Net Zero Electricity Market Design Expert Group report

Report for the Climate Change Committee

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Contents

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Executive summary

There is a building consensus that market reforms will be needed in order to operate a cost efficient, reliable and low carbon electricity system to support the UK's Net Zero ambitions. As such, the Government announced as part of the British Energy Security Strategy in April 2022, its intention to consult on a Review of Electricity Market Arrangements (REMA), with the consultation published on 18th July 2022.

In anticipation of this consultation the Climate Change Committee (CCC) convened an Expert Group, of leading academics and industry players, to provide Government with advice on the scope and scale of market reform that may be needed to achieve a decarbonised electricity system by 2035.

The Expert Group met on three occasions, prior to the publication of the REMA consultation, between April and June 2022, discussing the context, key challenges, and how different market design options being proposed could address these challenges, leading to a number of recommendations and conclusions set out in this short report.

The Expert Group welcomes REMA, which it believes is very timely. Any major market redesign will need to consider the impact on ongoing investment in the sector (which we cannot afford to slow). The Expert Group believes that the current affordability challenge strengthens the case for decarbonisation (and REMA), but recognises further interventions may be needed in the near term to protect customers from very high prices.

The Expert Group felt that the biggest challenge in the 2020s will be mobilising the huge investment needed in low carbon generation, storage and networks; whereas in the 2030s the biggest challenges will be the efficient operation of the low/zero carbon electricity system (with a much more dynamic demand side).

The Group identified the following priority areas for REMA against the key challenges identified:

- **Incentivising low carbon investment:** Contracts for Difference should be retained but evolved to reduce dispatch distortions.
- **Security of supply:** Changes to the Capacity Market will be needed to address the energy duration challenge not just peak capacity adequacy, and to phase out non low carbon solutions.
- **Operating a low carbon electricity system:** The energy mismatch (extended shortfalls in some periods, excess supply in others) needs to be addressed, with more accurate market signals for curtailment.
- **Locational signals:** There is a case for stronger locational signals in the wholesale market to improve dispatch efficiency, and potentially to strengthen investment signals.
- **Whole system coordination:** Changes in the wholesale market must take into account potential changes in governance arrangements for the distribution system, and emergence of markets at the distribution level.

- **Customers and affordability:** Market design needs to unlock flexibility from small scale assets through effective customer engagement. Any market reform should aim to improve affordability through efficient signals, maximising competition and promoting transparency.

The Group favours an evolutionary approach, where possible in the 2020s, with any more fundamental reforms such as full locational marginal pricing and centralised dispatch considered for the 2030s.

That said, there is a strong case for better locational signalling in the near term, which could be addressed through zonal pricing in the existing wholesale market, and/or changes to network access and charging. The Capacity Market would need to be changed to reflect the pricing zones in any more locational wholesale market.

The appropriate level of locational granularity needs to weigh up the benefits, against the degree of market disruption and whether other mechanisms can achieve similar outcomes, particularly in investment timeframes. An earlier move to full nodal pricing (with centralised dispatch) cannot be ruled out, but in the opinion of the Expert Group, the case is yet to be made.

Evolution of CfD design should address dispatch distortions, and unintended consequences (such as the option to delay the start of the contract). The increasing volume of generation operating under CfDs should increasingly protect customers from the effects of high and volatile gas prices. Hence, the Group was not yet convinced for the need for separate markets for intermittent renewables (as-available) and dispatchable generation (on-demand).

Government will need to be certain that there are not other solutions that can achieve (close to) the same outcomes at lower cost and risk to consumers. Given the increasingly interconnected nature of an already complex energy system, it will be important to have coherent policies from a whole system perspective, and be clear on roles and responsibilities of different parties needed to deliver the reforms.

1 Background and purpose

As part of its policy to deliver Net Zero by 2050, the Government has committed to decarbonising UK electricity generation by 2035. The Climate Change Committee's (CCC) Balanced Pathway scenario, which would achieve that goal, suggests it is likely to require:

- An expansion of renewables, to around 70% of generation
- New schedulable sources of low-carbon generation (e.g. gas with carbon capture and storage (CCS), hydrogen)
- A more flexible electricity system

Decarbonising the power sector by 2035 will bring challenges which current market arrangements and policy are not designed for, including:

- Changing cost structures, towards high capital and low marginal cost assets
- The need to reward system flexibility, through both supply and demand sides
- The need to phase-out unabated gas, subject to security of supply

As part of its British Energy Security Strategy published in April 2022, and in recognition of the potential challenges, the Government announced its intention to launch a Review of Electricity Market Arrangements (REMA), and it published its first consultation on 18th July 2022 setting out the case for change, and an initial assessment of the options.

In its advisory role to Government, the CCC convened a high-level Market Reform Expert Group to feed into the REMA consultation.

