TSO Demand Side White Paper

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Executive Summary

High level summary of the TSO Demand Side White Paper

EirGrid and SONI consider that demand side response can develop further in the future to make an important contribution to achieving:

- The 2030 renewable energy and emissions targets;
- Improved security of supply; and
- Facilitating the electrification and decarbonisation of other sectors of the economy.

With the right arrangements and focus on how different types of demand customers could meet various power system needs, demand side response could play an important role in contributing to meeting these needs and decarbonisation. Demand side response has the potential to contribute to achieving Government targets and the TSOs' ability to operate the power system securely at very high levels of variable renewable generation, as detailed in the Shaping Our Electricity Future (SOEF) roadmap[1].

EirGrid supports the CRU's ambition of evolving the wholesale market arrangements in ways which would encourage more effective demand flexibility and help achieve the Climate Action Plan demand flexibility target as discussed in the CRU's National Energy Demand Strategy (NEDS) decision paper[2]. Equally SONI supports the ambitions of the Department for the Economy (DfE) in further developing demand side flexibility as part of the Energy Strategy for Northern Ireland[3], and the Northern Ireland Smart Systems and Flexibility Plan[4].

We believe that there is a need to focus on how to meet power system needs, and design mechanisms which best enable demand flexibility to contribute to meeting those needs. In designing any new mechanisms which enable demand flexibility to meet system needs, the potential impacts across other mechanisms with similar operational and investment signals will need to be carefully considered. Approaches to improving the performance of existing demand side resources and developing new capability can be effective in helping to meet power system needs while also supporting achievement of the Climate Action Plan demand flexibility target in Ireland and supporting the development and implementation of the Smart Systems and Flexibility Plan in Northern Ireland. These benefits would align for demand side response in the existing wholesale market arrangements through encouraging growth in MW capacity and availability, duration of response, and number of instances of response possible per day.

As the Transmission System Operators responsible for balancing the power system on a minute-to-minute basis, EirGrid and SONI believe it is essential that flexibility should be available and respond reliably when it is required, as otherwise system security or security of supply issues could arise. We have seen demand side response develop in the existing arrangements, in particular through the Demand Side Unit (DSU) mechanism. The growth of DSUs demonstrates how demand side response can successfully develop the capability, and successfully enter wholesale markets, to contribute towards meeting system needs. The TSOs have raised concerns with respect to the reliability and scale of this contribution which materialises operationally. This paper aims to add to considerations of how demand side flexibility should and could be enhanced to improve the contribution towards meeting system needs and to support government policies.

The availability of DSUs to date has been significantly less than the contracted amounts generally across all DSUs, and for some particular DSUs there have been issues of reliability of response when called upon. We have engaged with the Regulatory Authorities (RAs) and the demand side response industry on these matters on several occasions previously. It will be important to ensure that the flexibility from demand side response is consistent in being reliable and available when required to meet a system need, and therefore there will need to be a focus not just on capability but also on monitoring availability and performance to ensure greater certainty and reliability.

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[1] Shaping Our Electricity Future Roadmap – see here
[2] CRU National Energy Demand Strategy Decision – see here
[3] DfE Energy Strategy for Northern Ireland – see here
[4] Northern Ireland Smart Systems and Flexibility Plan – see here

We generally support encouraging implicit demand side response to help meet power system needs. We note the need for the operation of the power system to be able to account for implicit demand side response from operational and planning perspectives. Care will be needed on the assumptions about implicit demand side response and the interactions between implicit and explicit demand side response mechanisms. It will also be important to consider the difference in expectations of reliability and delivery between implicit and explicit demand side response. As the scale of aggregated or otherwise coordinated implicit demand side response grows there may be concerns about how it could impact the operation of the power system. There may be a need to consider setting requirements for greater transparency of information on implicit demand side response, and on how such large-scale implicit demand side response outside of the market arrangements would be expected to operate to ensure operational security and avoid unintended outcomes which could have a negative impact on the power system.

In summary, EirGrid and SONI would find it valuable to:

- Have demand side response with characteristics which are suitable to the secure and reliable operation of the future decarbonised power system;
- Which can be instructed in volumes which would make a large positive impact when required to meet various different system needs;
- Which can be reliable in providing certainty with its availability and performance when it is needed and has been requested to meet a system need;
- While being deployed efficiently to provide the greatest value and security possible to the end consumer.

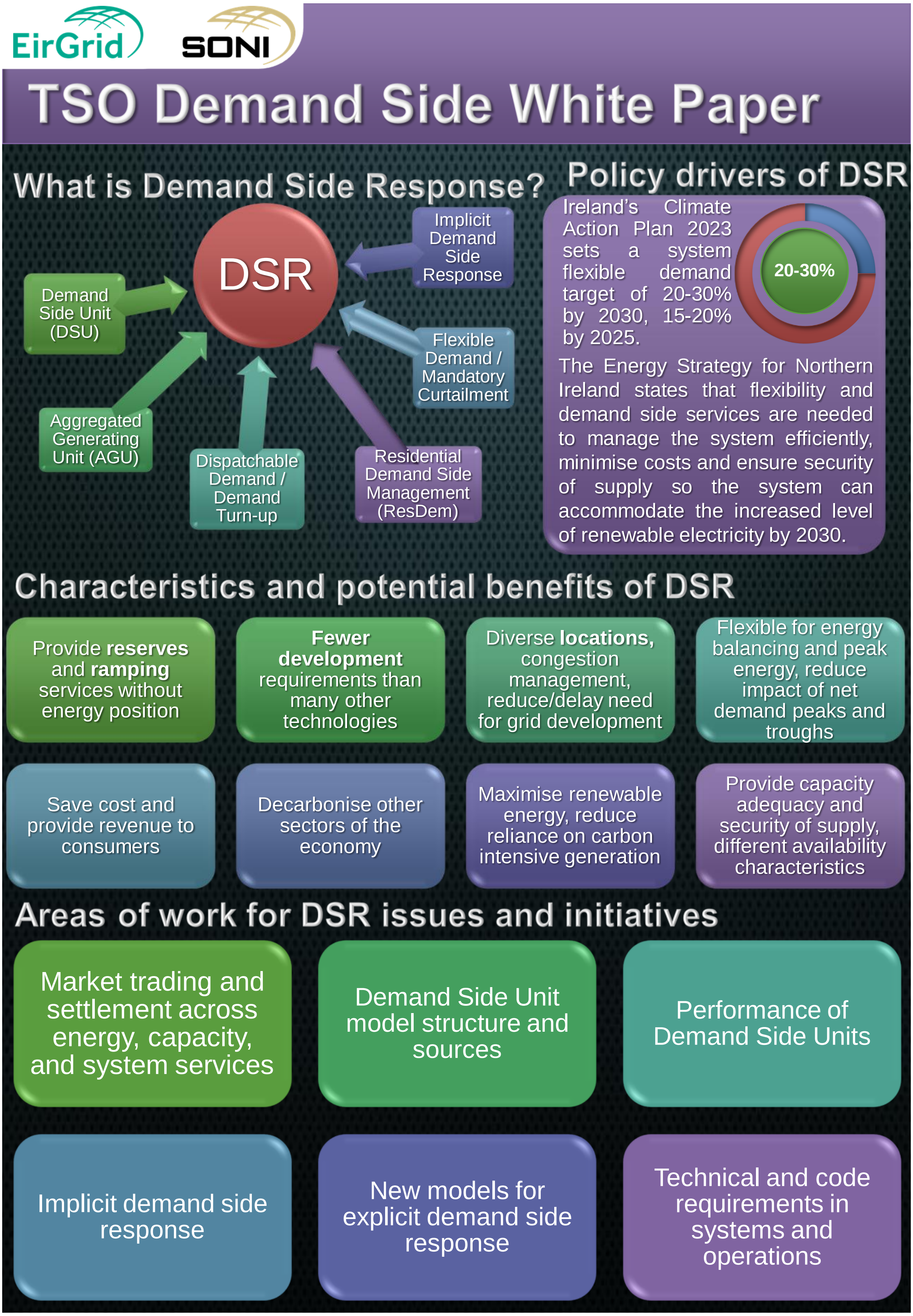
Based on operational experience to date and discussions with stakeholders, we believe that further work and developments are needed to reach a point where this can be achieved. Several issues need to be resolved, and initiatives undertaken, to enable demand side response to develop to provide maximum value to the power system. In considering these issues and initiatives, it will be important to balance between those issues which the demand side response industry has raised as barriers to development, and the issues experienced by the TSOs with demand side response to date (for example with the performance and operation of Demand Side Units).

In this White Paper, we aim to identify, highlight, and summarise issues that exist or may arise, complemented by potential initiatives which may be required, and trends which may emerge, which would need to be considered to enable opportunities to positively change the potential for demand side response to contribute to meeting system needs. The intent of this white paper is to provide as full a picture as possible of all the various potential areas of work to be considered.

