use. Assets would be much more widely accessible while the retailer would be incentivised to reduce overall energy costs, and reward consumers for flexibility.

The Retailer
A wide range of propositions would be provided to customers and the retailer would be able to manage the asset, its installation and its energy consumption. The retailer would be incentivised to use the assets most efficiently, managing peak demand and accessing the best prices. In addition, through the new market mechanisms they would be able to receive a small but useful Capacity Market or CfD payment if the asset was either a generator, delivered flexibility or reduced overall demand needs. In addition, the retailer could sell its customers' assets capabilities through a Flexibility Purchase Market and play in the Balancing Market. [See Recommendation 2 from Reward Customers: from Supply to Demand.]

Prices to Devices
By "energy enabling" all energy consuming products, device retailers could enable products to play in the DSR and Balancing Markets directly without intermediaries. See Deep Digitalisation.

Retailer Relationships with Networks
Through longer-term relationships and obligations, retailers will be able to build up contractual and stable revenues built off their customers to provide new services to enhance capacity on networks, thus sharing in the value of optimising network utility. These can be unlocked by Flexibility Purchase Agreements and just-in-time markets for demand-side response.

Regulation
This requires a streamlining of the energy licence agreements and greater flexibility about how and what customers can purchase. There will be a much deeper conflation between other regulatory models and non-energy consumer protection laws, not least product protection, financial services and long-term contractual relationships.

Networks Moving from Distribution to Capacity Services

While networks are taking significant measures to migrate from distribution to managing capacity through the proposed DSO model, more progress is needed. Regulation should focus on capacity services pushing risk and rewards towards doing more with less.

Sharing factors on capacity utilisation need to be increased, balanced with greater pressure on enhancing efficiency, promoting new business models such as distributed storage and promoting smarter system management.

In addition, the recommendations that demand must top the merit order for networks will drive greater value towards innovative retailers and benefit consumers. See From Fossil to Low Carbon.

Network Services

New service agreements should be investigated around capacity blocks and locational pricing regimes. This again is similar to the sale and access to data where ceiling blocks of data are procured and provide much better optimisation and ability to plan.

The core service is a capacity service that can be enhanced by networks purchasing "flexibility" from retailers in areas of constraint with location pricing as the reference price. This would help with the growing distributional concerns between those with high capacity needs and those with much lower capacity requirements.

Buying capacity ceilings would further incentivise retailers to optimise their customers' demand so as not to have to move from one capacity block to a more expensive one, all having a downward pressure on the cost for the whole system.

The rub here would be much more reduced incentives to build more infrastructure, driving better system management, markets to optimise the utility of the networks and exposure to the competition from new entrant networks.

A derivative of this has been developed by North West Electricity in providing a low voltage service at a significantly reduced price for low energy users. These forms of differential services will become more and more desirable and necessary with clear regulation underpinning essential service obligations.

In Spain, customers are offered "shared storage" services for excess solar, to draw on when needed. This offers significant cost reductions for access to storage and delivers technical and cost advantages

- **Cost of storage less than peak prices**
- **No upfront costs to consumers**
- **Lower grid system losses and less battery degradation**
- **Lower total battery required due to aggregation**
- **30% less whole system investment**
- **Provides additional services to the system**

Value for Generators

Currently generators have few incentives to add value to their commodity and with curtailment payments the rewards sit in all the wrong places. However, generators could add value through delivering longer-term "fully-balanced" energy contracts.

The Commodity is Important but ...
By squeezing renewables into a fossil fuel paradigm we are trying to get intermittent generation to behave as if it were a "ramp-it-up" asset and we are costing every electron as if they were equal. In addition, there is no reason why consumers should have to "play" the international commodity markets when their energy is coming from a fixed asset totally unrelated to a global commodity market.

Utility is the Service, the Commodity is the Feedstock
There are two different outcomes that need to be distinguished and differentiated: the commodity as generated any time of the day or night, and an energy service that delivers energy at the time of demand. One is a commodity market and the second an energy service.

These two outcomes have different types of customers:

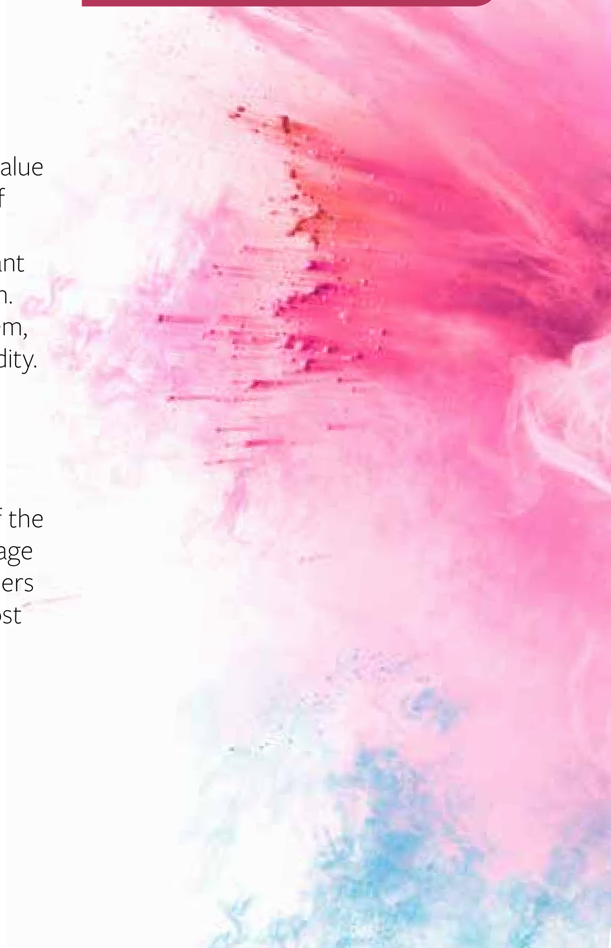
- **Vanilla Commodity:** This commodity is of interest to those who have the ability and access to demand actions and assets and storage assets and can "add value" to the commodity by shaping its deployment in line with demand.
- **The On-demand Service:** This is of interest to those who want the generator or an energy "processor" to manage the intermittency of the commodity and provide a service shaped to the customers' needs. This passes the risk but also the rewards to those who add value to their own commodity. It also opens up revenue to deliver inter-seasonal storage and services that are so lacking in the system.

FROM MILK TO CHEESEMAKER
Milk has a value but is a commodity. It needs to be pasteurised to be widely sold and then even more added value can be gained from making cheese.

For those large "purchasers" of energy it is likely that they might want to purchase a combination of commodity and the top-up security of an "on-demand" service.

For generators and storage owners this allows them to increase the diminishing value of the commodity, building more sophisticated and added-value business models. It will also allow for greater investment in the "processing" of energy through storage, and more sophisticated demand predictions.

In addition, it opens up the retail market to new purchasers who do not want to take the risk of imbalance and the complexities of the energy system design. This might in time break down some of the silos that exist in the current system, improving efficiencies and driving out cost through less waste of the commodity.



The Importance of the Wholesale Market
This world of services does not exclude the need for markets to calibrate demand needs, time, weather and location. In many ways that market will be more important with the more dynamic, volatile and unpredictable nature of the balance between demand and supply. However, the volatility and risk to manage this in a service-based model will sit with the companies and not the consumers and will probably be a useful reference price mechanism rather than how most currently contract with each other.

System Benefits of a Service Market

Unlocking the "Processing Assets" throughout the System

It is not just consumers who require services but the system as a whole. Storage is a service and is challenged by having to contort its capital to play in a volatile commodity market. Services that reward full seasonal value rather than just "in-minute" value also assist with unlocking inter-seasonal storage, and contractual obligations between storage services and retailers, generators and the ESO, will ensure greater predictability and resilience across the changing nature and dynamism of peaks and troughs.

In addition, the "softer" assets such as digitalisation, system redesign, and optimisation assets are just not unlocked by the just-in-time commodity nature of the market, but would be through longer-term services with strong optimisation incentives and competition to do more with less.

Supporting Security of the System

With strong contractual obligations relating to service contracts, the actual management of the system and its predictability and stability would be increased as these important actions would not be dependent on volatile price fluctuations, but on a contracted service provided when needed. In addition, business models that are varied, tailored and specific to customers' needs actually create greater system stability with an increase and diversity of actions able to hedge, shift, and support the shaping of demand and supply.

Recommendation 1: Championing Customer Services

Ofgem needs to accelerate, deepen and broaden its review of the current retail licence model and champion the development of services, working with first movers to understand the key elements of consumer benefit, detriment and protection needed, not least the essential service obligation.

While regarded as difficult by Ofgem, these models exist in a wide range of other consumer-facing sectors.

MODERATELY EASY
Ofgem does have flexibility even within the current legal framework to vary the customer experience but should identify any show stoppers in legislation that might need amending ready for the next Energy Bill.

Recommendation 2: Consumer Protection Regime

Ofgem, drawing on learnings and working with other sectors, can develop appropriate consumer protection measures addressing longer-term product and financial service-based contracts. These consumer protection regimes work across many other sectors to greater and lesser effect. However, this is not a blank sheet of paper in terms of consumer protection.

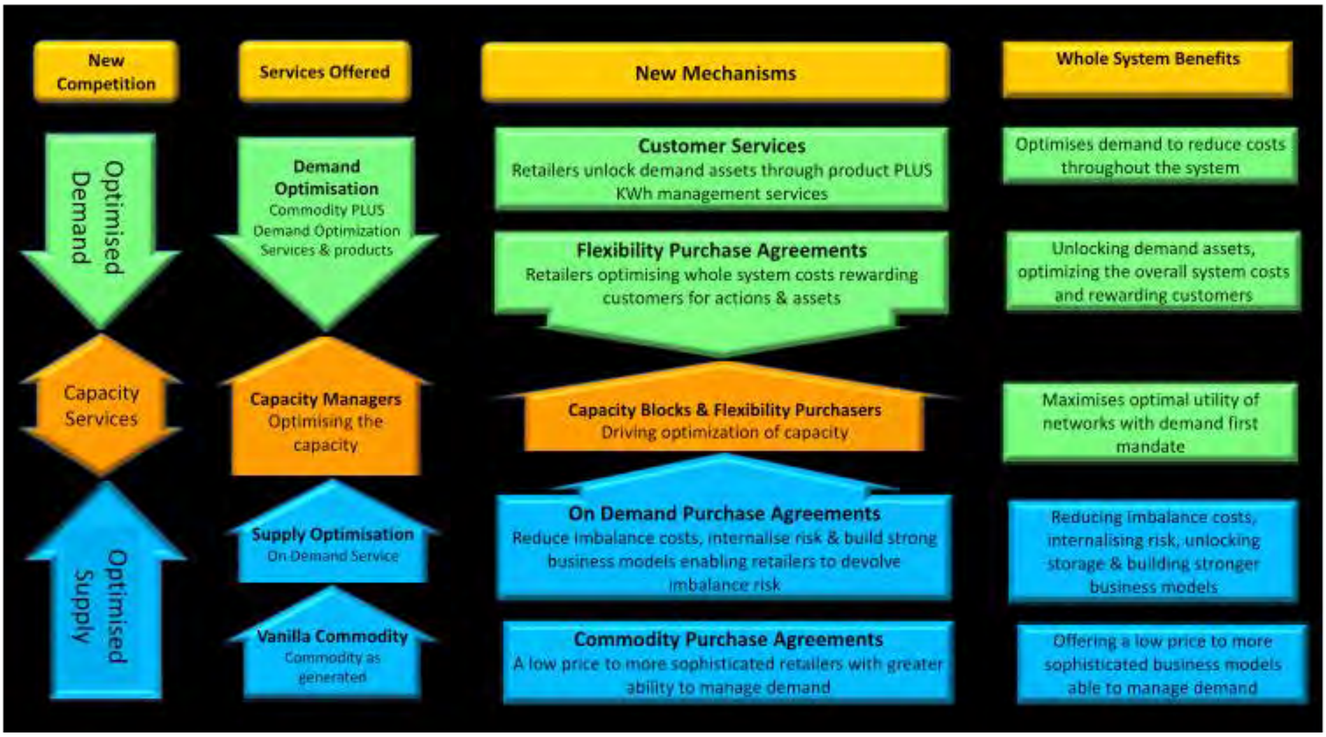
Recommendation 3: Promote New Service Agreements

Policy and regulation should promote the development of new service agreements as an integral part of the future energy landscape, working with generators, storage investors and system optimisers to build a range of common contractual frameworks and terms and conditions.