The purpose of this Expert Group is to:

- Develop a consensus around the key question(s) and challenges market reform should be aiming to address
- Consider and, if possible, prioritise the range of options suitable for addressing those questions and challenges
- Propose recommendations for Government to take forward in their work on market design

The following areas were considered in scope for the Expert Group review:

- Wholesale market arrangements (and relevant links to retail markets)
- Capacity Market
- Climate policy instruments
- Locational decisions

Areas out of scope included:

- Retail markets

- Methodologies and charges for transmission and balancing
- Ancillary services, including inertia and frequency provision

The Expert Group members were:

- ***Chair***: Duncan Sinclair, Baringa Partners
- Will Blyth, Oxford Energy Associates
- Kisha Couchman/Adam Berman, Energy UK
- Rob Gross, UCL/UKERC
- Gauri Kasbekar-Shah, Edmond de Rothschild Asset Management
- Andy Manning, Citizens' Advice
- Dan Monzani, Aurora Energy Research
- David Newbery, EPRG/Cambridge University
- Rebecca Williams, Global Wind Energy Council
- ***Observer***: Apu Shah, BEIS
- ***Observer***: Eleanor Wood, Ofgem

The Expert Group met on three occasions:

- **26th April 2022**: Background and context, the exam question for market reform, key challenges
- **9th June 2022**: Options for market reform and criteria for assessing
- **23rd June 2022**: Preliminary conclusions and recommendations

This short report by the Chair summarises the key findings of the Expert Group. It is structured as follows:

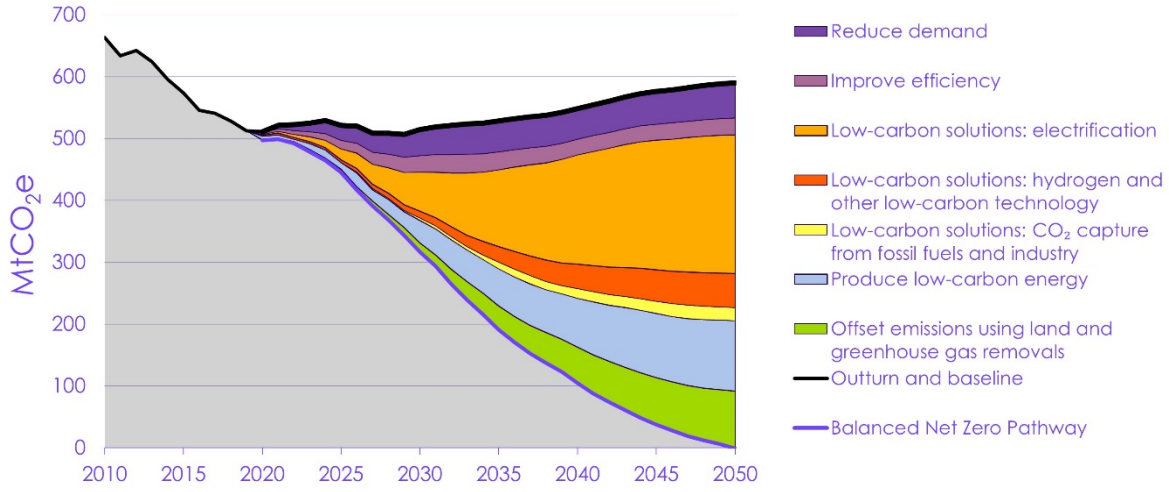
- In Section 2, we recap the objectives for decarbonising the power sector
- In Section 3, we summarise the key challenges (and opportunities) facing the sector and identify priority areas for market reform
- In Section 4, we introduce some of the policy options being proposed for market reform and assess how well they could address the challenges, and identify potential gaps in current thinking
- Finally in Section 5, we summarise the conclusions of the Expert Group, and provide recommendations to Government for REMA

It should be noted that the work of the Expert Group pre-dated the publication of the REMA consultation. The views expressed in the report are those of the Expert Group and not the CCC.

2 Objectives for decarbonising electricity

Total UK carbon dioxide emissions have been falling steadily over the past two decades through the combination of more renewables, the removal of coal-fired generation and greater energy efficiency. To achieve Net Zero by 2050 will require emissions to continue falling at similar rates, but this will become progressively more difficult given the harder to decarbonise sectors such as transport, heating and industrial processes, as illustrated in Figure 1 below. Electrification is the largest single route to reducing emissions across the economy, and the Government have committed to fully decarbonising emissions from electricity by 2035 (subject to security of supply).