To assist with this, we have also included in this White Paper the output of an assessment undertaken by the TSOs which considers the primary high level power system needs and services that demand side response could have a role in meeting and providing, respectively. A high-level indication is provided of the TSOs' current view of the potential capability of various models of demand side response to contribute to meeting those needs and services, now and in the future. Due to the overall scale of work required to meet electricity policy targets to 2030 in both jurisdictions, we need to prioritise work programmes to resolve issues and undertake initiatives in a holistic way within the context of the overall Shaping Our Electricity Future roadmap. Priority areas should focus on changes which would be the most impactful to meeting the 2030 targets, while also being the most achievable. They should also consider the requirements to implement the future Network Code for Demand Response when that enters into force.

Following publication of this White Paper, EirGrid and SONI will engage further with stakeholders, including the Regulatory Authorities CRU and UR, the Department of the Environment, Climate, and Communications (DECC) in Ireland and the Department for the Economy (DfE) in Northern Ireland, ESB Networks and NIE Networks in their roles as DSOs, the demand side response industry, and retail electricity market suppliers, on the identification and prioritisation of work to be included in a TSO demand side plan. EirGrid and SONI will work to ensure this plan will align with the relevant plans and strategies developed by the government departments and regulators in Ireland and Northern Ireland. EirGrid and SONI would welcome any comments from interested parties on this White Paper, which will help to inform the development of this demand side plan. Delivery of future initiatives, identified as part of the planning process, are subject to future funding requests and regulatory authority approval of same.

Infographic summary of the TSO Demand Side White Paper



1 Introduction and purpose of TSO Demand Side White Paper

1.1 Introduction

Demand side response can play an important role in contributing to flexibility, energy balancing, capacity adequacy, system services, and congestion management. Enabling demand side response has consistently been recognised by policy makers as important to facilitating the achievement of climate and renewable energy targets. Because of this, a demand side strategy has been identified as a key deliverable under the TSOs' Shaping Our Electricity Future (SOEF) programme to 2030. Such a strategy will require a plan, and EirGrid and SONI will use this White Paper to inform the development of this plan. EirGrid and SONI will also work to ensure that this plan will align with the relevant plans and strategies developed by the government departments and regulators in Ireland and Northern Ireland.

This White Paper is intended to provide an overview of the drivers, characteristics, opportunities, requirements, issues, and initiatives to further develop demand side response to meet TSO power system needs. It focuses on demand side response impacting and meeting TSO power system operational and wholesale market needs, improving and developing new explicit response mechanisms in wholesale markets and power system operations in ways which can also help with meeting demand flexibility targets, and accounting for the impact of implicit demand side response.

This White Paper provides a high level assessment of the potential capabilities of various kinds of demand side response to contribute to meeting TSO power system needs. It summarises and highlights issues and potential initiatives, including those raised by the demand side response industry and by the TSOs, to be considered in future planning work intended in the next steps through the development of a high level demand side plan. This planning would need to include work to determine the relative priority levels of these items, considering the changes which would have the most positive impact and the areas which would be most achievable and technically deliverable by 2030. This exercise will also need to inform, and be informed by, the TSOs' work to implement the Network Code for Demand Response when that enters into force.

The focus on demand side response means that some other aspects of "demand flexibility" as defined and outlined in the CRU's National Energy Demand Strategy (NEDS), and as considered in Northern Ireland's Department for the Economy's (DfE's) Smart Systems and Flexibility Plan, are not in the scope of this White Paper, such as energy storage (unless acting as demand side response "behind the meter"). These will be considered separately in other developments, for example through the Long Duration Energy Storage (LDES) Call for Evidence paper[5] published by EirGrid and SONI. This White Paper focuses on an all-island perspective but also considers aspects which may be specific to only Ireland or Northern Ireland where appropriate.

This White Paper considers:

- The drivers for the development of demand side response into the future;
- The existing and potential future categories and sources for demand side response;
- The general characteristics of demand side response;
- How demand side response can currently meet TSO power system needs and how it could potentially meet these needs in the future; and
- The areas of work which would be required to enable demand side response to provide maximum value.

[5] https://www.eirgridgroup.com/site-files/library/EirGrid/LDES-Call-for-Evidence-EirGrid.pdf

1.2 Policy context

There is a strong emphasis in EU, Ireland, and Northern Ireland electricity policy on enabling demand side flexibility. This includes explicit requirements, starting in Ireland's Climate Action Plan 2021[6] which set a target to ensure that 20-30% of system demand is flexible by 2030, and subsequently updated in 2023 to include a target of 15-20% of system demand being flexible by 2025[7].

In Ireland, the Climate Action Plan was further updated with a 2024 version[8], and it includes explicit relevant actions on different stakeholders[9]. Particular actions include for the Commission for the Regulation of Utilities (CRU) to publish a new demand side strategy, on enabling distributed flexible customers to participate in wholesale and system services markets, and on incentivising flexibility of demand from Large Energy Users.

The Call for Evidence for the CRU's Energy Demand Strategy was published in June 2023[10]. In December 2023 and January 2024 a number of separate publications following up on different aspects of this Call for Evidence were published, including the CRU NEDS consultation[11], the CRU Review of Large Energy Users Connection Policy consultation[12], and the ESB Networks Demand Flexibility Product Proposal consultation[13]. In July 2024 the CRU's NEDS decision paper[14] and decision paper on the ESB Networks Demand Flexibility Product Proposal[15] were published. EirGrid has been actively engaging with the CRU on aspects relevant to the TSO.

The Energy Strategy for Northern Ireland, published in December 2021 by the Department for the Economy (DfE)[16], recognised the need to increase flexibility of demand, with a number of actions relevant to demand side response including preparation of a flexibility plan, and cost benefit analysis of smart meters[17]. In June 2023 it was announced that a plan for the implementation of electricity smart meters and systems would be developed[18] following the completion of this cost benefit analysis[19]. A consultation on the Northern Ireland Smart Systems and Flexibility Plan was published in January 2024[20], which considered in more detail a number of aspects relevant to demand side response including monitoring flexibility, smart appliances and EV charging, smart meters, demand side response, aggregation, system services and flexibility services, and markets to incentivise appropriate flexibility.

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[6] https://www.gov.ie/en/publication/6223e-climate-action-plan-2021/
[7] https://www.gov.ie/pdf/?file=https://assets.gov.ie/249626/1c20a481-bb51-42d6-9bb9-08b9f728e4b5.pdf#page=null
[8] https://www.gov.ie/pdf/?file=https://assets.gov.ie/284675/70922dc5-1480-4c2e-830e-295afd0b5356.pdf#page=null
[9] https://www.gov.ie/pdf/?file=https://assets.gov.ie/279556/9f07b7d3-c934-416a-9c4f-177c396f07e9.pdf#page=null https://www.gov.ie/pdf/?file=https://assets.gov.ie/252238/e48681c5-0a09-4a71-a14b-04c64ee46a9c.pdf#page=null
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[12] https://cruie-live-96ca64acab2247eca8a850a7e54b-5b34f62.divio-media.com/documents/CRU2024001_Review_of_Large_Energy_Users_Connection_Policy_Consultation_1.PDF
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[19] https://www.economy-ni.gov.uk/sites/default/files/publications/economy/smart-meters-cba-report.pdf
[20] https://www.economy-ni.gov.uk/sites/default/files/consultations/economy/Transitioning-net-zero-energy-system-Consultation-design-considerations.pdf

The Clean Energy and Fit for 55 Packages set out a clear mandate for System Operators to enable and promote demand side response solutions, with explicit requirements included in the Electricity Market Directive (EU 2019/944) and Regulation (EU 2019/943). The Agency for the Cooperation of Energy Regulators (ACER) also developed of a Framework Guideline for a future Network Code to be developed on demand response[21], a proposal on which was submitted to the European Commission[22]. Following development work considering this Framework Guideline, and a number of consultations, a joint proposal for the Network Code on Demand Response was submitted to ACER by the European Distribution System Operators Entity (EU DSO Entity) and the European Network of Transmission System Operators for Electricity (ENTSO-E)[23]. This Network Code considers many aspects relevant to the future development of demand side response, including: mechanisms for participating in wholesale markets; requirements for ex-ante prequalification and ex-post verification; interactions between aggregators and suppliers; calculation of baselines and response for checking delivery; interoperability and efficiencies between local markets and wholesale markets, including TSO-DSO coordination; and requirements for congestion and voltage support products.

EU emergency legislation to address high energy prices[24] also mandated an average of 10% reduction in gross demand, with at least 5% reduction required in particular peak periods. It is possible that similar enduring targets could be included in future electricity market design policy. The EU electricity market reform proposals[25] also contain a number of elements of relevance to demand side response, including: focus on flexibility needs including developing a methodology and carrying out the process of assessing these needs; objectives for demand side response; measures to better facilitate demand side response in capacity mechanisms and short-term market arrangements, or the development of additional flexibility support and peak shaving schemes; longer-term contracting for energy and price certainty for consumer protection against volatile prices; and the use of dedicated (sub)metering devices for observability and settlement.

Future work will need to consider EU legislation and policies as they develop, in particular the Network Code for Demand Response as that is finalised.

1.3 Decarbonisation and consumer impacts

As more heating and transport is electrified over time, overall electricity consumption is expected to rise, as well as consumption at peak times. The technologies behind this electrification, such as heat pumps, electric vehicles, and the electrification of industrial commercial and agricultural processes, could make it easier for consumers to be more flexible about how and when they consume electricity. Since this energy would be coming from an electricity system with increasing levels of renewable energy, demand side response can provide many advantages from a decarbonisation point of view if energy consumption can better match the variability of the renewable energy sources.