Four Potential Service Models

Building on the key components of a new system recommended in this report – Optimisation of the 5 Cs at its heart and Optimised Demand competing with Optimised Supply – new service agreements could be developed, such as:

- **Customer Optimisation Services:** Retailers optimise their customers' demand through assets, technology and automated actions, enabling customers to get more from less and sharing the system services rewards with their customers
- **Flexibility Purchase Agreements:** Retailers sell their customers' flexibility capabilities to DNOs, the ESO and directly to generators. This can be done on an options basis with a draw-down additional payment. See From Supply to Demand
- **Capacity Services:** Networks maximise capacity providing incentives to both the supply and demand side to maximise the utility of their networks at best cost, with service differentiated according to need.
- **On-demand Services:** A fully blended energy service meeting demand and taking responsibility to match their production to demand, rewarded for a fully balanced and managed energy service
- **Commodity Provision:** A basic low cost "as-generated" commodity with no added value but accessible and desirable to those that have optimised demand effectively to manage demand and supply misalignments.



These service agreements proposals have been shared with existing Power Purchase Agreement consultants and their development is considered feasible, practical and desirable.

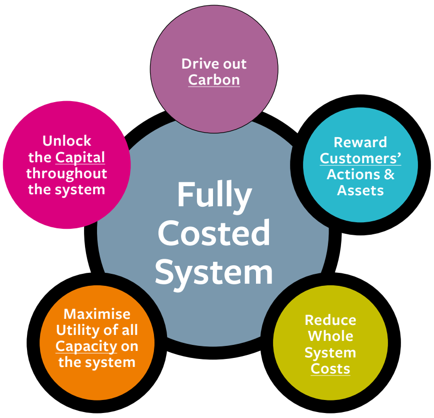
Conclusion

The changing nature of the system from an opex to a capex system requires a new form of contractual relationship to unlock the capital, utilise that capital most efficiently and allocate value to longer-term investments and reliable actions that the commodity-based system cannot effectively release. There is significant value sitting within the services model that can be realised through optimisation but which cannot be monetised through just the commodity market.

At the heart of reform is the retail market that must be first mover in changing its business model, otherwise there will be significant barriers to fair access to assets and actions that currently are only available to the rich.

STOP PASSING THE BUCK

FROM SPREADING RISK TO OWNING RISK



Optimising the Five Cs of a Fully Costed System

AMBITION: Risk needs to be allocated to and owned by the businesses that create it and are best able to manage it, instead of passing through to consumers. Competition in efficient risk management will build more sophisticated and resilient businesses, reducing costs to the system and ultimately the consumer

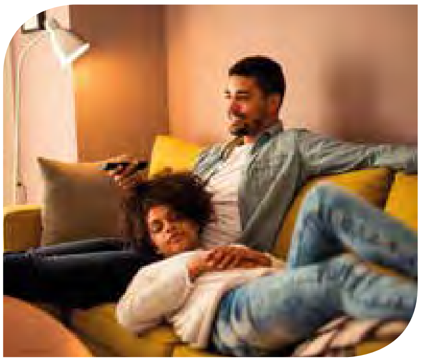
Recommendations: From Spreading Risk to Owning Risk

1. **Review System Management Responsibilities:** The ESO should be balancer of last resort and will need to perform crucial functions, as much of the risks need to sit with or be charged to the risk creators.
2. **Increase Imbalance Penalties:** Suppliers who consistently call on centralised services need to pay the fully-loaded cost of that service.
3. **Review Capping and Smearing of Real Costs:** Real costs must shine through to enable value to be captured and total system costs reduced. The smearing of the cost of failure should be reviewed and managed through insurance products.
4. **Employ more Insurance-based Products:** The energy sector is almost uniquely devoid of insurance products to manage and assess risk.

The Socialisation of Risk

To date far too much risk is "socialised" and spread to consumers. Risk "pass through" has been allowed, and even pandered to, throughout the system to "make it work". There are limited sanctions for risk creation and few incentives to manage risk effectively within the supply chain.

Of course, consumers face unmanageable risks in other sectors but in energy the design of the market creates more risk – and cost for energy consumers. Consider the list of risks that the consumer has to "manage" without the tools, visibility or agency to mitigate them.



The Customer is the Victim at the end of the line

The energy sector is almost unique in passing on all risks to customers with very little risk self-managed, and limited penalties for passing risk from part of the system to another. In other sectors more risk is absorbed, driven out or mitigated by companies through supply chain pressures, service and contractual relationships, product differentiation and appropriate "ownership" of risk.

To compound these risks the customer has almost no way of mitigating them. Just consider the risks that they face:

- **Commodity:** War between Iran and the US, as the commodity is still linked to global fossil fuels
- **Weather:** What time of day energy is available
- **Stability of the System:** The small but important costs of the system stability are not borne by the companies that create it but passed on to consumers
- **Misleading Comparison Sites:** Some switching sites are neither transparent nor reflective of the price ultimately experienced by the customer
- **Supplier Competency:** If their supplier is a good or bad hedger
- **Supplier Failure:** All consumers end up paying for business failure
- **Quality Control:** Little transparency on whether their energy really is green or not
- **Limited Options to reduce costs:** Limited products or services that allow for mitigation of these costs
- **Smeared Cost Allocation:** Finally, all these costs are not allocated to those customers who created the problem but smeared across all consumers

If not addressed soon, customers will be angry – and rightly so – at the rising costs that should sit within businesses but which they are currently picking up

Risk is transferred through costs, smearing of the cost of risk or the socialisation of the cost of failure.

With new technologies getting cheaper we should now expect the actors within the system to manage their own risk – and at the same time build themselves more robust business models with wider opportunity for revenues through cost-effective risk management.

The current practice of socialising the risk is also not rewarding those businesses who do manage their risk efficiently, effectively creating a race to the bottom.

The Risks of Tomorrow

The system is moving from 400 key players to over 50 million actions and assets engaging with each other in an automated manner, totally transforming the complexity, diversity and quantity of risk sitting throughout the system.

While seen as a marginal issue today, risk management will very shortly become much more important and allocation of where the risk lies needs to be addressed in anticipation of the growing complexity and interaction of the new system.

Risks facing us today will look like a walk in the park in comparison to the multitude of players, actions, interactions and the potential risk they create.

Reallocate Risk & Reward

All market players should own as much of their system risk as possible and benefit from managing these risks, but they should also be penalised for "socialising" the risk.

Risk ownership and risk management are key to driving out costs, improving productivity and reducing reliance on centralised mechanisms to pick up the pieces. This is also particularly crucial as the system becomes more complex and decentralised and where risk will lie throughout a much more webbed set of actors. Regulation will find it almost impossible to unpick the risk creator or develop the mitigation measures if it is expected to arbitrate between parties and the consumer.

We need to create the right incentives – and penalties for those that call on socialised services – to drive efficiency throughout the supply chain, breaking down the artificial barriers between each "risk" silo in the system.

Ofgem the Risk Regulator

In ReDesigning Regulation[1], we proposed that Ofgem start to change its approach from a "process" regulator to a "risk" regulator. This will become more and more important as the proliferation of actors, actions and interactions will demand the regulator to focus on risk and outcome. Regulating as they do today will become impossible.

Using insurance, assurance and perimeter regulation will assist with risk management and shape a more agile regulatory model.

The Food Standards Agency's rationale for regulatory reform

The existing 'one size fits all' approach to regulating food businesses is ill-suited to the incredibly diverse nature of the industry. In recent years we have witnessed large numbers of new players enter the global food and food-safety landscape; for example, online retailers, food-delivery services, private auditors, and independent food-safety certification schemes. These and many other developments have reduced risks, created different risks, and increased risks. But the current regulatory approach doesn't allow us easily to focus our effort on changing risks. It's clunky, rather than flexible and agile.

Perimeter regulation

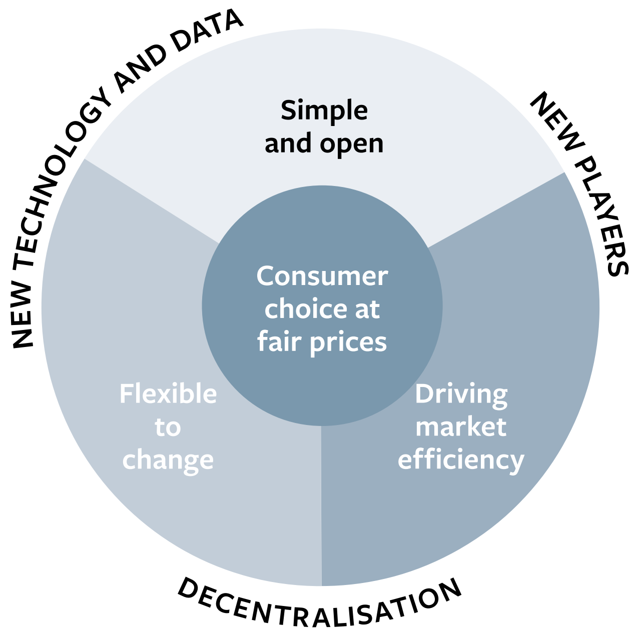
Energy regulation is facing one of the most important periods since privatisation, with the opportunity to reshape regulation from being 'of' the sector to being 'for' the consumer.

While a more dispersed and dynamic system cannot be regulated through process, regulation does have an extremely important role to play – it is just that its role needs to move to the perimeter of the system rather than sitting in the middle.