Figure 1 Pathway to Net Zero emissions

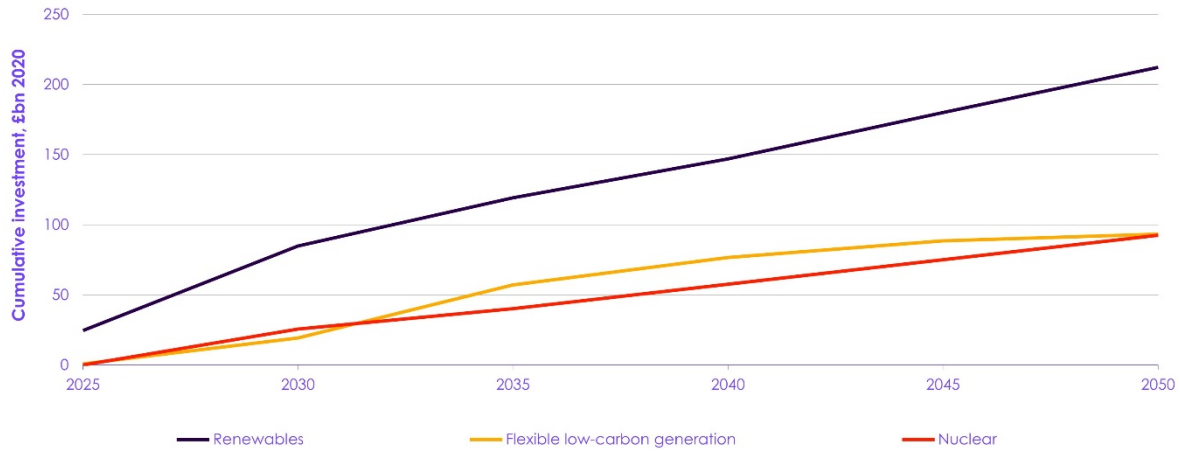


Source: CCC (2020) The Sixth Carbon Budget

There are a number of different pathways for achieving Net Zero by 2050, but the scale of investment required under any pathway is likely to be huge. Figure 2 shows the CCC's analysis of cumulative investment required in low carbon generation to 2050 based on the Government's Energy Security Strategy – over £200bn in renewables and nearly £100bn in each of nuclear and dispatchable low carbon generation. This does not include the investment required in electricity networks, estimated to be in the region of £147bn[1].

[1] Source: Utility Week: Catch 2050: the power system investment challenge in the race for net zero

Figure 2 Cumulative investment required



Source: CCC analysis based on Energy Security Strategy

The Net Zero electricity system is likely to look very different to the current system, as summarised in Table 1 below.

Table 1 Comparison of Net Zero and current electricity system

	Current system	Net Zero system
Demand	300 TWh	Up to 1,000 TWh in 2050
Emissions	200 gCO_2/kWh	1-2 gCO_2/kWh (excluding removals)
System	Meet demand by flexing supply	Flexible supply and demand
Role of demand side	Passive	Flexible, including for hydrogen production
Cost structure	Mainly marginal	Mainly capital

Decarbonising the power sector by 2035 will bring new challenges, including the need to:

- **Deploy high levels of non-dispatchable generation,** which will be increasingly likely to lead to periods where these are the marginal generator and to periods of surplus generation.
  - With zero marginal costs this means increasing periods with low or negative electricity prices, and generators' cost recovery may therefore need to be concentrated into fewer hours.

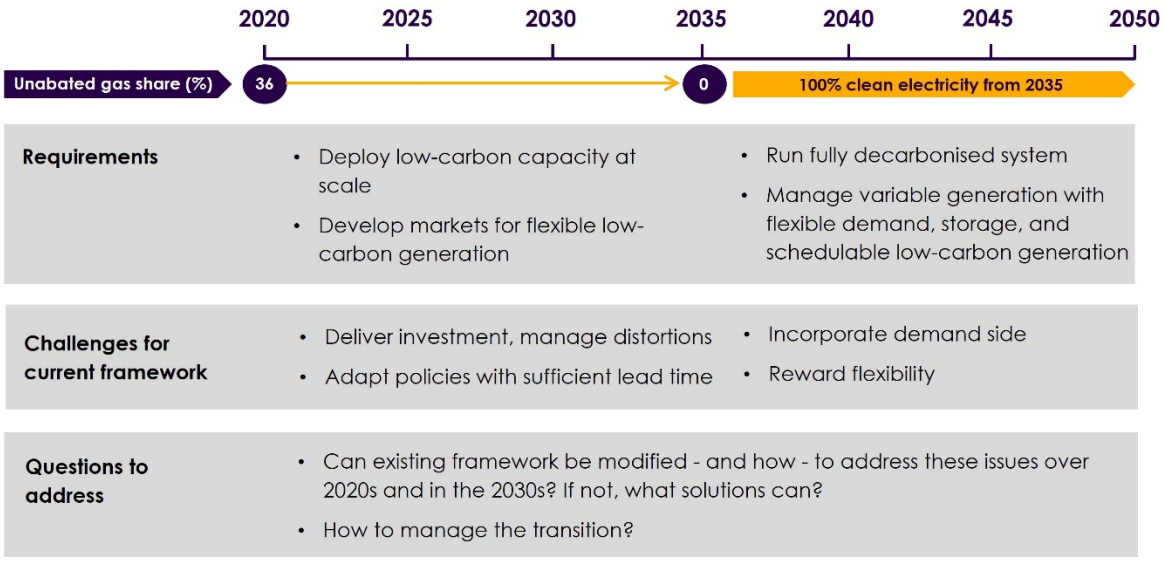
- These bring a range of risks, including:
  - For investment in low-carbon capacity, and new versus re-powered renewables, depending on access to contracts
  - More scarcity-driven price spikes
  - Increasing use of system charges
  - Inefficiently located generation