Demand side response can also help prevent or reduce the need for conventional fossil-fuel based generation to meet the needs from rising overall and peak electricity consumption. The primary energy sources of electricity at the time the demand side response actions are taken, and primary energy sources of the potential alternatives in other sectors, are an important consideration in how effective the electrification and demand side response can be in decarbonisation. Demand Side Response can also play an important role in contributing to flexibility and services provided in a way which can better complement renewable energy and decarbonisation than other sources of flexibility and services, such as conventional thermal generation.

Enabling provision of services and response from demand can help increase the affordability of the transition to 2030 for those consumers who are active in participating, by offering opportunities to avail of

[21] https://extranet.acer.europa.eu/Official_documents/Public_consultations/Pages/PC_2022_E_05.aspx
[22] https://www.acer.europa.eu/sites/default/files/documents/Official_documents/Acts_of_the_Agency/Framework_Guidelines/Framework%20Guidelines/FG_DemandResponse.pdf
[23] https://www.entsoe.eu/news/2024/05/08/dso-entity-and-entso-e-submit-joint-network-code-on-demand-response/
[24] https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=COM:2022:473:FIN
[25] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52023PC0148&qid=1679410882233

cost savings and to earn revenue. Many developments to 2030 and beyond would also be expected to empower electricity consumers to be more active in determining when they consume power and to change their behaviour where beneficial, through considering signals such as time-of-use tariff prices and relationship to periods of higher or lower renewable energy generation. Consumers would also be empowered to further develop Distributed Energy Resources (DER), such as rooftop solar, household storage, and other forms of microgeneration.

All of this would result in changes to demand consumption patterns through increased DER and increased implicit demand side response. EirGrid and SONI will need to consider the impact on the operation of the power system, and it is likely to drive changes to TSO processes such as demand forecasting across short- and longer-term timeframes. In this regard, the TSOs will need to work in collaboration with the DSOs to develop greater visibility of relevant aspects of the distribution system, in particular around network conditions and DER production / consumption in planning and real-time timeframes.

1.4 Past performance

In the past, the performance of Demand Side Units for capacity availability and energy market trading has not been as expected by the TSOs. There are also a number of Demand Side Units which have operating models that are based on relatively high carbon intensity resources, which could be misaligned with policies and general requirements to reduce carbon emissions, and which could have additional operational considerations due to environmental and emissions limits.

The operational processes and systems used by the TSOs and Market Operator also have limitations and considerations which require relatively resource-intensive manual workarounds in order to represent demand side response, which are likely to increase in impact if the scale and number of demand side response providers grows. Therefore, these are aspects which need to be better understood and improved to enable the potential for enhanced demand side response contribution.

1.5 Approach to change

EirGrid and SONI, as TSOs, and SEMO, as Market Operator, have key roles in helping to implement the changes required to enable the potential for enhanced demand side response contribution. There are different approaches that could be taken to making these changes.

On the one hand, changes could be considered in an ad-hoc manner, with different areas of focus from different parties depending on their priorities. This could make it more challenging to implement changes in a timely manner, considering competing priorities within work on demand side response and in the many other different areas of work required to achieve the 2030 policy goals.

On the other hand, a more holistic approach could be taken which considers all of the areas of work for demand side response in a joined-up way with the other areas of work required to help achieve the 2030 policy goals. Areas of work could be prioritised based on the level of impact they would have on helping achieve or enable high level policy goals, and how achievable they are in themselves, within the context of the other work needed within the timeframe to 2030.

The Shaping Our Electricity Future (SOEF) roadmap is an approach which considers all of the areas of work required from a TSO perspective to meet the higher-level policy objectives, across networks, markets, operations, and engagement. By considering this holistic approach in the White Paper and the follow-on work to develop a demand side plan, alongside the rest of the SOEF programme, it is anticipated that the changes which make the most meaningful impact on the higher level policy objectives to 2030 for increasing renewable energy, decreasing emissions, enabling other climate action policies, and increasing power system security will be prioritised and delivered.

2 What is demand side response?

Demand side response involves users of electricity (business, residential, commercial, or industrial consumers) having the capability to change their electricity usage patterns from their normal or current consumption patterns, i.e. to temporarily turn down or turn up demand, or shift demand, in response to signals. Such signals could be relatively static, such as prices applying to different times of the day, or more dynamic, such as information on system conditions or explicit market or operational signals. For the demand side response service providers, there can be benefits in terms of reduced costs for consumption of energy, and potential sources of revenue for providing services.

Demand side response can help the TSOs in managing the power system efficiently. Demand side response is typically most effective to the TSOs at times of high demand and periods of congestion on the network, which currently tends to coincide with the daily evening demand peak. At present, typical demand side response can help reduce load at these times or shift the load to a different time, so the demand profile is flatter overall. However, there may be other emerging models where the use of demand side can be effective at other times, such as increasing demand at times of high variable renewable generation.

The following sections outline from the TSOs' perspective the existing models for demand side response, and a number of potential or emerging models.

2.1 Demand Side Unit (DSU)

A DSU consists of one or more Individual Demand Sites (IDS) that can be dispatched by the TSOs to reduce demand when instructed. A DSU may contract with a number of IDSs and aggregate them together to operate as a single DSU (if each site contributes less than 10 MW, otherwise a site with capabilities greater than 10 MW must be considered individually as its own DSU). The DSU is usually a third-party company specialising in demand side participation and service provision. This third party typically does not take title to the energy being consumed by the IDSs, i.e. those IDSs still have a relationship with a separate Supplier Unit for the purchase of the energy they are consuming, and the aggregator is not their energy supplier.

Dispatch instructions are issued by the TSOs at an aggregate level and the DSU then coordinates the required demand reduction from its IDSs. The IDSs use a combination of on-site generation[26] and reduction of energy consumption activities (complete reduction, scheduling for another time, complete shutdown of equipment or just reduction of energy consumed by equipment) to deliver the required demand reduction. When these units are dispatched to positive MW levels, this represents an instruction to reduce the net demand on the sites included in the aggregation. This is equivalent in energy terms to dispatching a generator to increase its generation output, hence why operational and settlement sign conventions are the same between a DSU decreasing net demand and a generator increasing net generation.

There are two broad technology approaches for DSUs based on how they provide the net demand reduction across their sites, which include:

- "turn-down" of energy consumption; or
- "turn-up" of local on-site generation which decreases the net demand observed by the system operator.

There are also typically two operating models which DSUs tend to follow. There are:

- "peaking" types, which typically expect to be consuming their baseline net demand import from the grid for the majority of the time, and are relatively infrequently activated to reduce this net demand import from the grid in a smaller number of periods, usually when wholesale market prices are high. This type can come from turning down of energy consumption or from turning up of on-site generation; or

[26] Where a DSU uses on-site generation, to date this has typically been in the form of a small diesel generator.

- "long-run" types, sometimes also referred to as "always-on", where the default state is that the DSU expects to be constantly reducing their net demand import from the grid in nearly all periods. This type typically structures its trading and commercial data so that it would be dispatched by the TSOs to provide this response in most periods, and there may be a smaller number of periods where this dispatch is reduced so that it draws more power from the grid to balance the site load. Typically, this type uses on-site generation for the provision of this demand side response, as a constant source of meeting demand on its site rather than importing from the grid to meet that demand.

2.2 Aggregated Generating Unit (AGU)

AGUs are a unit type which is currently specific to Northern Ireland – there are currently none registered in Ireland. They consist of an aggregation of multiple small generators, each below 10MW, which can be across a number of different sites. They act similarly to DSUs in terms of how they are operated in real-time and the fact that their response to an instruction comes from activating generation across their different sites in the aggregation. However, there are differences in other aspects, in particular where they are treated as generation rather than as demand, such as in Grid Code requirements and in settlement rules where they are settled largely like a normal generator. While AGUs would not be a form of demand side response in themselves, they are included in this white paper as they would have a lot of overlaps in terms of characteristics, operational approaches, and impacts with forms of demand side response which are based on changes in on-site consumption. The AGU model could also be considered as a potential alternative approach to the DSU model for these kinds of sites.

2.3 Demand turn-up

Separate to DSUs, there is also a new unit type being considered, the Dispatchable Consumption Unit (DCU), which would increase demand on-site directly from dispatches and signals in the wholesale electricity market through a registered market unit. This unit would be providing capability for "demand turn-up", where rather than being dispatched to provide a reduction response against a baseline level of power consumption from the grid, they would be dispatched to increase the level of consumption on the site from the grid above a baseline level of power consumption. To accurately reflect such an instruction, the unit would need to be dispatched into a negative output range, i.e. being instructed to a negative MW level below zero, similar to the power consumed by pumped storage units when in pumping mode. This unit-type is not yet covered under Grid Code or Trading and Settlement Code requirements. This would require a number of developments, as it would be a new market and operational model unit type. This is currently being considered under the "dispatchable consumption" initiative in the Strategic Markets Programme being developed by the TSOs.