TOO COMPLEX TO MANAGE

PROCESS REGULATION

MANAGING THE PERIMETER



MANAGING THE RISK

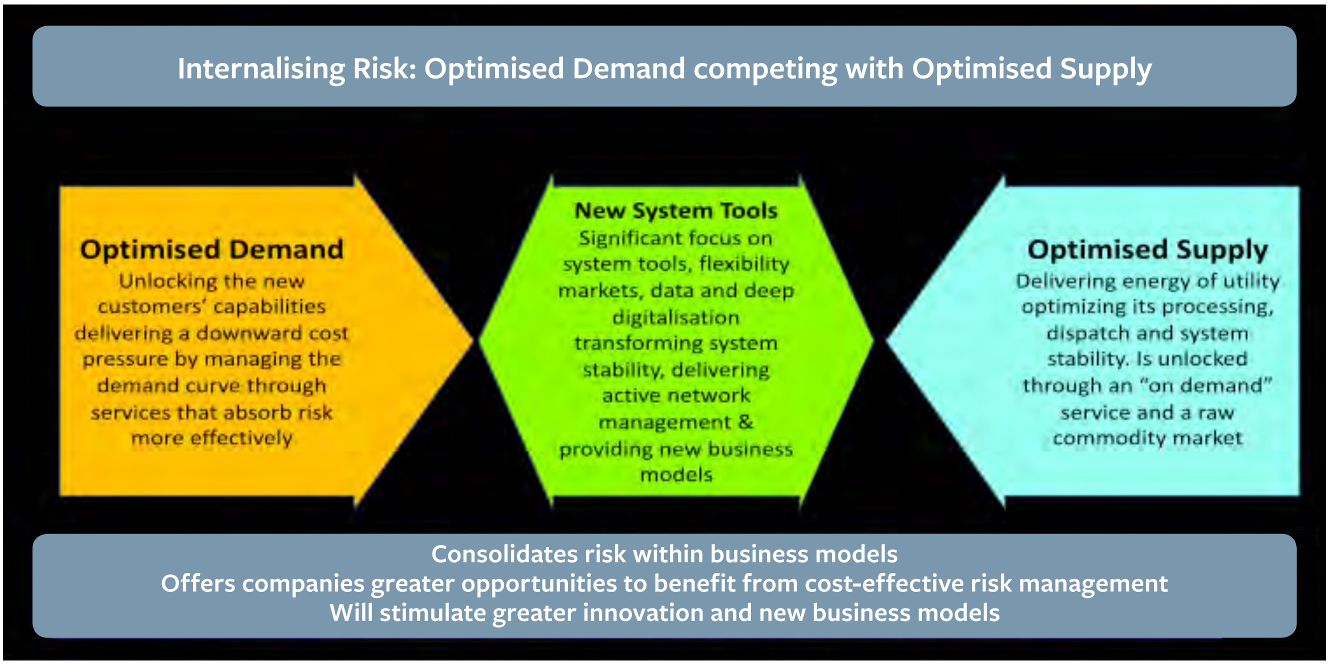
Moving towards Better Risk Allocation

The ReCosting Energy project has proposed several solutions that assist in allocating risk to businesses away from the customer.

- **Optimised Demand competing with Optimised Supply:** By shaping the market between these two competing tensions many of the sub-risks lying hidden in the system can be squeezed out more effectively. The ability to manage and mitigate these risks will be greatly supported by deep digitalisation.
- **Whole System Costings:** A whole system costing methodology will highlight where risk is being passed from one part of the supply chain to another.
- **Services not Commodities:** Good service-based business models in general manage risk more effectively than commodity markets. While the cost of the risk is integrated into the service agreements, incentives for companies to manage the risk are greatly enhanced and best-in-class risk mitigation will create important competitive advantage.
- **Deep Digitalisation:** Much better system tools sitting throughout the system will enable risk to be managed much more effectively and will spur on new businesses and drive innovation.

SERVICE-BASED BUSINESS MODELS

The additional value of service-based business models is that in general they are designed around the business managing the risk rather than the consumer. While the risk might be incorporated into the price, the risk mitigation is the role of the company where risk management will be more effective and cost efficiently addressed.



The ESO needs to be the Balancer of Last Resort not the First Call

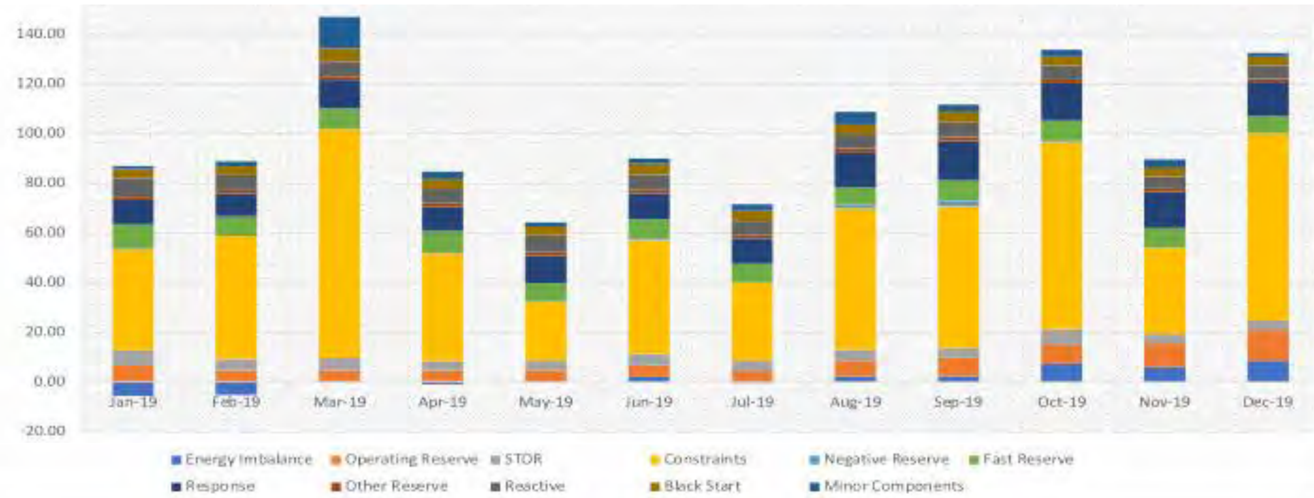
COVID-19 has given us a glimpse into the future volatility between demand and supply and illustrates the new paradigm of risk. However, when there are 50 million assets and actions active on the system, the volatility and potential risk will increase significantly.

Suppliers rely on the balancing market to pick up their imbalance risk. This is understandable with still limited demand data and, while there will always be a margin of tolerance required, this is becoming a smouldering platform.

Measures need to start to be put in place to address this over-reliance on a socialised cost to the system. In addition, the "security blanket" that the ESO provides needs to reflect the fully loaded cost of having a balancer of last resort – not just the imbalance cost.

SYSTEM STABILITY
While there will be a crucial function for system stability and security, the ESO is now having to take action across over 17% of the market whereas in the past it intervened on just 5-7%. of the market. Addressing this before it becomes unmanageable and very costly is important.

Costs in 2019 for System Services – £1.2bn



These costs were incurred in 2019. The costs for 2020 will be significantly higher, but 2019 represents a year of "near normal".

Recommendation 1: Review System Management Responsibilities

The default risk manager has become the ESO. There needs to be a distinction between stability and security services and picking up the pieces of others' unmanaged risk.

So, while there are crucial roles for the ESO, system stability actions should be, where possible, taken within the supply chain. Those that create risk should be subjected to the fully loaded costs of accessing central services. This would include the administrative costs of ESO and Elexon and, while not huge, would drive businesses to consider new ways of managing their risks.

Recommendation 2: Increase Imbalance Penalties

To drive greater understanding of the demand curve and to stop sloppy suppliers from relying on the ESO to pick up the risk, the Suppliers Information Imbalance Charge should be progressively increased for those that consistently exceed a prescribed margin of tolerance.

This will drive greater consumer insights, more blended procurement of supply assets, and new competitive pressures to develop best-in-class risk management.

The most effective method of managing this risk would be through insurance that would be able to calibrate the risk of calling on central services, allowing new companies to enter the market and become progressively more accurate at managing demand and supply with premiums commensurate with their dependency on the central services.

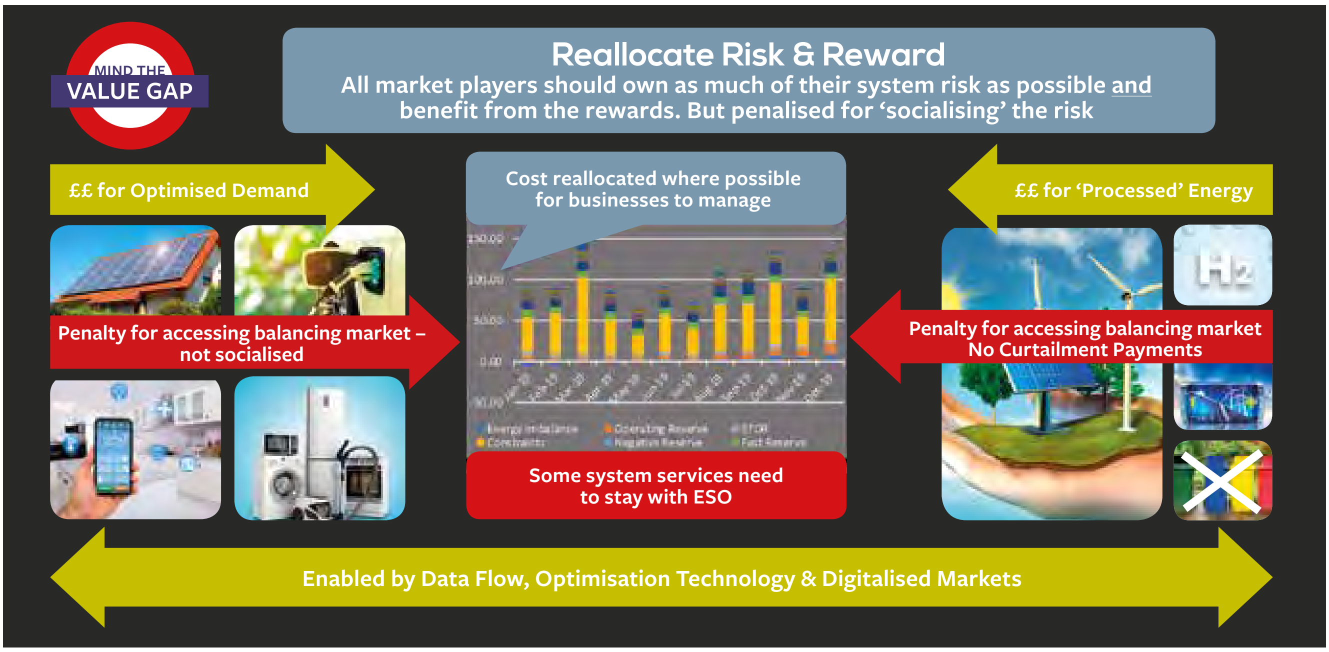
The important outcomes of this would:

- **Add Value:** Drive generation developers to deliver energy on demand through blending their generation assets with storage, further unlocking the value of blending assets and reducing the risk to suppliers of imbalance charges
- **Grow Demand Assets and Actions:** Incentivise retailers to unlock more value for demand actions and assets thereby delivering new value to their customers
- **Create More Sophisticated System Management Tools:** Open up more optimisation tools and technologies to manage and mitigate risk

MODERATELY EASY
The risk that the ESO has to manage can be triaged to determine where others are creating risk that can be better managed through their business models than by central services. In some instances, it will be more effective for the ESO to manage these risks, but the risk creator should incur the full cost of that service.