- **Reward system flexibility,** which will be critical for integrating high levels of variable renewable generation. That flexibility could come from low-carbon generation (e.g. gas CCS, hydrogen) or from other sources including demand, hydrogen production with surplus generation, storage, and interconnection.
- **Phase-out unabated gas by 2035,** which means developing the market for the alternative sources of low-carbon schedulable generation, providing incentives to ensure they are dispatched ahead of unabated gas, and preventing lock-in of unabated gas technology.
- **Deliver at pace under uncertainty**, including:
  - Co-ordinating generation and network build-out
  - Attracting sufficient capital from a range of sources
  - Building supply chains

We explore some of the challenges identified by the Expert Group in further detail in the next section.

In Figure 3 below, we summarise the requirements to achieve a decarbonised electricity system by 2035, and operate it thereafter, some of the challenges and the questions that REMA will need to address.

Figure 3 Timeframe to Net Zero



3 Challenges for electricity markets

3.1 Introduction

The scale of the challenge to decarbonise the electricity system by 2035 is well documented – how to finance and deliver vast amounts of new infrastructure, whilst maintaining reliable supplies and keeping electricity affordable for customers. There are also huge opportunities for building a green economy, levelling up and engaging communities in local energy schemes.

This section is not intended to be an exhaustive review of all of the challenges (and opportunities), but highlights a number of specific topics raised by the Expert Group which they believe are particularly important, and perhaps under-represented in some of the more theoretical debates about market design.

3.2 Summary of key challenges

The view of the Expert Group is that there is a tendency to focus on solutions for market reform before necessarily being clear on what the problem is that it is designed to address. Hence, the Group started by identifying the main challenges, before assessing how fit for purpose current market arrangements are, whether each challenge was being addressed or could be addressed through other reforms, and therefore what should be the priority areas of focus for REMA.

The Group considered the objectives and changes that will be required as described in Section 2, and concluded that the following key challenges would need to be addressed under any reforms:

- **Incentivising low carbon investment:** Ensuring certain, predictable and timely signals for investors, that bring forward the range of technologies required and appropriately allocate risks.
- **Security of supply and reliability:** Guaranteeing sufficient low carbon capacity for security of supply (including periods of low wind), providing a business model for required facilities even when operating at low load factors, and ensuring the system operates and balances in a reliable manner.
- **Whole system coordination and locational signals:** Providing clear signals for coordination across the system as whole, including networks, location of assets, and interactions with hydrogen production.
- **Customers and affordability:** Market design needs to work for consumers and minimise costs and incentivise efficient dispatch decisions, in the long-term and over the transition.

In addition, from a practicality perspective, any changes would need to be simple and implementable on realistic timeframes, with scope to adjust over time, and minimising risks from public or political acceptability, delivery complexity, novelty or lack of clarity.

The Group used a simple Red-Amber-Green (RAG) rating to assess these key challenges, and the results are summarised in Table 2 below.

Table 2 Assessment of priorities for REMA

Challenge	Fitness of current policies	Priority for other reforms	Priority for REMA
Incentivising low carbon generation			
De-risking low carbon investment	CfDs, RAB model for nuclear		Medium
Removing dispatch distortions			High
Phasing out unabated gas	Carbon pricing		Low
Security of supply			
Peak capacity	Capacity Market		Medium
Energy duration			High
Operating a reliable system			
Rewarding flexibility	Capacity Market Balancing Services market I/C cap and floor		Medium
Energy mismatch			High
Operability challenges	Balancing Services	BS market reforms	Low
Locational signals			
Investment	TNUoS	Reformed TNUoS	Medium
Dispatch	Balancing Services	Dynamic TN/DUoS	High
Whole system coordination			
Transmission and generation	OTNR NOA	OTNR	Low
Transmission and distribution		DSO Governance	High
Electricity and Gas	NOA CAM	DSO Governance LAEP	High
Customers			
Affordability		Energy Bill Support Scheme	High
Engagement		Dynamic TN/DUoS	High

We expand on the Group's thinking behind this assessment below.

3.3 Incentivising low carbon investment

There was general consensus within the Expert Group that CfDs have been successful in stimulating investment in low carbon generation, and the competitive award of CfDs through auctions has helped deliver a significant reduction in the cost for consumers, particularly offshore wind. The risk reduction benefit of providing long term hedges for low carbon generators is evident in the lower cost of capital (and in particular the ability to raise debt).

It was noted that CfDs are no longer about subsidising low carbon generation, but about de-risking investment, and on the flip side providing some degree of price stabilisation for consumers. They are helping to break the link between wholesale gas price and electricity prices for customers, a trend that will continue with the further expansion of CfDs.