An example of when demand turn-up could be used is when there is a surplus amount of generation on the network from wind or solar. By increasing demand on-site, this can help reduce surplus renewables, curtailment of renewables, and/or constraint of renewables. Increased demand from the grid generally enables increased generation from these sources which would otherwise be dispatched down, and therefore enables this energy to be used in useful ways rather than going unused. This could include productive end uses which otherwise would not have happened, reducing a corresponding amount of electricity consumption at other times which would have been more carbon intensive, or replacing more carbon intensive non-electricity energy consumption which otherwise would have been used at the time.

The relationship between the amount demand increases and the amount dispatch down can decrease will depend on what constraints are binding at the time. For example, if SNSP is binding then it is unlikely that 100% of the increase in demand could be met by an increase in non-synchronous renewable generation. Further work is needed to assess where this model may be suitable, and whether the model is suitable to the system in general. For instance, it may need to be considered if it would cause adverse or unintended consequences if many large demand sites were to use such a model.

2.4 Flexible Demand

The concept of Flexible Demand has recently been introduced in Ireland as a requirement of connection agreements for a number of data centres. This allows for connections to be offered in areas where firm capacity may not be readily available, and in return EirGrid reserves the right (after taking other actions required in a hierarchy, such as dispatch of available relevant generation and DSUs) to instruct the data centre to reduce their load. This would not be considered a TSO action in the wholesale markets, as it is not on a registered market unit, and it would not be considered "Demand Control" under the current definition in the Grid Codes.

Elements of Flexible Demand are included in the decision on data centre grid connection processing in Ireland from the Commission for the Regulation of Utilities (CRU). This includes the need to consider the ability of the data centre applicant to develop onsite dispatchable generation (and/or storage) equivalent to or greater than their demand, and the data centre applicant's ability to provide flexibility in their demand by reducing consumption when requested.

2.5 Mandatory Demand Curtailment

Mandatory Demand Curtailment is a mechanism also recently introduced in Ireland, which applies to large industrial customers connected to the 110kV network or above when the system enters an Emergency State. It allows EirGrid to instruct customers to reduce demand to pre-agreed levels, as made provision for in the case of Demand Customers in the Grid Code. In the case of customers with full generation backup capability, EirGrid can instruct a reduction in their consumption by 50% at a minimum of one hour's notice. This mechanism is not a market measure, and is to be used in advance of Demand Disconnection under an Emergency State, if time permits it. This mechanism is also not relevant to Northern Ireland as there is currently no large industrial demand connected at transmission voltage levels there.

The instruction of relevant sites for Mandatory Demand Curtailment forms part of the ESB Networks' DSO Load Shedding Plan, first approved by the CRU in December 2021, where it is prioritised over the disconnection of other Customers where practicable. For the avoidance of doubt, other forms of Demand Control / Load Shedding (such as emergency manual load shedding and planned rota load shedding) are not considered a form of demand side response in the context of this document.

2.6 Other "implicit" demand side response

Electricity consumers can more generally participate in demand side response through changing their behaviour to consume energy at different times to the pattern of consumption they otherwise would have naturally followed. This kind of behaviour could be driven by a combination of technology advancements, energy awareness, policies, or pricing, outside of the explicit market arrangements and mechanisms. This could involve indirect signals, where a consumer is responding based on information or prices they are exposed to and determining what action would be most advantageous for them to take. This could also involve direct signals, where a consumer is responding based on receipt of a signal from someone (which could be a TSO or other parties) containing information on, or a request for, the action which would be most advantageous for them to take. Such direct signals could also help to better align the implicit consumer demand response and shape it to be more effective and efficient from a system perspective.

Indirect signals to consumers to encourage their demand response to align with when it would be most economically efficient is extremely useful from a system perspective. Such signals to participate in demand side response are currently available through retail electricity market time-of-use tariff structures where consumers are encouraged to move their energy consumption to cheaper off-peak times. Current examples of this for customers without smart meters include Economy 7 (Northern Ireland) and NightSaver (Ireland).

The introduction of smart meters is enabling further opportunities for implicit demand side response, especially from residential electricity consumers. For example, through access to more detailed and accurate electricity consumption data in half hourly periods, consumers can learn more about how their behaviour drives their consumption patterns and therefore the ability to change this behaviour where beneficial. More granular time-of-use tariffs applied to those periods, and more accurate billing of consumption, also provide more precise signals and opportunities to consumers to take part in demand side response activities. Electricity consumers could change their consumption patterns either by actively changing their behaviour in response to these signals, or through the aid of smart home devices or service providers which respond to these signals. Some of these response opportunities could be manual while others could be automated or following algorithmic or parametric methods.

As an example of direct signals, in the past, the TSOs have operated specific schemes to reduce demand which are not explicitly represented through the wholesale electricity markets (e.g. not through dispatching a DSU). These include the Winter Peak Demand Reduction Scheme (WPDRS), Power Off and Save, and Short Term Active Response (STAR). While these were not explicitly in the market, they were also not purely implicit either, as the demand side response was in some cases based on signals and messages from the TSO directly, or signals against certain metrics defined in advance by the TSO such as frequency, rather than being based on a consumer's own behaviour in response to more general price signals and other generally available information.

There are different potential models of implicit demand side response, with different impacts, which could be categorised at the highest level into:

- Load-shifting (the same amount of energy gets consumed overall but the demand side response means that it is consumed at a different time than it otherwise would have been);
- Consumption-reduction (there is less overall energy consumed due to the demand side response than otherwise would have been the case); or
- Consumption-increase (there is more overall energy consumed due to the demand side response than otherwise would have been the case).

Energy efficiency measures, such as switching light bulbs from halogen to LED or a resistive heating system to a more efficient heat pump solution, are another means of achieving an overall level of demand consumption reduction, with some similar advantages and impacts to the other means discussed. They are not considered here in the scope of demand side response, since they usually mean ongoing permanent reduction in consumption, rather than demand responding flexibly to different signals. However, the levels of consumption reduction achieved through energy efficiency will have an impact on consumption reduction through demand flexibility, which will need to be considered in this work.

2.7 Demand side response categorisation

A break-down of the different demand side response categories in terms of the typical kW or MW level of the sites which participate can be seen in Table 1 (note that this is intended to be indicative, and there may be instances of sites in different categories and sectors having different kW or MW levels than those outlined in the table). Development in demand side response to date has largely focused on the Commercial and Industrial sectors, with demand side response coming from various mechanisms including on-site behind-the-meter generation, and load reduction or load shifting which would differ depending on the site (for instance, changing the times in a day that large energy intensive industrial processes are run, or shutting off large flexible non-critical energy consumption sources in businesses for a period of time).

Currently, Residential Demand Side Management (RDSM or ResDem) is not mature in the SEM or in meeting either TSO or DSO power system needs. However, there have been a number of proof-of-concept trials, and there are plans for further trials in the coming years. ResDem would be expected to focus on heat pumps, electric vehicle charging, and on-site small-scale renewable generation or storage. However, with the development of smart meters, smart appliances, home controllers, and aggregators with more sophisticated response algorithms, and other sources there are a wider range of opportunities for ResDem to become more readily available in the future.

On-site storage "behind the meter" could potentially be used as a source of demand side response, being able to increase demand on a site when charging and reduce the demand on a site consumed from the wider power system when discharging. However, standalone storage sites, including for pumped storage and battery units, are not in scope for this demand side White Paper. Although they offer a source of "demand flexibility" as considered by the CRU's NEDS decision[27] or DfE's Northern Ireland Smart Systems and Flexibility Plan, the focus of this White Paper is on demand side response. The TSOs see a lot of value in considering the development of standalone storage resources, and are considering this separately. For example, in October 2023, EirGrid and SONI published a Call for Evidence on the Market Procurement Options for Long Duration Energy Storage (LDES)[28], which covers some of the aspects relevant to more standalone storage sites.

Other than a smaller number of larger Industrial or Large Energy User (LEU) sites, the majority of sites which could provide demand side response would be connected to the distribution system. This is especially the case in Northern Ireland, where there are no large industrial transmission-connected demand sites, and therefore nearly all possible demand side response would be coming from sites which are connected to the distribution system. Therefore, coordination between the TSOs and DSOs will be important to enable access to, and opportunities for, distribution connected sites and resources to provide demand side response. The new Network Code for Demand Response jointly developed between ENTSO-E and the European DSO Entity is also expected to include obligations that ensure good co-ordination between TSOs and DSOs.

Table 1: Different indicative demand side response categories by sector and size

Sector	MW Level
Residential Demand Side Management (RDSM or ResDem)	< 11 kW
Commercial	11 kW - 500 kW
Industrial	500 kW - 10 MW
Large Energy Users	> 10 MW

27 https://www.cru.ie/publications/28200/
28 https://www.eirgridgroup.com/site-files/library/EirGrid/LDES-Call-for-Evidence-EirGrid.pdf

3 Characteristics and potential benefits of demand side response

3.1 Peaking energy, energy balancing, and capacity

The focus of demand side response to date has largely been on providing availability for response at times of peak energy demand, as this is typically when it has been most valuable to date. One main benefit of meeting peak demand through demand side response, rather than more traditionally with generation, is that it typically does not have the same negative carbon impact as having conventional fossil fuel plants provide that peaking power (depending on the source of the demand side response). This is the case not only to units explicitly in the wholesale markets, but also other more implicit sources of demand side response, where load-shifting by consumers can reduce peak demand rather than needing to activate more expensive and potentially carbon intensive wholesale market actions to meet the peak.