CHARGING FOR USE
Charging for the full cost of a centralised service is common in many other regulated sectors, where those that call on central regulated services pay more than those that have little call on them.

EASY
The mechanisms already exists so regulation could start slowly placing an increasing ratchet payment on actors who consistently have to call on the ESO services.



Recommendation 3: Review Capping and Smearing of Costs

MODERATELY EASY
Audit the whole system cost implications of all capping and smearing of costs sitting throughout the system.

Real costs must shine through to enable value to be captured and whole system costs reduced. While it is very understandable that Ofgem has aimed to reduce consumer bills through manipulating the real costs, in the medium term these caps will not support lower customer bills, but hide value, and inhibit investment in the assets required to decarbonise the system. While this is a contentious area, Ofgem needs to review where real value is actually being lost through capping real time prices. In the new world that will actually cause whole system detriment and increased costs.

Supplier of Last Resort
While there are merits to the system as it stands today, the principle behind consumers and good businesses picking up the costs of failed businesses is not sustainable or fair. In addition, well-run businesses feel that the system does not incentivise good business management.

While Ofgem is tightening up the market entry requirements, it is possible to use insurance to manage business failure risks that these companies pose to the system. So, while no scheme should preclude new entrants to the market or raise any artificial barriers, new entrants could take out insurance as “learner drivers” that assesses their risk of failure.

In addition, this would also create an early warning system for Ofgem of which suppliers were at risk as the level of premiums would provide the regulator with an agile “at risk” indicator.

Recommendation 4: Employ More Insurance-based Products

The energy sector is almost uniquely devoid of insurance products to manage and assess risk.

Predicting and costing these risks are exactly the skills that sit within the insurance sector and in a more complex system could provide useful risk dashboards for the regulator.

Insurance products have many benefits:

- **The Cost Sits with the Risk Creator:** The cost of risk sits with the businesses through their premiums.
- **Flexible and Adaptive:** The calibration of risk can change, dynamically and doesn’t have to wait for regulatory or legislative change providing a much more agile system.
- **Continual Improvement:** The premiums drive businesses to to continually improve, in oder to reduce costs.

Examples of where insurance could play a role:

- **Imbalance Risk and Capital Surety:** Insurance products could assure actors replacing lodged capital. Elexon proposed an insurance scheme some years ago but it was never adopted.
- **Business Failure:** Businesses could be insured, creating a continual improvement incentive.
- **Contractual Insurance:** Throughout service-based business models, insurance plays an important role in costing the risk of contractual obligations.

Conclusion

Risk is going to proliferate in line with the increasing number of actors and actions sitting throughout the system. The current method of socialising and spreading risk across all the players eventually coming home to the consumer will be neither feasible nor desirable for the system of the future.

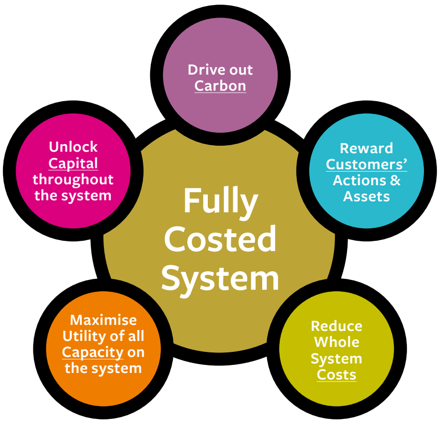
Before we get to a "wild west" with central and socialised services overwhelmed, it is now time to reallocate risk to where and with whom it lies.

The key to this will be how the regulator decides to change its role and functions to manage this significantly increased level of activity and players.

1 http://www.challenging-ideas.com/redesigning-regulation-powering-from-the-future/ p 19

UNLOCK INVESTMENT

FROM SUBSIDIES TO THE MARKET



Optimising the Five Cs of a Fully Costed System

AMBITION: Move more mature technologies into the market, removing current distortions and releasing government support for more immature technologies. Unlock £20bn by accelerating investment throughout the supply chain

Recommendations: From Subsidies to the Market

1. **Decouple the Low Carbon System from the Fossil Fuel Paradigm:** Recognise the differences between a commodity-based system and a capital-intensive system
2. **Bite the Bullet but Spread the Joy:** Significantly accelerate investment support, and broaden access to it for new assets throughout the supply chain, with a particular focus on customers' assets through miniaturising CfDs and the Capacity Market
3. **Support a Vibrant 'Market-First' Strategy:** Provide a very low powered floor price to the open market, and lead on building a robust, more transparent and liquid market
4. **Reform Contracts for Difference:** Put in place additional freedoms, while also placing new obligations; and in the medium term pivot the mechanism back to its original purpose – immature technologies
5. **Financial Sandbox:** BEIS should establish a financial 'sandbox', working with new investors with a different risk profile to existing investment and developing diverse routes to investment, reflecting the diverse set of assets required.

Funding the Decarbonised Energy System

Despite the great success of the current government funding regimes, policy time is almost uniquely spent examining these support regimes for generation, with much less time taking leadership in designing a robust, fair and transparent unsupported market.

The amount of investment needed to transform our energy system is significant and with other parts of the world aiming to decarbonise it will be a highly competitive environment to secure resources and capabilities to deliver Net Zero. The UK is one of the leading countries on the path to decarbonisation but the task of securing the investment cannot be underestimated.

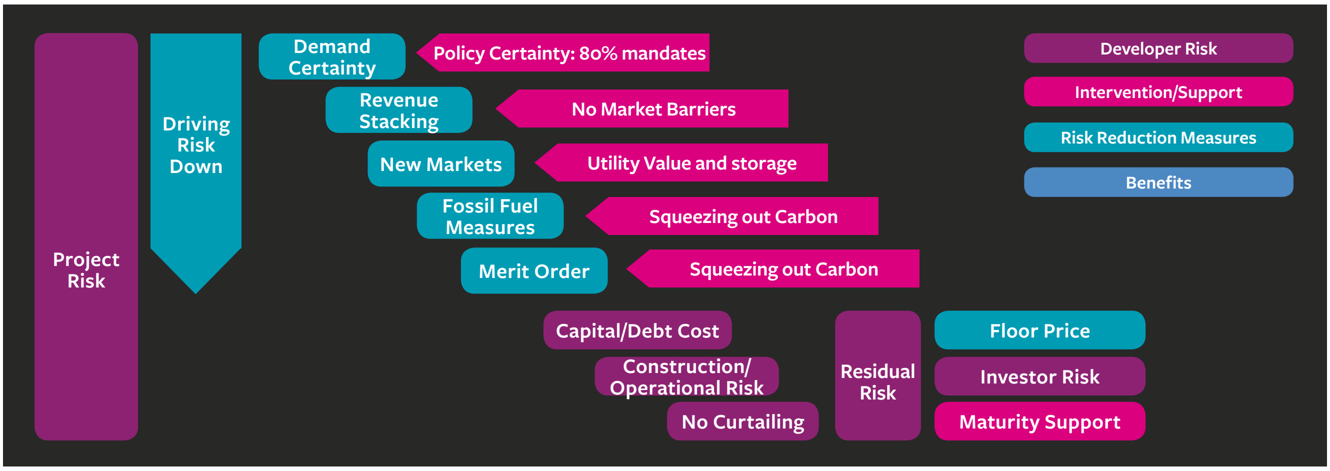
There will need to be a strong investment pull with clarity on the role of government, the market rules and the expectations of investors. The challenge is to develop an attractive investment environment, incorporate wider industrial objectives, while also being fair to the public purse. In addition, the nature of the assets required are more complex and with different characteristics, so a 'one size' support mechanism will not fit all.

We have tested the impact of some of our recommendations on the cost of risk with investors and while risk still exists, a combination of actions could and should reduce risk and therefore the cost of capital.

The five Ds

- **Destination Clear**
- **Decarbonised Always**
- **Double Investment**
- **Diversify Investment**
- **Demand Assets Crucial**

DeRisking the Capital through Policy Measures and Low Powered Floor Price



Recommendation 1: Decouple the Decarbonised System from the Fossil Fuel Paradigm

By squeezing renewables into a fossil fuel paradigm, we are trying to get the intermittent generation to behave as if it were a "ramp-it-up" asset and are costing every electron equally. Fundamentally we have to recognise that the new system has different characteristics and requires new investment models that a volatile commodity price can no longer effectively unlock.

Significant changes required include:

- **Focus on the Capital not the Commodity:** The pricing of energy against a volatile and a less relevant commodity price is inhibiting investment in the much wider set of assets required throughout the system. The feedstock is of marginal cost but the assets are capital intensive, and the processing, fixed assets and system management are an important and growing cost to the system.

- **Address the Fossil Fuel bias:** As indicated in From Fossil to Low Carbon there are many "hidden" market and support biases sitting at the heart of the system that need to be addressed
- **Unlock New Assets and Actions:** The current market is not unlocking the energy "processing" and storage assets that are capital intensive and have an increasing value across a fully costed energy system. While "processing" assets have been developed through the balancing and ancillary markets, the value becomes cannibalised quickly and long-term investment signals are weak. The volatile price of a commodity is never going to offer the investment case for the quantity of these assets required.
- **Support Consumer Assets:** There is very limited support or focus on ensuring greater access to behind-the-meter assets, crucial to the decarbonisation of transport and heat..

QUITE EASY
The review of all policies for fossil fuel bias is important and policy needs to develop different approaches to support to unlock storage and consumer assets. See From Supply to Demand

Recommendations: From Fossil to Low Carbon

1. **Clear Destination:** Mandate suppliers to deliver 80% decarbonised electricity by 2030, with different but clear trajectories for other energy sectors.
2. **Review all Policy and Regulatory Fossil Bias:** Government, Ofgem and other regulated bodies must urgently review all their actions to reduce any fossil fuel bias.
3. **Require Onerous Reporting of Fossil Choices:** Place bureaucratic burdens on all regulated actors who procure fossil fuels.
4. **Tighten up the Renewable Energy Guarantees of Origin Scheme:** Ensure that REGOs are linked and related to UK-based renewable technologies.

Recommendation 2: Bite the Bullet but Spread the Joy

Accelerate the Timeframe for Investment

The UK needs to be less squeamish about significantly increasing support for investment in decarbonising the energy system – and doing so quickly. We have all seen the wider economic and industrial benefits of driving hard on decarbonisation and the UK has an impressive track record it can build on.

The UK Government's Energy White Paper investment proposals are significant. However, the timescale is not fast enough as it will be spread over the next ten years. The investment proposed in the White Paper needs to be front-loaded, with the majority invested in the next five years to ensure that we stay within our carbon budget but also capture the significant innovation and industrial opportunities.

Accelerating investment and deployment requires a specific policy and institutional focus to deliver these projects. While it is welcome that there will be a cross-government working group to coordinate this, we believe that there needs to be a specific Delivery Agency established to drive this investment forward.