However, the Group noted a number of issues with current CfD design, which will need to be considered as part of REMA:

- The 15 year duration of CfDs does not cover the full economic life of projects (e.g. debt is available for much longer), and hence the "merchant tail" (in the absence of CfD/support extensions) is important to the investment case, and the investor must be confident that the underlying wholesale market will be free from distortions and not subject to excessive policy/regulatory risk.
- Further to the above, the issue of price cannibalisation was raised as a concern - not per se if the value of the output for a generator at certain times and locations is diminishing, since that is a genuine market signal, but if distortions created by poorly designed support contracts exacerbate that price cannibalisation (e.g. incentivising generators to bid into the wholesale market below true costs). This could fuel additional demand for government backed contracts, and then further distortions in the wholesale market, creating a vicious cycle.
- This is particularly an issue for existing renewable projects which will require repowering, and market arrangements should ensure that there are appropriate incentives for repowering.
- The market can take on a degree of market risk as evidenced by the growth in the corporate PPA market. There is a risk that if the volume of CfDs in the market is too great this could limit this market, since corporates exposed to CfD difference payments could become 'overhedged' if they sign long term fixed priced PPAs with low carbon generation to cover their full needs.

3.4 Security of supply

The Group recognised the critical importance of a reliable and resilient electricity system, given the increasing proportion of our overall energy needs that will be met with electricity in the future.

It was noted that the current Capacity Market is very much geared to ensuring sufficient MWs of generation, storage and demand side response to meet the peak demand requirement, but that the nature of the security of supply challenge is shifting much more to one of sufficient available energy, for two key reasons:

- The risks from extended periods of low renewable output in a more renewable dominated system
- Greater seasonal and weather driven volatility in demand with increasing electrification of heat (combined with limited longer duration storage options)

The risks to gas security of supply, where gas-fired generation (abated or unabated) is needed to fill the gaps in low carbon generation, was also noted.

Another factor when considering reforms to the Capacity Market is whether the locational signal is sufficient to ensure that capacity is developed in the right locations, for example avoiding situations where transmission constraints could reduce available supply at times the system is under stress. Given the scale of investment and lead time for new assets, any poorly sited plant would have enduring consequences.

3.5 Operating a reliable low carbon system

The Group noted the considerable advances that National Grid ESO has made in understanding how to operate a decarbonising electricity system, and what was until quite recently seeming impossible – operating a zero carbon electricity system – is now within our grasp. The biggest challenge will be how to do this as cost effectively as possible.

The need to appropriately reward flexibility, and provide investable signals for both supply and demand side solutions, is well understood. Ongoing reforms to Balancing Services, and Pathfinder projects, have been designed to offer commercial arrangements that work for both the ESO and flexibility providers, and to attract new players to the market. Flexibility providers are able to 'stack' revenues across the wholesale market, Balancing Mechanism, Balancing Services and Capacity Market in order to make their business case. Consideration should also be given to the impact on single asset owners against those with large diversified portfolios including co-located storage and renewable projects.

As markets for distribution level services start to mature, these may become an increasingly important part of the revenue stack for smaller scale providers, and it will be important that their flexibility can be optimised across the whole system.

The scale of the challenges in operating a low carbon system facing the ESO are emerging, with Balancing Services costs increasing dramatically over the past 3 years (reaching £2.64bn in 2021). Given that the ESO is now sole counterpart to all these contracts, the transparency of its actions is becoming increasingly important. Whilst some options for market reform may reduce the scale of the ESO actions, for example the resolution of transmission congestion through locational prices in the wholesale market, the ESO's (or Future System Operator's) role will likely remain very significant and hence the need for transparency in its decision making will continue to be vital.

One of the biggest challenges identified by the Expert Group for operating a low carbon electricity system was what it termed the 'energy mismatch' – the risk of having too low renewables output at some times, but conversely too much at others. Adding more renewables to the system to help address the former could compound the latter. It seems likely that the most efficient way of achieving a zero carbon electricity system will involve a degree of curtailment, but the question is how much is optimal, and what is the true economic cost so as to send the correct signals to avoid it (be that for demand turn up, more storage, or more network capacity).

This is particularly important with respect to hydrogen electrolysis which could play a vital role in balancing a low carbon electricity system – through its ability to use up excess low cost electricity, and to produce a storable energy product. This provides a perfect example of the need for joined up policy, across specific support for hydrogen electrolysis, how it might be remunerated through security of supply mechanisms in electricity (and potentially gas), and efficient dispatch signals coming through the electricity wholesale market.

Another area that the Expert Group discussed was whether the electricity system has to be absolutely zero carbon, or whether some level of residual emissions (for example for peaking plant), offset by negative emissions elsewhere in the economy, could be the most cost effective way of achieving Net Zero. This could have a bearing on market design. Hence, it will be important to clarify what level of flexibility there may be surrounding achieving a fully decarbonised electricity system by 2035.

Finally, the critical importance of interconnection for operating a secure low carbon electricity system was noted. The ending of implicit market coupling following the implementation of the Trade and Co-operation Agreement (TCA) is already contributing to inefficient flows on interconnectors (increasing costs and carbon emissions, and potentially weakening security of supply). With more interconnection expected (and necessary) it will be important that interconnectors are utilised as effectively as possible to keep the costs of operating a low carbon electricity system both in GB and neighbouring countries as low as possible.