Simply reducing demand at peak demand times, or shifting demand from higher-demand periods to lower-demand periods, could help with reducing the need for committing on or turning up conventional peaking generation. This peaking generation is typically a high carbon intensity technology type, such as Open Cycle Gas Turbines fuelled by natural gas or distillate oil. Avoiding the need to dispatch these peaking plants due to a reduced peak demand will result in lower overall carbon emissions intensity of the power system.

Conventional peaking generation are likely to have relatively higher operating costs due to their efficiency levels and the types of fuel they use. By not running these generators at as high output levels, fuel costs are avoided which has the effect of lowering the average system costs for running these generators (this would also have the impact of reducing those generators' revenues). Depending on the way the demand side response values this in their commercial arrangements, which would be different for each explicit and implicit model, this difference in the cost of production could also put downward pressure on consumer costs, while also potentially providing cost savings and/or revenue to the active consumers.

Demand side response can also help accommodate an improved load factor for increasing amounts of variable renewable generation on the system. When variable renewable generation levels are high, demand side response can be used to increase demand to help reduce the need for curtailment or other dispatch down of that renewable generation. Surplus power could be used for different purposes, such as to charge electric vehicles, heat, electricity storage, or different kinds of industrial and commercial production. Therefore, the increased renewable energy generation could be used to the benefit of decarbonising the electricity system or to help decarbonise other energy sources and parts of the economy such as transport or heat.

Furthermore, by flattening the electricity demand curve over time, i.e. reducing the peaks and troughs on the daily load profile, demand side response has the potential to increase the operating efficiency of some existing generation plants, allowing them to run at higher load factors, leading to less cycling and ramping which affects plant performance and the required maintenance regimes. By flattening the demand curve, there is opportunity to increase operational efficiency and therefore potentially improve power plant forced outage rates and general lifecycle of various different technologies, including wind, batteries, and conventional generators. All types of power plants are impacted by heavier duties in ramping, and by the number of times they are synchronised and desynchronised (or charged and discharged in the case of battery storage). A flatter demand curve may make it possible to run conventional generators in ways which reduce the additional carbon emissions that may arise from modes of operation requiring more ramping and starting up of units.

Explicit demand side response with peaking type units to date has not generally been very active in gaining non-zero positions in the ex-ante energy markets, while the long-run type units typically try to gain a position for their maximum available response at all times. However, they are generally very flexible in being able to quickly respond to a TSO request for energy balancing. With the sources of non-renewable energy meeting demand likely to continue decreasing over time, demand side response could become more active in the general supply-and-demand balance through the ex-ante markets in addition to their valuable flexibility in TSO balancing timeframes. Creating a more active and elastic demand element in the market could also make price discovery more reflective of the value of energy in every period and allow for more robust price determination in periods with high levels of renewables. This could help increase competition and generally increase the efficiency of the wholesale energy market prices, which could have a knock-on positive impact on all consumers.

Since decreasing net demand consumption import for a given site is equivalent to turning up net generation export from a site (from the perspective of an energy supply-demand balance), demand side response can be helpful in providing capacity adequacy in ways which can be made equivalent to generation providers. Implicit demand side response can in itself help reduce the level of peak demand feeding into capacity adequacy requirements, without taking part in the formal Capacity Market arrangements itself. However, it will likely be complex to account for the impact on capacity adequacy requirements from different assumptions and drivers for the behaviour of this kind of implicit demand side response.

3.2 Reserve and ramping services

In a future power system where the majority of energy will be provided by variable renewable sources, there will be many scenarios during periods of high renewable energy generation where it is expected that there will very few, or no, conventional synchronous generators synchronised on the system, and therefore low levels of certain system services provided from these sources. Therefore, new options for the supply of system services which are suitable to these scenarios would be required, and this includes demand side response.

Service provision from other alternative sources may depend on other factors which would not impact demand side response. For example, the level of headroom available from renewables may depend on the extent to which they need to be dispatched down due to surplus renewable availability or curtailment of renewables, or services from batteries would depend on their state of charge. However, regardless of the levels of variable renewables or conventional generation operating on the system, there will always be an element of demand present on the system. Therefore, there will be the potential to gain flexibility through demand side response in all scenarios. If it can be mobilised to offer services at various magnitudes of total system demand, such as at different times of the day and different times of the year, then demand side response could become a very important and more reliable source of system services in the future, at least for the provision of reserves and ramping capability.

Different sources of demand side response can provide these services in ways which directly align with helping achieve the SOEF targets and goals. Demand side response can provide reserve and ramping services while considered “off” at “zero MW output” (i.e. while not providing any demand response), whereas most conventional generation would need to be synchronised at a relatively large MW minimum stable generation energy level to provide the services. At times of high renewable energy output, these minimum stable generation levels are a driver of curtailment where renewable energy needs to be dispatched down to make room for the energy of the conventional generation providing system stability and services. This means that demand side response could be more advantageous from this perspective in providing system services where possible, because it could help reduce curtailment of renewable energy over using conventional thermal generators for system services.

The system service market is evolving, so that a wider range of technologies can provide individual through to multiple products from a single technology. There are a number of services which demand side response are not currently able to provide and which may be difficult for them to provide based on their technology, such as reactive power / voltage support and inertia. The provision of these system services has to date typically relied upon synchronised conventional thermal generators, but there are a number of alternative technologies being developed (such as synchronous condensers) which could provide these services in a way which could allow the conventional thermal generators to be desynchronised. When these conventional thermal generators are synchronised for these services, they then also naturally provide reserves and ramping capability, which are the system services that to date demand side response has been best placed to contribute towards. Therefore, demand side response's relative contribution towards meeting reserve and ramping services in the future may to an extent depend on the development of alternative technologies providing voltage support and inertia services in ways which allow for conventional thermal generators to be desynchronised. Demand side response's relative contribution to these reserve and ramping services may also be impacted by the development of other alternative technologies with similar beneficial characteristics for the provision of these services, such as batteries which can also provide reserves at a position of "zero MW output".

3.3 Network congestion and development

The TSOs will be faced with greater network management challenges as heat and transport electrification increases demand in the long-run, and more renewable generation is installed. Network congestion is very locational in how it manifests and in how it can be managed, but the impacts (and therefore the importance and benefit in managing it) can be system-wide. For example, if renewable generation dispatch down due to network constraints could be avoided, this would help with decarbonisation of electricity consumption across the system, not just at that location.

While demand growth could be part of the cause of these challenges, demand side response could be used by the TSOs for managing the challenges operationally for pre- and post-fault constraints at specific points on the network. Demand side response could provide the TSOs with one way to manage congestion, such as by reducing demand on the importing side of a congested line, or by increasing demand on the exporting side of a congested line, thereby reducing the flow on that line and reducing the congestion. It could also do this in response to congestion being caused by increased renewable energy generation. If there are high levels of renewable generation on particular areas of the network, demand side response could be used to increase consumption in those areas to absorb the surplus renewable energy so that localised constraints on the network can be mitigated and reduced, or it can be used to reduce consumption on the other side of a line to the renewable energy, and therefore reduce flows on the line drawing that power in.

Currently, TSO congestion management depends largely on using a small number of generator sources, which may not be placed optimally in electrical locations on the system to manage all of these future congestion issues. Demand side response has the potential to be much more diverse in its electrical location and therefore valuable for a congestion management service. Using demand side response means that a particular constraint could be targeted by considering using demand on either side of the congested line, if that locational information is available and actionable. Locational aspects of demand side response could be easier from certain sources, such as single large Individual Demand Sites connected to the transmission system, but would not typically have been the focus in the past for sources which are an aggregation of a number of smaller sites. Therefore, this may be something worth considering in incentives or obligations in the future. Also, the potential to use demand side response varies by time as well as location, and therefore the correlation between the times where congestion management services are required, and when the demand side response resources are available to provide them, would be important.

This explains how demand side response could be used to manage constraints in operational timelines. In addition to this, if there are projections about the magnitude and location of such demand side response being available, with sufficient levels of incentives and obligations to provide certainty that this demand side response could be relied upon, it could also be considered in longer term network planning. If demand side response can be used to manage congestion issues, this could help reduce or defer the need for network developments, such as capital investment in new or reinforced network. This could have additional wider benefits, such as being an alternative to network development where such projects would be more difficult to practically implement, and if the cost of procuring these services are less than what the cost of the network development would have been, then this would result in a positive impact for overall consumer costs.

Similarly, the distribution networks may have congestion issues due to the increase in distributed electricity resources and demand, particularly if take-up rates of electric vehicles, heat pumps, rooftop solar, and other technologies increases. Demand side response could provide the DSOs with an alternative solution for managing congestion. This will have knock-on impacts on overall supply and demand balance, to the transmission network flows, and to the wholesale electricity market, which would need to be determined and managed by each TSO in co-ordination with their respective DSO. DSO network congestion issues may also result in the need to limit the availability of certain sites to provide explicit demand side response, such as is managed through "instruction sets"[29] today, and potentially limit the scope for implicit demand side response. The extent of these limitations would depend on the interaction between these forms of demand side response and distribution network congestion (e.g. would the response make congestion worse or would it help with congestion), and the impact of "recovery" or "rebound" periods on network congestion before or after the time of the demand side response.