MODERATELY EASY
This will require accelerating investment which is challenging but the benefits significantly outweigh the challenges

Spread the Joy

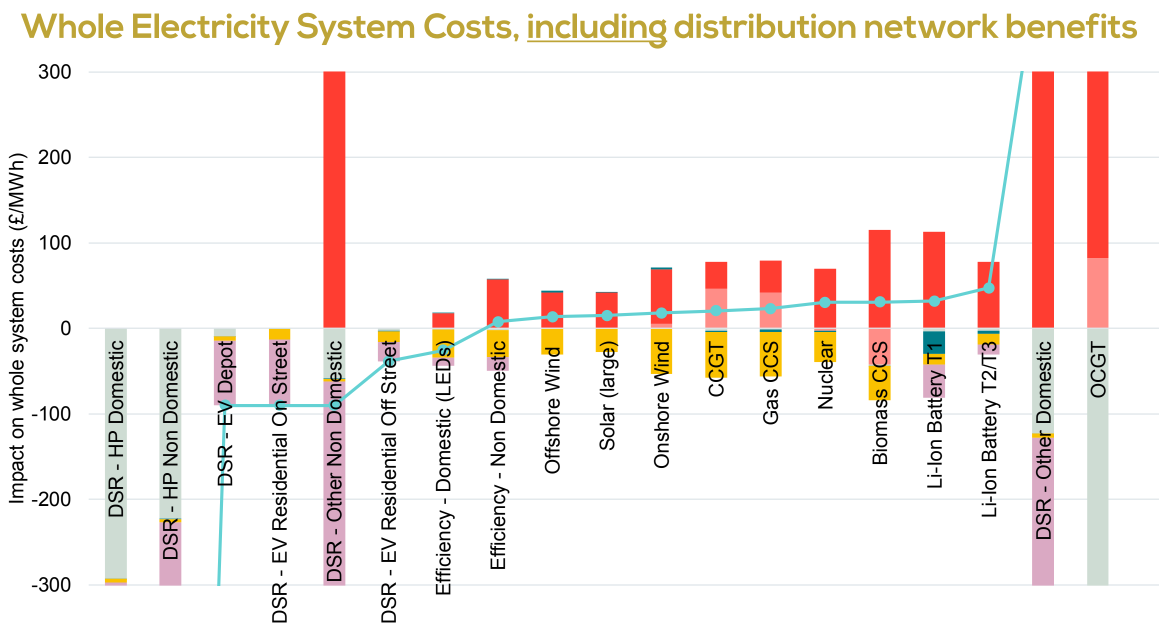
It is extremely welcome that the White Paper outlines the broadening of the technology portfolio, for long-term investment in storage, CCUS and hydrogen. However, disappointingly there is less focus on the distributed assets, not least behind-the-meter assets, that require support.

The new metrics developed for this project shows the significant value of demand side assets alongside generation assets.

The ReCosting Energy project has aimed to "spread the joy" of this value to consumers throughout its set of recommendations, and believes that consumer demand side assets must be given equal access to all support mechanisms commensurate with their value to the whole system cost.

Through services, the cost of these capital assets can be spread over a contract period and service providers can act as the counterparty to the support mechanism, driving down the overall cost of the product to the consumer and accelerating take-up.

Recosting Metrics



These example figures should not be interpreted as "generic" estimates of the whole system impact of a class of technologies. Whole system impacts are dependent on the wider electricity system and when technologies are assumed to be built.

Recommendation 3: Support a Vibrant "Market First" Strategy

Pathway to the Market
All actions in terms of policy and regulation should be driving more and more of the mature technologies towards the market and reducing their dependence on support. We should reserve the supported market to those technologies that have not yet grown to scale, proven their operational abilities, reached cost parity or built an optimised supply chain.

Increase Policy Focus
Policy and regulatory focus has in the main been focused on the Contracts for Difference and Capacity Market mechanisms rather than investing the time and leadership in supporting the market, reducing barriers and facilitating more investors to default to unsupported routes to invest.

Much greater focus is required to understand the barriers and develop the mechanisms that support the market, looking at and learning from other countries that have developed more vibrant markets, such as the USA and Germany.

Inherent Barriers to the Market
Historically there have been several biases that have encouraged investors to defer to the supported market and avoided the merchant or PPA options. It must be made a priority to facilitate greater market-driven investments. This will, however, need some de-risking and policy action, along with time for greater confidence to be built.

- **Fossil Fuel Bias:** As stated throughout this report there are several embedded fossil fuel biases that need to be addressed to significantly reduce the undercutting of the decarbonised market.
- **Complex Contractual Relationships:** While there are moves to rationalise and simplify PPA agreements, there is still a lot of work to do to simplify and commoditise the procurement of PPAs to create much greater liquidity and tradability.
- **Counterparty Risk:** Whether suppliers or corporates, purchasers have had their credit-worthiness significantly weakened by COVID-19. Even before COVID-19 there was reluctance to enter longer-term PPAs and the UK market was not as liquid as, for example, the German market. In addition, some of the ratings agencies regard PPAs as a credit risk, further disincentivising corporates from signing PPAs with long enough terms to to unlock investment.
- **Capacity Market and CfD Distortions:** While important mechanisms, these are having a negative impact on the unsupported market and undermining investor confidence.

FAIR ACCESS TO CONSUMER PRODUCTS

Focus on demand side support is crucial if we are not to increase inequality and drive greater whole system costs to those who cannot afford the capital costs of the new decarbonised assets.

While we recognise that there is a big requirement for large investment in generation assets, politically it is extremely important that the "Joy" is spread and that support mechanisms are designed around empowering and serving all consumers.

Consumers have a veto on Net Zero so their lives, their assets and their experiences must be enhanced and supported throughout this transition.

Strengthening the PPA/Merchant markets through a Low Power Floor Price
In this current market, with fragile suppliers and weakened corporate balance sheets, the PPA market is likely to suffer in the short term. While it would be desirable to have totally unsupported PPA/merchant markets, there is a need for a very limited de-risking action that government could take to address the current risks while supporting greater moves to the market away from subsidies.

While government should not underwrite revenues, it can play a role in de-risking the debt associated with the investment.

There is a very low powered floor price regime that Ofgem employs for those with Contracts for Difference. The 'Offtaker of Last Resort' mechanism has never been called upon and as a mechanism is almost "forgotten". However, a similar floor price, extended to the PPA and merchant market for a 10-year period, would build confidence in the unsubsidised market. The floor price would be designed around the cost of the capital – so not rewarding profits but as a backstop to reduce cost of debt.

This could be tapered, as this mechanism is unlikely to be used, but as a key interim de-risking mechanism would stimulate greater confidence in the unsupported market, delivering more competitive pricing and reducing the market distortions currently impacting the merchant market from the wide spread use of Contracts for Difference.

Building a stronger unsupported market for wind and solar will also release more government funds and support for those less mature technologies that are so important for delivering Net Zero.

MODERATELY EASY
The mechanism exists for Contracts for Difference but needs to be extended to the PPA /merchant markets

A generation floor price would attract "investor confidence, dispatch efficiency, capacity adequacy and optimal investment. It also would reduce the impact on consumers reducing their exposure to excessively high prices."[1]

Recommendation 4: Review Contracts for Difference

There is a need for short-term reform to the Contracts for Difference regime followed by a more fundamental pivot away from mature technologies such as wind and solar, to return to its original purpose – to unlock cost efficiencies in emerging not established technologies. Currently it is having a deleterious impact on the market and is unsustainable in the long term in its current form.

Some of the Challenges of the CfD Mechanism

Many of the challenges we face are borne out of the success of the current funding model for large scale low carbon generating assets. The key misalignment is that we are trying to squeeze a capital-intensive investment into a commodity market.

- **The Wrong Difference:** The price of fossil fuels is no longer an appropriate or relevant reference point and does not reflect the whole system costs
- **Distorting the Market:** The CfD regime has a price impact on the viability of the merchant and PPA market
- **Treating all Electrons Equally:** There is no distinction between an electron of utility and one wasted
- **Rewarding Waste:** Paying for wasted energy is not incentivising the blending of generating assets with storage or identifying new utility
- **End of the Subsidy Cliff:** There are limited incentives to continue generating post CfD period, thereby wasting the capital investment

Short-term Reforms
There are tangible measures that can be introduced quickly that would drive better value for money and greater capital "sweating" while also putting in place some important restrictions and obligations to reduce waste.

- **Market Certainty and Carbon Reforms Reducing Risk:** With the "deck" squeezing fossil fuels out of the system, risk will be reduced and should be reflected in the strike price.

- **Sweat the Capital already Invested:** All decarbonised assets should be able to access all energy markets with no false barriers to delivering services across these markets. This would unlock investment cases, lower risk and offer new revenues to investors. The current false "competitive" silos do not deliver best value to consumers and do not reflect the imperative to get more from less across the system. This should start with giving access for those with CfDs to the Capacity Market.
- **Mandate Storage:** Mandating procured or co-located storage for generation projects over 500MW would mean a small increase to the strike price but would bring down whole system costs.
- **Connection and Planning Reforms:** The Energy White Paper in December 2020[2] heralded changes to the planning and connection regimes that would further de-risk capital and also bring projects to fruition more quickly. It stated: "We will also work to reduce consenting delays and ensure that planning guidelines and environmental regulations are fit for purpose."
- **No More Waste:** Progressively reducing access to constraint payments will drive developers to identify markets for excess generation and invest in storage, hydrogen production and other technologies. This will also reduce the prevalence of negative prices, which will further support the investment case (see box).
- **Obligation to Continue Production:** Capital de-risked by citizens cannot be wasted once the supported period is finished so there should be an obligation for continued operation which can be underpinned by the market floor price as described above.
- **Whole System Cost and Value:** CfDs need to adopt a much stronger focus on whole system costs, of which there is limited analysis under the current contractual arrangement. This will become more and more essential as we move forward and should be included in the proposed National Audit Office audit of whole system costs. See From Silos to Whole System
- **Citizens' Dividend:** For those projects that are supported by customers through the government, there must be an explicit Citizens' Dividend, representing a sharing factor related to the amount of support provided

CONFLATE CFDS WITH THE CAPACITY MARKET
A new contractual structure would provide both security of supply and low carbon generation.

As it would be a single asset providing both these two roles and benefits, there would be no need to provide payments to two different generators, resulting in an avoided investment.

MODERATELY EASY
Most of these measures are changes to contractual agreements

Medium-term Reforms: Focus on Immature Technologies

Funds allocated to the CfD mechanism going forward need to be scaled up quickly but focused on the less mature technologies such as hydrogen, CCUS long-term storage and demand side assets, driving the same significant changes in cost that we have seen in offshore wind to these new areas of investment.

No new 'One-Size-Fits-All' Products and Assets: A Different Difference

The success of the CfDs for offshore wind provides us with a clear pathway on which to take the additional and new immature technologies that are essential for decarbonisation.

However, investment in these new products and assets can be unlocked through the "difference" between a fossil fuel market and the new asset. In addition, they are not all assets that respond to a 'just in time' commodity price.