3.6 Locational signals

Locational signals are a key area of focus for discussions around future market design, and the Expert Group concurs that this is a very important area. Whilst closely related, the case for locational signals to address the dispatch challenge is somewhat different from that for addressing the investment challenge.

There are already locational signals for investment coming through network use of system charges (albeit not necessarily perfect due to the lack of certainty of future Transmission Network Use of System charges, for example). Furthermore, decisions on where to locate generation (and storage) projects are constrained by other factors such as resource availability, the planning system, and availability and cost of grid connections.

Locational signals in the wholesale market would, however, reduce the amount of redispatch that the ESO has to do to manage transmission constraints, and may provide a clearer signal for demand side response. They may also reduce the risk of inefficient flows across interconnectors, for example by reducing imports flowing into parts of the GB system already with excess generation, but conversely increasing imports into parts of the system with supply deficits.

Hence, the view of the Expert Group is that the case for stronger locational signals in the wholesale market is perhaps greater in response to addressing dispatch issues rather than necessarily investment issues. Also, the need to counter any potential negative impact on investment cases of more volatile and harder to predict very granular locational prices was discussed.

The Group also noted the very large distributional effects that the introduction of locational pricing in the wholesale market could result in, for example stronger regional variations in electricity prices for consumers. These effects may need to be countered by other measures to protect equitability. Furthermore, the likely transfer of welfare from generators to consumers (since generators behind export constraints would receive a lower price and no compensation for curtailment) whilst on face value good for customers, could be challenged on the grounds of breaching grandfathering principles (since generators may claim they have financially firm access rights to the national wholesale market price). Hence, not all of the headline large savings in constraint costs from locational pricing can automatically be assumed to flow through to customers.

Finally, the Group noted that some of the effects of locational pricing in the wholesale market could also be achieved by more dynamic network charges, which may be less disruptive to implement.

3.7 Whole system coordination

To achieve Net Zero across the whole economy in a relatively short space of time will require a highly integrated and coordinated energy system across:

- **Transmission and generation**. This is particularly acute for offshore wind where targets simply cannot be achieved without a coordinated offshore grid that can provide grid access in time for generation projects coming on-line.
- **Transmission and distribution.** Ensuring timely grid access for a massive expansion of DER, and coordinated dispatch of flexible resources needed to operate the zero carbon electricity system.
- **Electricity and gas.** Given the challenge of decarbonising heat there will be a need for coordinated system planning at both the national and local level. Furthermore, given the potentially critical role of hydrogen in balancing supply and demand across the electricity and gas systems, the market design should incentivise investment in hydrogen production and its efficient dispatch.

REMA will be only one part of a set of policies to deliver this coordinated energy system. Whilst this sounds obvious, it is an important point to dwell on – first, to ensure coordinated policy making, as noted above, but second to be realistic about the limitations of wholesale market reform given the challenges we face. A theoretically perfect wholesale market design has limited benefit if the biggest challenge is delivering on massive capital infrastructure projects, be that new nuclear or large transmission upgrades, which are largely independent of the wholesale market signal.

3.8 Customers and affordability

The Expert Group expressed their concern about the rapid increase in the cost of energy for customers, and the hardship it will cause certain customer groups. The view was that in the medium and longer term a decarbonised electricity system (together with a greater push for energy

efficiency) should reduce costs and improve security of supply. However, affordability is a significant concern and any interventions that could put further bill pressures on customers in the near term are not desirable.

The Expert Group felt there were likely to be different solutions to meet these near-term priorities than the longer-term challenge of designing energy markets which provide lowest cost for consumers in a Net Zero system. It could be a mistake to choose market designs solely on the basis of mooted short-term cost savings if these increased medium term cost or undermined investor confidence.

CfDs were seen as a positive in breaking the link between gas prices and electricity prices, and the further expansion of CfDs should lead to lower and more stable electricity bills in the future. It was recognised that nuclear and pre-CfD renewables plant had they not already been largely hedged would be benefitting from the very high wholesale prices. If high prices endured beyond the current hedging horizon, then this could be an area of concern.

The Group noted the critical importance of customer engagement, for acceptance and also to capture the potentially large flexible resource of controllable assets on customer premises which will be needed to operate the low carbon electricity system cost effectively.

3.9 Priorities for REMA

There was a strong consensus within the Group that there was a case for change, with the key priorities for REMA identified as being:

- **Incentivising low carbon investment:** Contracts for Difference should be retained but evolved to reduce dispatch distortions.
- **Security of supply:** Changes to the Capacity Market will be needed to address the energy duration challenge not just peak capacity adequacy, and to phase out non low carbon solutions.
- **Operating a low carbon electricity system:** The energy mismatch (extended shortfalls in some periods, excess supply in others) needs to be addressed, with more accurate market signals for curtailment.
- **Locational signals:** There is a case for stronger locational signals in the wholesale market to improve dispatch efficiency, and potentially to strengthen investment signals.
- **Whole system coordination:** Changes in the wholesale market must take into account potential changes in governance arrangements for the distribution system, and emergence of markets at the distribution level.
- **Customers and affordability:** Market design needs to unlock flexibility from small scale assets through effective customer engagement. Any market reform should aim to improve affordability through efficient signals, maximising competition and promoting transparency.