3.4 Decarbonisation

Demand side response can play an important role in contributing to flexibility and services in a way which better complements renewable energy and decarbonisation than many other sources of flexibility and services, such as conventional thermal generation. It can be helpful in reducing demand peaks, in reducing the delta between demand peaks and troughs, and it can be an alternative source of capacity than more carbon-intensive sources from a security of supply perspective, which is needed in the shorter and longer timeframes due to the current security of supply and capacity margin issues. All of this can help with decreasing reliance on carbon intensive resources for these system needs.

Many models of demand side response can be low in carbon intensity themselves (in particular those which reduce or shift on-site demand consumption), and some models can help with the decarbonisation of other sectors of the economy (in particular demand turn-up and ResDem). They can also help with maximising the output of renewable energy and managing the operational challenges which are expected to grow in the future with the growth in renewables, such as congestion management, curtailment of renewables, and surplus renewables.

Finally, demand side response to date has generally had lower barriers to development than other technology types. From a grid infrastructure perspective, there is often fewer network and power system development requirements and costs (including connection requirements) and shorter lead times in developing services to be provided by demand side response as opposed to many other service providers. This is because the consumers providing the services are usually already connected and operational, mostly with a Connection Agreement with the DSOs. Usually, the main development required is around software for gathering real-time and forecast data, and issuing / complying with instructions. Since carbon emissions targets are based on cumulative effects up to 2030, rather than a snapshot at the target year, any technology which can help reduce emissions earlier in the decade would be beneficial. However, all of this means that care is needed with the underlying source of the demand side response developed into the future, focusing more on those models which are not carbon intensive than those which have greater levels of carbon emissions. Also, there is likely to be more significant amounts of work required in the future for developing demand side response, including aspects around IT systems changes (not just for the System Operators but also for demand side response providers), metering, codes, performance monitoring, etc., which may offset some of the lower barriers experienced to date. Further considerations on the carbon emission impacts of demand side response now and in the future are provided in Section 4.9.1.

3.5 Consumer financial benefits

Normally consumers of energy would be paying for the costs of energy, networks, policy objectives, etc., which would include the costs of the developments which enable the transition to the 2030 policy goals. However, using their demand to provide response and services would mean that those consumers could also benefit from a source of revenue and/or cost savings for providing some of the response and availability for services required to enable this transition. This would mean that the net cost to those

[29] "Instruction Sets" are limits on distribution connected customers' participation in transmission markets (the SEM and DS3) to protect against unsafe or insecure conditions on the distribution system because of their market activities. Today, instruction sets are issued annually based on technical studies of the expected worst-case conditions over the course of the coming year.

consumers who actively participate in demand side response could be lower than they otherwise would have been.

The reduction in net costs to these consumers could come from explicit participation in the markets, providing capacity, energy, and system services, with consumers being in receipt of both market revenue and cost savings either directly or through arrangements with aggregators. Implicit demand side response may not have the same opportunities to earn revenue, but could enable cost savings. Depending on the retail electricity market time-of-use tariffs available, there could be various approaches consumers could take to achieving savings from changing their energy consumption patterns through a day, by demand shifting, demand reduction, and electricity storage. While smart meters within people's homes can help accommodate such changes in behaviour, work would also be required to ensure the relationships between the relevant retail and wholesale market signals are in place to fully harness this aspect of demand side response.

Retail electricity market suppliers have a key role to play in enabling, providing, and benefiting from demand side response with their customers. Smart tariffs from retail electricity market suppliers will be a large driver for such demand side response. It will be important to ensure that there is an appropriate linkage between what is happening in the wholesale market with what the suppliers can offer in the retail electricity market. Suppliers could also provide explicit demand side response if their customers sign up to "smart services" in addition to smart tariffs, where suppliers could help to manage aspects of their customers' electricity demand to help maximise the benefits to themselves, the system, and the customer. This could have additional benefits to the supplier and customer on top of reduced costs from tariff charges, by being remunerated through the wholesale market arrangements.

Demand side response, explicit and implicit, could contribute to meeting a large number of system needs, and impact on the operation of the power system. This impact includes energy balance, capacity adequacy, the economic dispatch of the system, provision of reserves and therefore management of frequency, management of network congestion, etc. Since these contributions and impacts are so wide-ranging, it would be important to operate these resources with consideration of all system requirements and metrics to maximise value and effectiveness.

Different approaches to demand side response may also provide different levels of value for money and effectiveness for different consumers. The extent to which consumers respond to retail electricity market price signals would need further investigation to find the most effective approaches. This may require different solutions and offerings for different consumers depending on preferences and impacts. For example, some residential consumers may be less interested in following dynamic price signals, prioritising instead having energy available at any time at a fixed price. The cost impact of a move to "smart tariffs" will also not be the same for every consumer, and so this would need to be carefully considered. Different approaches and different signals may be more effective and more suitable for different types of customers.

When considering what is required to be developed to enable each demand side response approach, it would be important to consider the cost of the response, the availability of the response, and the effectiveness and reliability of the response. For instance, approaches enabled through wholesale energy markets would likely have a different set of development requirements, operational costs, and effectiveness associated with them than mechanisms which are developed outside of the markets, such as the WPDRS in the past. Gaining a better understanding of these differences could help with guiding the areas of focus for further development in enabling demand side response in a way which represents the maximum value to the consumer.

3.6 Availability and duration of response

Many forms of demand side response by their nature have a greater level of uncertainty in availability, particularly in longer timescales prior to real-time operations. This may to be more of an issue for those forms of demand side response which rely on turning down or off on-site energy consumption activities, rather than those using on-site generation to meet demand. The level of demand available to be reduced largely depends on the level of baseline demand consumption on a site at any given time, and if that demand is from an activity which can be interrupted and therefore offered for demand side response.

This response may only be available at certain times, e.g. during working hours for industrial and commercial sites. This information is needed to know exactly how much demand side response could be available for offer. This can be complicated if there are other incentives active on the demand, for example time-of-use tariffs which may encourage implicit reduction in demand before it can be made available for explicit response. For an aggregator, they would need information from different sites about which will be running and available.

The information such providers have at a day-ahead stage about how much they forecast will be available is more uncertain and subject to change than such information would tend to be for a more conventional type unit. Conventional generation may have forced outage rates driving uncertainty, but from the point of view of the maximum amount of power it can provide when the plant is available, this tends to be more certain. The closer it is to real-time, the better the information is about the likely baseline consumption of demand sites. This may mean either differences between forecast availability information in longer timescales versus the actual real-time availability, or may mean more conservative forecasts of availability in the longer timeframes.

The availability of aggregated demand side response is also dependant on the availability across the portfolio, where each Individual Demand Site may have different times where the source of the demand which can be turned down is operating. It is unlikely that the maximum theoretical availability from all sites in the portfolio would occur at the same time or be available at all times, depending on underlying consumption patterns and how the aggregator has structured their portfolio. Therefore, this type of demand side response may have a more complex availability characteristic than conventional generation. For conventional generation, it is more likely that the maximum theoretical generation level could be made available in a majority of periods. Even if there are periods where each Individual Demand Site is available for its maximum theoretical availability, the periods where this occurs for each site are unlikely to coincide for the aggregated unit to reach its theoretical maximum.

Many forms of demand side response are also energy limited in nature, where the Individual Demand Site cannot offer to provide a response for more than a certain period of time or more than a certain number of activations. This could be due to various reasons, such as meeting physical or safety requirements for the main activities of the site, operational considerations arising out of emissions limits under environmental legislation for on-site generation, or commercial reasons agreed between the site operator and the aggregator. This means that their availability is also more likely to change once they have been activated, or their ongoing availability could be seen as dependent on not being activated. However, this may not be the case for all sources of demand side response which may be able to continue activation for much longer. For example, longer continued activation of demand side response may be more likely for some applications of demand turn-up, and if demand side response can be provided through on-site generation using lower carbon or renewable sources.

It will also be important to consider the difference in expectations of reliability and delivery between implicit and explicit demand side response. Given its contractual nature, there is an expectation of delivery and performance against obligations for explicit demand side response. However, implicit demand side response is based on encouragement and incentivisation, and therefore while having the potential to be helpful it may not have as much expectation to be relied upon, and may have different impacts even for similar situations. Getting a clear understanding of this potential variability will be important in the realistic consideration of the potential contribution and impact of implicit demand side response in different timeframes, including longer term system reliability and capacity adequacy through to real-time considerations.

In the CRU's NEDS decision, they outline a proposal to use a "Volume Shift" definition of demand flexibility to meet the Climate Action Plan targets, considering the percentage of average daily demand which can be flexed up or down compared with an average daily consumption amount, both in MWh terms. This approach to defining the demand flexibility targets appears to align with what would help improve demand side response's capability to meet power system needs.