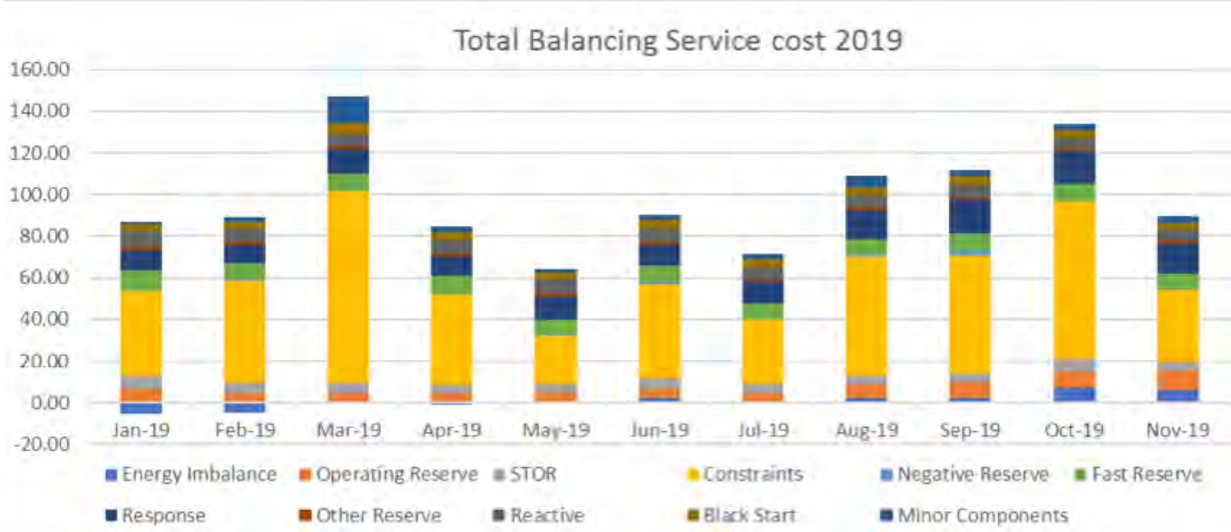
By employing the whole system costings, the value of these new assets can be judged on the difference in whole system costs between, for example, having storage on the system and not having it on the system. When examining the new metrics there is also an "avoided cost of energy" that currently has no mechanism by which to be rewarded. CfDs could be developed to assist with unlocking these assets by providing long-term contracts to make investments in these highly valuable assets.

The whole system cost differential between having these assets on the system or not could provide a reference price for a long-term fixed contract.

MODERATELY EASY
The concept of a Contract for Difference should be tested measuring the whole system cost differential

Stop rewarding waste

The UK faces unprecedented costs related to curtailment. The cost of National Grid ESO dealing with constraints ranged from £23million to £94million per month between January and December 2019, totaling over £625million for that year. To put this constraint cost into perspective, ahead of the Clean Growth Strategy UK government announced up to £557 million to be allocated for Pot 2 CfD auctions[1]. The actions needed during COVID-19 to support curtailment when released will further show the realities of the new system going forward.



Furthermore, analysis by LCP[1] forecasts that in 2026 National Grid will be fronting £1billion on resolving the Scottish export constraints alone (Figure 1). This cost does not include the associated carbon of turning up gas plants south of the constrained border, which LCP estimates at 3 million tonnes per annum up to the forecasted completion of network reinforcements in 2029.

This wasted zero-carbon generation is not acceptable under Net Zero and reflects a system that is not optimised.

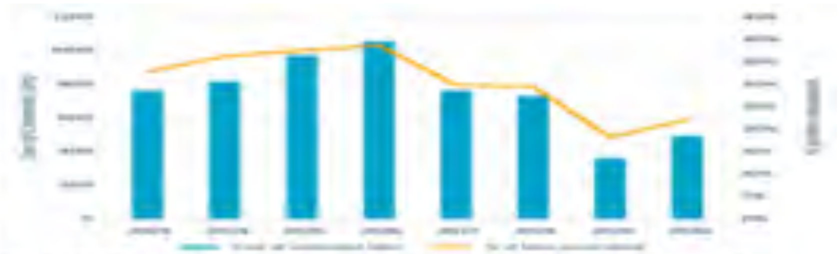


Figure 1: LCP forecast of thermal export constraint cost on the B6 (Scotland/England) boundary and the percentage of each year in which constraints occur along this boundary

Developers with intermittent generation should be incentivised through redeploying their curtailment liabilities to invest in all forms of storage, electrolysis or through their active incentivisation of off peak consumption. This very much promotes the need to have a value for “blended” assets and new business models that reduce wasted energy.

Miniaturising Support for Distributed and Behind-the-Meter Investments

While government needs to ensure investment in large big-ticket decarbonised assets, there is also a need for significant investment in a much wider set of smaller assets both at the local level and behind the meter. Small-scale generation (under 5MW) represented 14% of the UK's total renewable capacity in 2019, comprised of over 1.01 million installations[3], highlighting their importance for achieving Net Zero.

Contracts for Difference can be designed to unlock these important distributed and customer facing assets. This is particularly important for our journey to decarbonize heat and transport. It is crucial that we find mechanisms by which we can de-risk the upfront capital costs.

Some of this investment can be driven by customers. However, to achieve the scale and allow for fair and equitable access to these benefits, routes to supporting deployment need to be facilitated.

From conversations with investors there is growing appetite from large infrastructure investors to look at distributed assets through aggregators and with CfD underpinning, this could signficantly accelerate the deployment of heat pumps, PV and batteries.

MODERATELY EASY
Miniaturised Contracts for Difference should be developed and tested with investors

INFRASTRUCTURE INVESTMENT IN SMART METERS
Infrastructure investors have financed the deployment of smart meters showing that "distributed assets" with clear revenue projections can be appealing to big capital if an appropriate regime is established

Recommendation 5: Financial Sandbox: Attracting new Investors

There is a problem at the heart of funding our decarbonisation and that is the nature of the investors that are currently dominant in the sector. There is a risk aversion and also an opportunity deficit, with investors looking for risk to sit with the government who is the proxy for the consumer.

BEIS should establish a Financial Sandbox that allows for new models for investment to be trialed and developed, opening up the system to greater risk capital that might nevertheless actually deliver greater full systems benefits and price reductions.

In the medium term we must make sure that we don't exclude new types of investment with multiple revenue streams rather than the vanilla investors that the sector currently attracts.

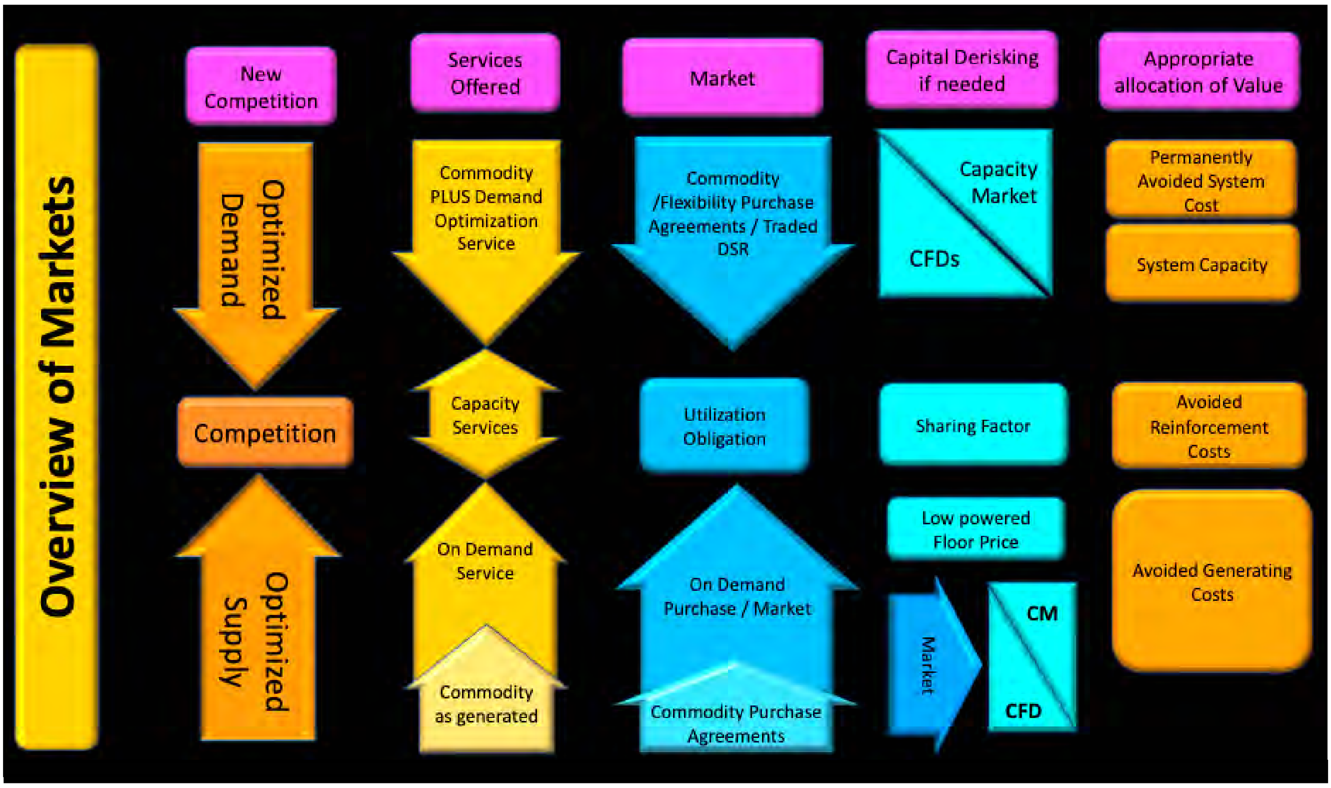
Conclusion

In a system that is capital intensive with a reducing commodity value, we need to focus support on de-risking the capital and less on underpinning the commodity revenues.

A combination of policy certainties, less competition from fossil fuels and the service agreements proposed in this report, plus a low floor price, will make the market options for mature technologies look much more attractive.

However, we do need a lot of investment. We need over time to pivot the majority of government support to the immature technologies such as large CCUS, hydrogen and tidal power projects but also make all mechanisms accessible to investors interested in distributed and behind-the-meter assets.

Cumulatively, these recommendations would restack the deck towards the different nature and characteristics of the renewable energy sector. The whole system costs of these measures would be reduced, and capital would be sweated effectively by dismantling the market "silos" preventing existing assets from performing more than one action. As these measures were tested over time, investor comfort and increased revenue certainty would have an increased downward pressure on risk and cost.



1 Cornwall Insights "The net zero paradox: Challenges of designing markets to bring forward low marginal cost resources" See report at https://www.cornwall-insight.com// uploads Download from https://bit.ly/35iD3jV
2 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/945899/201216_BEIS_EWP_Command_Paper_Accessible.pdf
3 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/875410/Renewables_Q4_2019.pdf

CONCLUSION

ReCosting Energy has aimed to question the changing nature of the cost, value and price of our new decarbonised energy system. This is a very big subject and we do not have all the answers. However, we have developed some key principles that need to guide policies, regulation and practices, and made specific recommendations that can assist with unlocking the value in the new system.