4 Options for REMA

In the second Expert Group meeting, a number of the current proposals for market reform were presented and discussed. The main focus for the Group was how well these options covered the highest priority challenges previously identified. It was felt that there is not yet sufficient evidence to reach any firm conclusions on preferred options, but the Group did formulate some recommendations on which options should be in scope, and identified potential gaps that should be considered.

The options presented to the Group were:

- **Evolution of CfDs**. Evolution of CfDs could take multiple forms:
  - A primary focus should be to remove dispatch distortions which may incentivise generators to generate below costs. One way of achieving this would be to pay CfDs based on deemed output, rather than actual output, so that they are not incentivised to keep generating behind a transmission constraint (so as not to forsake payment at the CfD strike price). An example here is David Newbery's Yardstick CfD approach[2].
  - Another option considered was to introduce CfDs for low carbon generators currently operating under the Renewables Obligation, and benefitting from the very high wholesale prices. For generators to do this voluntarily they would need to be prepared to forsake near term revenue for future de-risking of revenue streams. This approach could help to ease bill pressures in the near term.
  - A potential loophole in the CfD design that the current high wholesale prices has revealed is the option to delay the start of the CfD contract, effectively giving the generator the choice of the greater of the wholesale price or CfD strike price. This needs to be addressed in future CfD design in order to protect customers.
  - Current CfDs are offered for 15 year contracts, thereby exposing generators to uncertainty on wholesale prices after this period. Other changes to CfDs could include, for example, offering longer contracts (covering up to the expected lifetime of an asset) or shorter contracts (which assets with expired CfDs could bid for).
- **Nodal pricing and centralised dispatch**. This approach would replace the current bilateral single price market with US style locational marginal pricing and centralised dispatch, and is the model recommended by National Grid ESO[3].
- **Zonal pricing**. This would be a less granular form of locational pricing with around 10 different pricing zones coinciding with the main transmission boundary constraints in Great Britain, and might be implemented within the current bilateral market design. This

[2] Newbery, D., 2021, 'Designing Efficient Renewable Electricity Support Schemes', Cambridge Working Papers in Economics

[3] https://www.nationalgrideso.com/future-energy/projects/net-zero-market-reform

approach would be consistent with the re-zoning concept incorporated in the current EU Internal Energy Market design.

- **Dual electricity market/Green Power Pool**. These are models that split the market into a intermittent renewable (as-available) and dispatchable (on-demand) market, creating two different products and market prices. One of the main aims is to decouple the price for renewable generation from the marginal price set by gas. They could also include locational pricing. Variants of this model are being formulated by Malcolm Keay and David Robinson[4] and Michael Grubb and Paul Drummond at UCL[5].
- **Decarbonisation mandate**. This is the model being proposed by the Energy Systems Catapult which would place an obligation on suppliers to purchase an increasing proportion of their customers' energy needs from zero carbon sources[6].

We have not attempted to describe each of these options, some of which are still being formulated, in this short report, but further details are available in the links provided.

In Table 4 we show our assessment of the coverage of the different policy options against the challenges identified, with a 'Y' indicating those challenges that the option could address. This is not intended at this stage to assess how well the options could address the challenges, but simply whether the option has the potential to. The extended amber and red bars show which challenges we believe none of the options considered are addressing.

[4] Keay and Robinson, 2017, The Decarbonised Electricity System of the Future: The 'Two Market' Approach, Energy Insight.

[5] Grubb and Drummond, 2018, UK Industrial Electricity Prices: Competitiveness In A Low Carbon World

[6] Energy Systems Catapult: Rethinking Electricity Markets – The case for EMR 2.0

Table 4 Coverage of policy options against challenges

Challenge	Fitness of current policies	Priority for other reforms	Priority for REMA	Evolution – reformed CfDs	Zonal pricing	Nodal pricing and central dispatch (ESO)	Dual electricity market (UCL)	Supplier obligation (ESC)
Incentivising low carbon generation								
De-risking low carbon investment			Medium	Y			Y	Y
Price cannibalisation			High	Y			Y	
Phasing out unabated gas			Low				Y	Y
Security of supply								
Peak capacity			Medium					
Energy duration			High					
Operating a reliable system								
Rewarding flexibility			Medium		Y	Y	Y	
Energy mismatch			High					
Operability challenges			Low		Y	Y		
Locational signals								
Investment			Medium		Y	Y		
Dispatch			High	Y	Y	Y		
Whole system coordination								
Transmission/Generation			Low					
Transmission/Distribution			High					
Electricity/Gas			High					
Customers								
Affordability			High	Y				
Engagement			High					