In particular, it recognises the value not just in demand reduction, but also in demand shifting including reduction and increase where helping to meet system needs. It also recognises the value not just in increasing capacity, but also in increasing the amount of energy response over the course of a day. This is because improvements in meeting the target could come through an increase in capacity, an increase in availability, an increase of duration of response, or an increase in the number of times response can be achieved in a day. A decrease in the denominator, being the total amount of demand, could also improve meeting the target. This can help to give a sense of how to align incentivising participation of flexible resources to meet power system requirements in ways which also meet the demand flexibility target.

In the definition outlined in the CRU's NEDS decision paper, the input values for this flexible demand target are taken for demand side response from the availability of what can be provided, rather than based on actual utilisation of response. This is helpful in recognising that the incentive is to encourage this capability to be used when needed, whereas basing it on actual utilisation could have encouraged the use of response when not needed just to meet the target. However, since this proposed approach to calculating the target would be based more on capability than operational measures, it would also be very important to monitor the actual availability and effectively measure the delivered response to ensure that this capability is available and reliable when required to meet a system need (e.g. capacity adequacy).

4 Demand side capability to meet TSO system needs

4.1 Explanation of methodology

The focus of this section is on identifying, from the TSOs' perspective, the primary high level power system needs and services which demand side response could have a role in meeting and providing, and to give an indication of the TSOs' current view of the potential capability of various models of demand side response to contribute to meeting those needs and providing services.

The high-level indicative view provided considers several nuanced aspects. Different models of demand side response might be more suited to providing different types of services based on their characteristics, and their ability to contribute currently might be different to their potential to contribute in the future. Each system need and service has a particular context in terms of how they are currently being met and what way they may be met in the future based on different projections. This assessment also takes a more "theoretical" perspective, considering what the potential contribution could be with the right incentives and issues being resolved. The practical issues and requirements that would need to be considered to enable this are considered in Section 5.

This indicative view of the potential capability of demand side response to contribute to meeting system needs is provided based on separate indicative scores for each model of demand side response, for the potential to contribute currently and the further potential that could be unlocked in the future, and for each system need and service. Brief commentary is also provided to explain the thinking behind these indicative scores. An indicative score is provided from zero to three where:

- zero means the resource currently does not, and is not expected to, meet the need;
- one reflects a lower potential to contribute to meeting that need;
- two reflects a moderate level of potential to contribute to meeting that need;
- three reflects a higher level of potential to contribute to meeting that need.

This approach could assist with identifying where initiatives may be required to help incentivise or enable such opportunities for a change in potential to contribute. It may also help identify where trends are emerging which will naturally lead to such a change in potential, and therefore create an impact which needs to be managed. In addition to considering the current and potential capability, the indicative impact score implicitly considers at a high level the relative value compared with other sources of demand side response and other sources able to provide those TSO power system needs outside of demand side response, and the level of change required to reach the potential.

The assessment is based on past experience and discussions with TSO experts. However, these views are not definitive, and represents a snapshot of the TSOs' views at this point in time. The actual potential for these different forms of demand side response will emerge as enabling changes are made, and the approaches and technologies mature and evolve.

The main TSO power system needs considered in this process are the following:

- Capacity adequacy;
- Energy markets participation / Energy balancing;
- Reserves;
- Congestion management;
- Ramping;
- Fast Frequency Response;
- Voltage control / Reactive power.

4.2 Capacity Adequacy

This year's Generation Capacity Statement[30] predicts a challenging adequacy outlook for Ireland in particular, with capacity deficits identified during the 10 years to 2032. The deficits will increase up to 2025 due to the deteriorating operational availability of power plants, resulting in their unavailability ahead of intended retirement dates as well as increasing electricity demand. In later years, the deficits are expected to reduce as new capacity comes forward through the SEM Capacity Market auctions.

In response, the CRU updated its published response "CRU Information Paper Security of Electricity Supply - Programme of Actions"[31], updated in February 2023. This outlines measures including securing enduring capacity through market measures, improving demand side response, and in the short-term, keeping units open or delivering generation on a temporary basis as we transition from older power plants to new capacity. This programme of work, directed by the CRU, will provide additional stability and resilience to the power system.

The SEM Capacity Market is the primary mechanism for incentivising market participants to provide the right type of capacity to meet the system reliability requirement. To date issues have been highlighted with some awarded capacity in Capacity Market delivering late or terminating; other resources having lower operational availability and therefore unable to meet their reliability obligations. These issues are relevant to a range of technologies including demand side response resources.

Capacity Adequacy - Indicative High-Level TSO Assessment			
Technology	**Current**	**Potential**	**Comment**
Industrial and Commercial: Long-run DSU (turn up on-site generator)	2	2	Already contributes to capacity adequacy, scope for potential to contribute potentially lesser due to generation sources less closely aligned to carbon emission policies, unless can move to lower carbon or renewable sources.
Industrial and Commercial: Peaker DSU (turn up on-site generator)	2	2	Already contributes to capacity adequacy, scope for potential to contribute potentially lesser due to generation sources less closely aligned to carbon emission policies, unless can move to lower carbon or renewable sources.
Industrial and Commercial: Peaker DSU (turn down on-site energy consumption)	2	3	Already contributes to capacity adequacy, scope for greater relative contribution vs conventional alternatives due to lower carbon emissions.
Aggregated Generator Unit	2	2	Already contributes to capacity adequacy, scope for potential to contribute potentially lesser due to generation sources less closely aligned to carbon emission policies, unless can move to lower carbon or renewable sources.
Residential Demand Side Response	1	2	Does not yet contribute to capacity adequacy but has scope to develop this capability, relative contribution may not be as high as others as may not be main focus vs other system needs and services.
Dispatchable Demand (turn up on-site energy consumption)	0	0	Does not contribute to capacity adequacy - rather an increase in demand increases capacity requirement.
Implicit Demand Side Response	0	0	By definition, does not take part in explicit arrangements to meet capacity adequacy requirements. Inclusion in capacity requirement calculation can lead to reduction in capacity adequacy requirements.
Large Energy Users	1	2	Does not yet contribute to capacity adequacy but has scope to develop this capability, relative contribution may not be as high as others as may not be main focus vs primary activities.

[30] https://cms.eirgrid.ie/sites/default/files/publications/19035-EirGrid-Generation-Capacity-Statement-Combined-2023-V5-Jan-2024.pdf
[31] https://cruie-live-96ca64acab2247eca8a850a7e54b-5b34f62.divio-media.com/documents/CRU202317_Electricity_Security_of_Supply_Programme_of_Work_Update_February_2023.pdf

4.3 Energy Markets Participation / Energy Balancing

Active participation in the ex-ante and balancing markets has not been an area of focus for demand side response to date, which appears to be driven by the market design approach to energy revenue settlement. However, there is a large amount of potential for demand side response to contribute in many aspects of the energy market. This could include a more active demand-side in ex-ante market trading responding to price signals. Such price signals could flow to customers responding in ways which help to generally smooth out the demand curve, shifting demand from times of higher emissions and lower renewables to times of lower emissions and higher renewables. This would help to balance the system at peak periods and to integrate what would otherwise be surplus renewable generation at other times. This could play an important role in reducing overall emissions from the electricity sector, integrating electrification of other sectors such as heat and transport, and reducing dispatch down of renewables.

Energy Markets Participation / Energy Balancing - Indicative High-Level TSO Assessment			
Technology	**Current**	**Potential**	**Comment**
Industrial and Commercial: Long-run DSU (turn up on-site generator)	2	2	Actively participates in energy trading, scope for potential to contribute potentially lesser due to generation sources less closely aligned to carbon emission policies, unless can move to lower carbon or renewable sources.
Industrial and Commercial: Peaker DSU (turn up on-site generator)	1	2	Does not actively participate in energy trading, occasionally used in energy balancing, scope to develop active participation, scope for potential to contribute potentially lesser due to generation sources less closely aligned to carbon emission policies, unless can move to lower carbon or renewable sources.
Industrial and Commercial: Peaker DSU (turn down on-site energy consumption)	1	3	Does not actively participate in energy trading, occasionally used in energy balancing, scope to develop active participation, scope for potential to contribute potentially greater in shifting demand from periods of high emissions or peak demand to periods of low emissions, surplus renewables, or lower demand.
Aggregated Generator Unit	1	2	Does not actively participate in energy trading, occasionally used in energy balancing, scope to develop active participation, scope for potential to contribute potentially lesser due to generation sources less closely aligned to carbon emission policies, unless can move to lower carbon or renewable sources.
Residential Demand Side Response	1	3	Does not yet actively participate in energy trading but has scope to develop this capability, scope for potential to contribute potentially greater in shifting demand from periods of high emissions or peak demand to periods of low emissions surplus renewables, or lower demand.
Dispatchable Demand (turn up on-site energy consumption)	1	3	Does not yet actively participate in energy trading but has scope to develop this capability, potential to contribute potentially greater in periods of lower carbon emissions or periods of surplus renewables.
Implicit Demand Side Response	1	2	By definition would not actively participate in energy trading or balancing, scope to develop capability responding to price signals which would indirectly impact on energy trading and balancing through suppliers, scope for potential to contribute potentially greater in shifting demand from periods of high emissions or peak demand to periods of low emissions, surplus renewables, or lower demand, relative contribution may not be as high as others as may not be main focus vs cost certainty.
Large Energy Users	1	1	Does not yet actively participate in energy trading, scope for potential to contribute potentially lesser as may not be main focus vs primary activities.