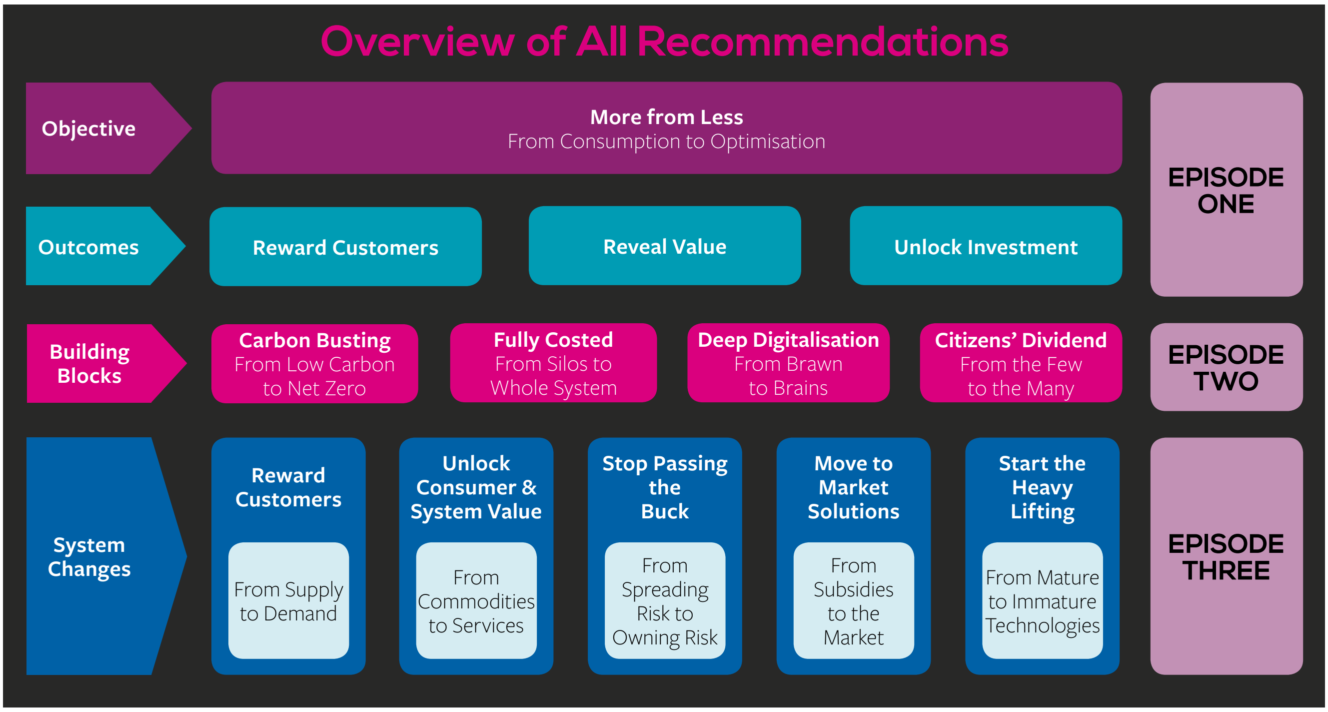
The changes that we need to respond to
The energy system will move from 400 key players to over 50 million actions and assets, all interacting with each other, creating a dynamic, diverse, distributed system that will require a very different approach to market design, regulatory practice and consumer experiences.

The Future Realities

The Decarbonisation Dividend

We have aimed to shape our recommendations to unlock the decarbonisation dividend that we believe sits at the heart of our new system and will also spread the joy to customers.

Dividend	Barriers	Challenge	Recommendations
Drive out Carbon			
A Modern, Climate-Safe Energy System Low carbon solutions quickly squeezing out fossil fuels throughout the system	**Fossil Fuel Bias** There are still far too many cases of fossil fuels taking priority and discriminating against low carbon options	**Restack the Deck** What measures are needed to give priority to low carbon and drive out the inbuilt "bias" towards fossil fuels	**Carbon Busting** Clarity of direction, changed incentives, and significantly increased barriers to defaulting to fossil fuels
Reward Customers			
Crucial Value for Customers Customers and their actions will become a growing and ultimately a critical part of the energy system with so much more value flowing in their direction	**Designed around Supply of Energy, not Demand** The customer is still the victim and has limited access to the assets and actions that enable value to flow in their direction	**Access to Assets and New Services** How to release the capital all customers need to access and benefit from decarbonisation assets	**Demand is Equal to Supply** In a fully costed system, customer demand is of equal value to supply and can be unlocked through new market design and new asset-based services
Whole System Cost			
Reduce Costs All actions and policies to account for and reduce whole system costs and allow for value to flow across the silos of today	**Silos Capturing Value** Policy and regulation consider and cost the system in silos and do not "trust" the power of demand actions	**Squeezing Value from the System** Complexity of fully costing the system and assessing the impacts of one actor on another	**Accountable for Full System Costs** All policy, regulation and markets need to account for full system costs with a value to avoided costs to the system and consumer
Maximise Capacity			
Doing More With Less Optimise the capacity on the system increasing the productivity of assets and focus as much on the processing of energy as its production	**More is More & Siloed Actions** The system is designed around rewarding the quantity of a commodity not the value of services or functions provided	**Changing to More with Less** Moving from a consumption to an optimisation model reflecting the new assets and actions required to turn the commodity into a utility	**From Commodities to Service** Incentivising outcomes not inputs through valuing services not the commodities and driving risk into businesses not sitting with consumers
Unlock & Sweat Capital			
Accelerate Investment & Maximise its Utility Efficiently use all assets on the system, unlocking significant investment and reducing waste	**Artificial Silos** Silos preclude revenue stacking, while rewarding wasted energy and not unlocking investment in serious system gaps	**Capital not Commodities** How to unlock capital in a most efficient manner delivering the appropriate assets designed around the system needs	**Deepen Support & Build the Market** Focus support on immature technologies while underpinning the open market



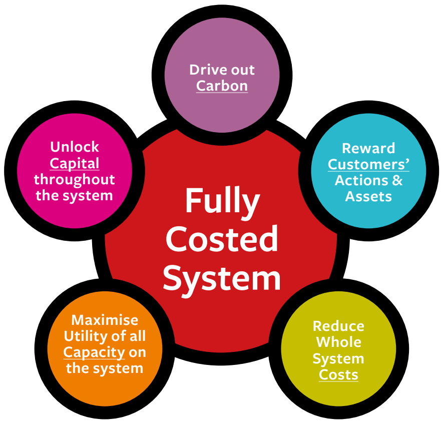
How to Unlock the Decarbonisation Dividend

Optimisation not Consumption

As the heart of our work is that we need to decouple the decarbonised system from that of fossil fuels due to their different functionality, character and system needs. Net Zero itself demands a very different set of objectives – one of optimisation not consumption. So, our overall framing is one of optimising carbon, customers, costs, capacity and capital moving from a linear consumption model that rewards quantity of energy consumed to one of whole system optimisation.

Carbon Busting

There are far too many hidden and quite large pockets of fossil fuel bias sitting throughout the current system that needs to be addressed and we highlight some of these areas for focus. But ongoing identification and correction of where the old design is benefitting fossil fuels needs to be addressed. In addition, government can make the timeframe for the destination clearer to help reduce cost of capital and unlock greater investment throughout the system.



The Five Cs of a Fully Costed Energy System

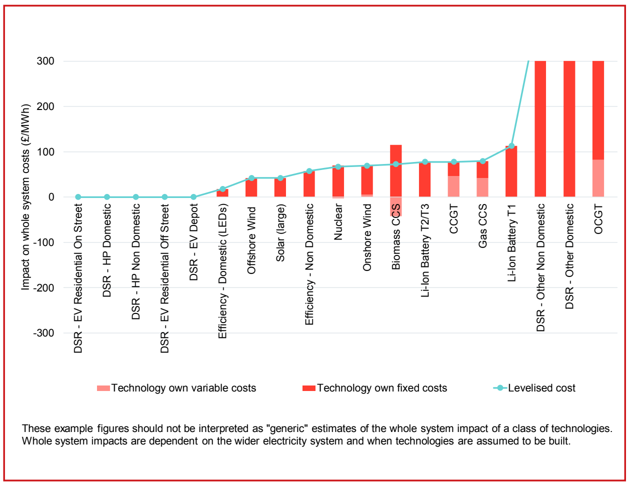
Whole System Costings

This principle of whole system costings needs to be matched with different practices throughout the system – optimisation against a fully costed system, rejecting the silos costings, regulation and policy making, with the aim of driving out carbon and cost across the supply chain. There are many hidden pockets of cost and carbon!

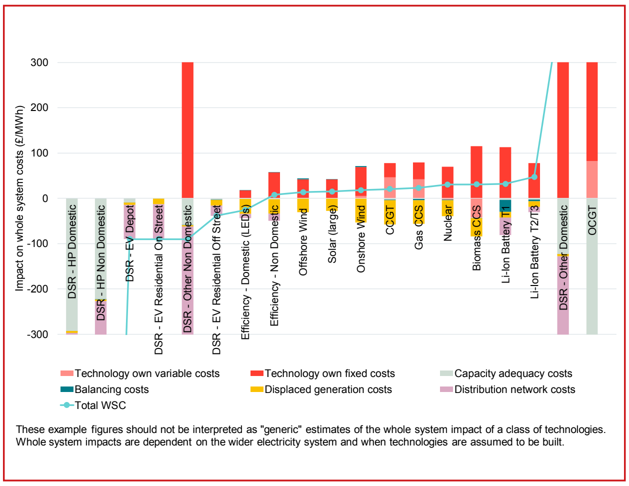
To fully understand what whole system costing means in a fully optimised system, we commissioned some new metrics that have informed our wider set of policy recommendations. We believe that this new work is a first of its kind, as it takes the whole system – from behind the meter through to the North Sea – and compares the whole system costs of each asset.

These metrics also reveal an increasingly important "value" within the energy system – that of "avoided cost" – that should be utilised much more widely throughout system planning and is at the heart of optimisation.

LEVELISED COST OF ELECTRICITY



NEW METRICS: WHOLE SYSTEM COSTS



Revealing different outcomes for all forms of demand & flexibility and generation assets
Showing LCOE is not able to reflect the overall value or cost to the system
This value is calculated on an additional MW put on the system

Modelling conducted by the BEIS DDM team, LCP, and analysis delivered by Frontier Economics

Source: @Challenging Ideas: ReCosting Energy

Demand is Equal to Supply

A new competitive tension between demand and supply requires that demand is regarded as equal to supply in terms of value. We recommend therefore that demand assets and actions are given equal access to markets, support mechanisms and regulatory frameworks. The value of demand assets and actions to the system is shown through our new metrics. The Capacity Market, Contracts for Difference and all ESO markets should be designed to allow for demand-side assets to access them.