The emerging conclusions from the Expert Group were:

- Evolutionary reform of CfDs, combined with a greater degree of locational pricing (not necessarily full nodal pricing), and associated changes to the Capacity Market could address a number of the challenges identified and ensure stability from an investor confidence perspective
- There are other key challenges that none of the options satisfactorily address:
  - Energy duration (renewables drought problem on one hand)
  - Energy mismatch (excess generation and need to curtail on the other)
  - Interactions between wholesale market and distribution level markets
  - Ensuring good alignment of incentives for Carbon Capture, Utilisation and Storage (CCUS) and hydrogen production with respect to how they could operate within the wholesale market and Capacity Market
  - Engaging customers to release the potential from flexibility of customer assets (e.g. EV charging)
- There is an open question surrounding how important locational prices in the wholesale market are for locational investment decisions given other signals such as TNUoS, and constraining factors such as resource availability and planning

The Group was unclear about the potential benefits of the dual electricity market proposals, when the expansion of CfDs (financial contracts settled against the physical market) could achieve similar outcomes in terms of de-risking investment and decoupling gas and electricity prices for customers, without having to separate the wholesale market physically. However, the Group noted that these proposals are in their infancy, and may warrant consideration when further details are developed.

The Expert Group could see the theoretical benefits of the ESC's proposals for a decarbonisation mandate with obligation on suppliers in terms of promoting competition and reducing the role of Government in determining pathways for decarbonisation. However, given the scale of the investment challenge and need to coordinate infrastructure build out across the whole system it was felt confidence in achieving Net Zero would be lower with this approach. Furthermore, the recent crisis in the retail market highlighted potential risks in relying on relatively poorly capitalised suppliers to underwrite major investment in low carbon infrastructure.

5 Conclusions and recommendations

It is clear current policies are not sufficient alone to meet the challenges identified for achieving Net Zero. Therefore, the Expert Group thinks that BEIS's REMA initiative is timely.

The biggest challenge in the 2020s will be mobilising the huge investment needed in low carbon generation, storage and networks; whereas in the 2030s the biggest challenges will be the efficient operation of the low/zero carbon electricity system (with a much more dynamic demand side).

We must avoid an investment hiatus, which suggests that an evolutionary approach is needed in the near term (2020s), with any more fundamental reforms such as full locational marginal pricing and centralised dispatch considered for the 2030s.

The Expert Group believes that the current affordability challenge strengthens the case for decarbonisation (and REMA), but recognises further interventions may be needed in the near term to protect customers from very high prices.

In Section 3 of this report we have identified what we believe should be the key priorities for REMA, and in Section 4 our emerging views on some of the policy options that were being considered prior to the publication of the REMA consultation.

The Expert Group welcomes the broader range of options included in the REMA consultation (which was published after its three meetings). It is important now to focus quickly on a package of options that addresses the key challenges facing the electricity market now, and is deliverable with minimal disruption to investment in the low carbon electricity system.

The Expert Group formulated a number of key recommendations for Government with respect to the REMA process:

- The importance of clarifying roles and responsibilities given the amount of reform being proposed and the number of initiatives underway
- The importance of coherent policy making, particularly across generation and networks, transmission and distribution systems, different forms of low carbon energy production, and between the electricity and gas systems
- Consideration of market reform on the wider economy and supply chains. The Group noted that we are already seeing inflationary pressures after the award of CfDs (in very competitive auctions) leading to the risk of non-delivery of some projects
- Due consideration of any potential divergence from EU market design given the importance of interconnection, and the efficient use thereof, for balancing energy systems with high proportions of renewables and security of supply
- Being clear on the scope of REMA and how it interacts with other policy and regulatory reforms to address the broad range of challenges
- Favour evolutionary approaches over revolutionary approaches, where possible, and avoiding new solutions that have not been successfully tried and tested elsewhere
- Where more fundamental reforms are being considered it is important to:

- Be clear which challenges they are or are not addressing
- Use a clear and consistent set of principles to evaluate them
- Be certain that there are not other solutions that can achieve (close to) the same outcomes at lower cost and risk to consumers
- Undertake thorough cost/benefit analyses that can demonstrate that the investment required is proportionate to the benefits that can be delivered
- Undertake comprehensive engagement with all the key stakeholders from investors to customers
- Factor in the market disruption and ensuring that this is fully considered in the business case
- Be careful not to undermine investor confidence and hence the importance of defining and maintaining appropriate grandfathering principles, and providing long term certainty

Of the options currently on the table the Expert Group favour (for the 2020s):

- Evolutionary reform of CfDs
- Consideration of locational signals for the wholesale market
- Associated changes to the Capacity Market

We think further policy options are needed to address the following challenges:

- Energy duration (renewables drought problem on one hand)
- Energy mismatch (excess generation and need to curtail on the other)
- Interactions between wholesale market and distribution level markets
- Incentivising CCUS and hydrogen in a consistent way across the electricity and gas systems
- Customer engagement in flexibility markets.