THE VALUE OF AN EV VAN TO THE SYSTEM

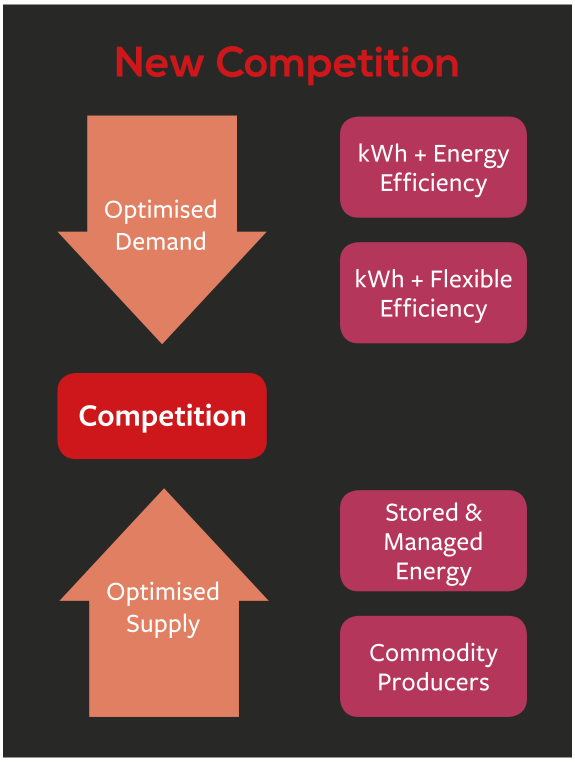
An electric van could deliver up to £500 per year value to the system through displaced generation costs, capacity adequacy value, balancing opportunities and reduced distribution network reinforcement costs

New Competition unlocking the Value

Our metrics and the optimisation model reveal the need for a new competitive framework – where demand competes with supply. This is the only way that true value can be released from the system and that the Five Cs can be optimised. This is, in our view, very exciting as it opens up much greater supply chain pressure between the old-fashioned silos.

More importantly, it changes the value that we all need to place on optimising demand through customer-facing decarbonised products and services, giving agency to customers and power within the sector for the first time.

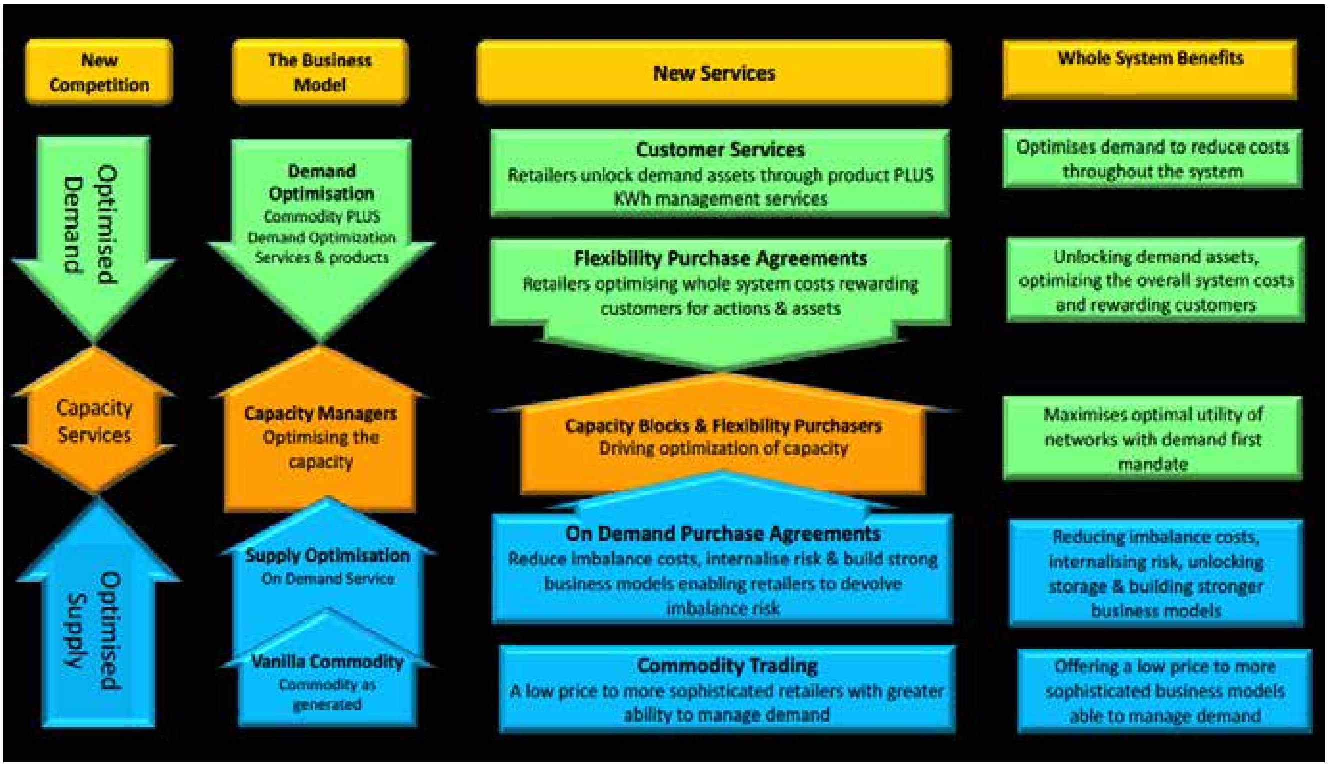
This new competition will have a downward impact on the cost of the system, creating real supply chain pressure and will result in more robust business models and significant innovation as value and rewards can be achieved through being "clever" rather than by delivering more commodity.



The New Service Economy

Fair and equitable access to the assets, actions and system management tools needed throughout the system will never be achieved off the back of a "commodity priced" system. Actually, all the incentives in the current system promote greater rather than optimal use of energy.

As in so many other markets, commodities are being replaced by service business models and in energy only services will unlock the decarbonised assets required by customers. Services should also be developed throughout the supply chain, optimising supply through adding value with storage and energy on demand service provision. The wider societal value of a service-based system is that the companies' incentives all reside in doing more with less – a key component of the Five Cs optimisation principle.

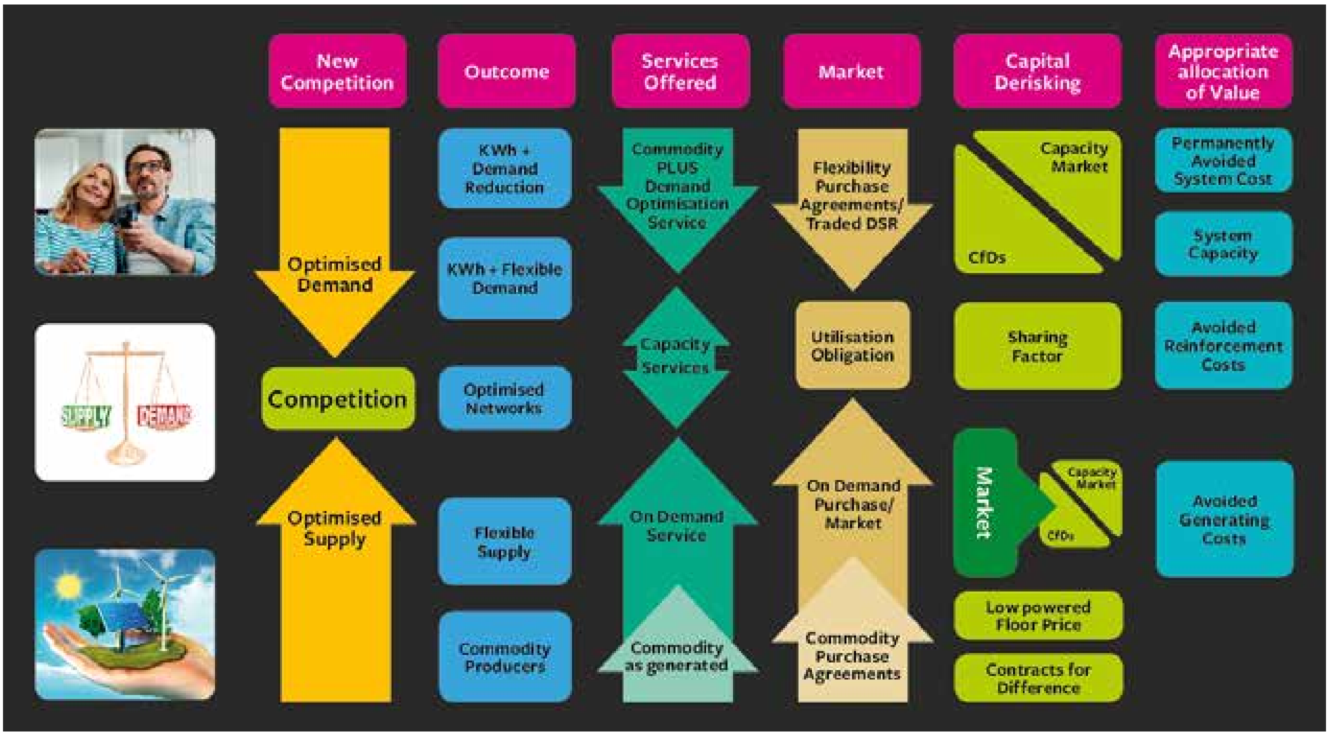


Move from Subsidies to the Market
While the report has been very focused on the new role for demand assets, that is not to say that significant increase in new generation assets are not required. However, we are relying on the Contracts for Difference mechanism far too much for more mature segments of the renewable energy market and need to encourage these assets to find the surety through the market not through support mechanisms. As an interim intervention we propose that the government institutes a very low powered floor price for the open market, driving more investors away from CfDs. The level of this aims to de-risk capital, not revenue support, and will be unlikely to be called upon but nevertheless gives confidence to the debt markets.

Diversify Support Mechanisms back to the Heavy Lifting
Contracts for Difference need some reforms but should pivot back to their original objective – to focus on the heavy lifting to support those technologies that have not yet reached parity. And yes, include demand-side assets throughout the system!

How the market could all fit together

Based on the report's recommendations we have developed an overarching market design that, by optimising the system against whole system costs, integrates the new services, has demand and supply competing and captures the value of an avoided cost of energy.



The Roles and Responsibilities
Our recommendations have different implications for each of the segments of the energy sector and for policy and regulation.

Optimising the System

Optimised Demand → Competition ← Optimised Supply

Department for Business, Energy & Industrial Strategy

ofgem

Design around customers	Reward customers' actions and assets equally	Unlock equitable access to customers' assets and actions	
Responsible for their customers' needs	Buy & Sell flexibility and demand services	Deliver product based services & commodities	
Demand first	Regulate to drive more from less	Provide local and transparent markets	
Anticipate & manage down security and stability risks	Responsible for whole system costs	Open up to all demand & flexibility opportunities	
Rewards for on demand energy not just commodities	Move towards market solutions	Increase & move support to immature technologies	

- Clear Destination
- Carbon Busting
- Whole Systems Costings
- Optimisation Regulation
- Deep Digitisation
- Citizens' Dividend

Our Ambition for ReCosting Energy

We recognise that there are many changes proposed in this report. However, while some will be contested, dismissed or encouraged, the purpose of this report has been to change the mindsets of those shaping the energy sector and start to land some key principles that we hope will help deliver the Decarbonisation Dividend. But if we could ask for 3 key changes as priorities these would be:

- **Optimisation not Consumption:** Shape all policy and regulation around an optimisation not a consumption model, fully costing the whole system
- **Demand becomes equal to Supply:** Recognise that demand-side assets and actions are of equal value to generation assets and should attract similar support and policy focus
- **Services not Commodities:** Open up of the license regimes to promote much greater prevalence of service-based business models away from commodities.

We look forward to your input, views and challenges to what has been a very complex but thought-provoking project!

Thank you to

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