4.4 Reserves

Given the current commercial arrangements for reserve system services where all available volumes are paid a regulated tariff, there are typically higher volumes of the reserve services available in most periods currently than are required to meet the system needs. This is one factor contributing towards what has been termed "overheating" of system services costs, where the cost of paying for these services has increased significantly. Analysis showing this impact, and considerations of options to managing it, have been included in a TSO consultation on DS3 system services tariffs[32]. Therefore, the addition of more available volumes for these services under the current arrangements would further increase costs.

However, this potential for cost increases is primarily expected to be a short to medium term issue, as the market and remuneration arrangements will change in the future with competitive auction-based arrangements (including the Day-ahead System Services Auction or DASSA) being introduced through the Future Arrangements for System Services (FASS) programme. These arrangements will look to procure a required volume of the service while participants can submit bids for the price they wish to be paid if they successfully clear in the auction. In this context, there is a potential for resources which can more easily provide services at times of high renewable generation output, such as by not requiring a large minimum stable generation level, to clear to provide these services at these times ahead of those that would be less flexible. However, certain types of reserves can also only be provided by market participants with certain characteristics e.g. dynamic reserves with tight frequency control deadbands.

Reserves - Indicative High-Level TSO Assessment			
Technology	**Current**	**Potential**	**Comment**
Industrial and Commercial: Long-run DSU (turn up on-site generator)	1	1	Already contributes to reserves, relative contribution may not be as high as others as may not be main focus vs other system needs and services.
Industrial and Commercial: Peaker DSU (turn up on-site generator)	2	3	Already contributes to reserves, scope for greater relative contribution vs conventional alternatives due to lower minimum stable generation level.
Industrial and Commercial: Peaker DSU (turn down on-site energy consumption)	2	3	Already contributes to reserves, scope for greater relative contribution vs conventional alternatives due to lower minimum stable generation level.
Aggregated Generator Unit	2	3	Already contributes to reserves, scope for greater relative contribution vs conventional alternatives due to lower minimum stable generation level.
Residential Demand Side Response	1	2	Does not yet contribute to reserves but has scope to develop this capability, relative contribution may not be as high as others as may not be main focus vs other system needs and services.
Dispatchable Demand (turn up on-site energy consumption)	1	2	Does not yet contribute to reserves but has scope to develop this capability, relative contribution may not be as high as others as may not be main focus vs other system needs and services.
Implicit Demand Side Response	0	0	By definition, does not take part in explicit arrangements.
Large Energy Users	1	2	Does not yet contribute to reserves but has scope to develop this capability, relative contribution may not be as high as others as may not be main focus vs primary activities.

[32] https://cms.eirgrid.ie/sites/default/files/publications/DS3-System-Services-Tariffs-Consultation-27-March-2024.pdf

4.5 Congestion Management

The mechanisms to enable demand side response resources to contribute towards meeting transmission system congestion management requirements have not yet been developed. In general demand side response has come in the form of aggregations of multiple sites in different locations, and the locational information of these sites is not considered in power system operations. However, there is potential for demand side response resources to contribute to meeting this need because of the wide diversity and flexibility of locations of sites which could contribute. For example, the DSOs are developing products and operational processes to use demand side response resources (among others) to help manage distribution system congestion management requirements. There could be potential for the TSOs to consider developing something similar for managing transmission system congestion when the new system services arrangements have been implemented through the FASS programme.

Congestion Management - Indicative High-Level TSO Assessment			
Technology	**Current**	**Potential**	**Comment**
Industrial and Commercial: Long-run DSU (turn up on-site generator)	1	2	Does not yet contribute to congestion management but has scope to develop this capability, relative contribution may not be as high as others due to lesser flexibility in locations, times of response, and generation sources less closely aligned to carbon emission policies, unless can move to lower carbon or renewable sources.
Industrial and Commercial: Peaker DSU (turn up on-site generator)	1	2	Does not yet contribute to congestion management but has scope to develop this capability, relative contribution may not be as high as others due to less flexibility in locations, times of response, and generation sources less closely aligned to carbon emission policies, unless can move to lower carbon or renewable sources.
Industrial and Commercial: Peaker DSU (turn down on-site energy consumption)	1	3	Does not yet contribute to congestion management but has scope to develop this capability, scope for greater relative contribution vs conventional alternatives due to greater flexibility in locations.
Aggregated Generator Unit	1	2	Does not yet contribute to congestion management but has scope to develop this capability, relative contribution may not be as high as others due to less flexibility in locations, times of response, and generation sources less closely aligned to carbon emission policies, unless can move to lower carbon or renewable sources.
Residential Demand Side Response	1	3	Does not yet contribute to congestion management but has scope to develop this capability, scope for greater relative contribution vs conventional alternatives due to greater flexibility in locations.
Dispatchable Demand (turn up on-site energy consumption)	1	2	Does not yet contribute to congestion management but has scope to develop this capability, relative contribution may not be as high as others due to less flexibility in locations, times of response, and may not be main focus vs other system needs and services.
Implicit Demand Side Response	1	1	Does not yet contribute to congestion management but has scope to develop this capability, scope for potential to contribute potentially lesser because this would be an implicit incentive to respond rather than an explicit requirement to respond.
Large Energy Users	1	2	Does not yet contribute to congestion management but has scope to develop this capability, relative contribution may not be as high as others due to less flexibility in locations, times of response, and may not be main focus vs primary activities.

4.6 Ramping

Ramping services typically cover longer timeframes, currently up to 8hrs, and aim to ensure that there is sufficient ramping capability to increase resources to balance energy supply and demand over those timeframes given the potential changes in demand vs supply, primarily driven by the variability in the output of renewables and uncertainty in their forecasts. Resources considering the provision of ramping services would need to have the ability to respond for a long duration. Based on experience to date, it would appear that many models of demand side response would not intend to provide such long duration responses, but there could be potential to provide these services if changes to current approaches or new approaches to demand side response are developed with characteristics better suited to ramping.

Ramping - Indicative High-Level TSO Assessment			
Technology	**Current**	**Potential**	**Comment**
Industrial and Commercial: Long-run DSU (turn up on-site generator)	1	2	Already contributes to ramping, scope for greater relative contribution vs conventional alternatives due to greater availability and flexibility at different times and in different conditions, scope for potential to contribute potentially lesser due to generation sources less closely aligned to carbon emission policies, unless can move to lower carbon or renewable sources.
Industrial and Commercial: Peaker DSU (turn up on-site generator)	1	2	Already contributes to ramping, scope for greater relative contribution vs conventional alternatives due to greater availability and flexibility at different times and in different conditions, scope for potential to contribute potentially lesser due to generation sources less closely aligned to carbon emission policies, unless can move to lower carbon or renewable sources.
Industrial and Commercial: Peaker DSU (turn down on-site energy consumption)	1	1	Does not yet contribute to ramping, scope for potential to contribute potentially lesser due to consumption sources less available to respond for extended lengths of time as required for ramping.
Aggregated Generator Unit	1	2	Already contributes to ramping, scope for greater relative contribution vs conventional alternatives due to greater availability and flexibility at different times and in different conditions, scope for potential to contribute potentially lesser due to generation sources less closely aligned to carbon emission policies, unless can move to lower carbon or renewable sources.
Residential Demand Side Response	1	2	Does not yet provide ramping but has scope to develop this capability, relative contribution may not be as high as others as may not be main focus vs other system needs and services.
Dispatchable Demand (turn up on-site energy consumption)	1	2	Does not yet contribute to ramping but has scope to develop this capability, relative contribution may not be as high as others as may not be main focus vs other system needs and services.
Implicit Demand Side Response	0	0	By definition, does not take part in explicit arrangements.
Large Energy Users	1	2	Does not yet contribute to ramping but has scope to develop this capability, relative contribution may not be as high as others as may not be main focus vs primary activities.

4.7 Fast Frequency Response

Fast Frequency Response has quicker response times than the reserve products, which mean that different models of demand side response may be more or less suited to this service than slower reserves. In particular, sources with on-site generation may not be as suited if this generation is not synchronised to the grid to increase their generation in the timeframes required, or if synchronised if they would typically not have headroom available to provide the service. Those which turn down or off on-site consumption could be better suited to such a fast acting service if quickly switching processes consuming electricity on or off. However, they would not be able to provide “dynamic” FFR. Having sufficient volume of this service will be important for managing the power system at very high levels of SNSP and, given the reduction in conventional units synchronised to the power system at higher levels of SNSP, it will be important to have alternative resources with characteristics which are well suited to such high renewable energy output periods.

Fast Frequency Response - Indicative High-Level TSO Assessment			
Technology	**Current**	**Potential**	**Comment**
Industrial and Commercial: Long-run DSU (turn up on-site generator)	1	1	Already contributes to fast frequency response, relative contribution may not be as high as others as may not be main focus vs other system needs and services.
Industrial and Commercial: Peaker DSU (turn up on-site generator)	1	1	Already contributes to fast frequency response, scope for potential to contribute fast frequency response generally less for non-synchronised generation sources than consumption sources.
Industrial and Commercial: Peaker DSU (turn down on-site energy consumption)	2	3	Already contributes to fast frequency response, scope for greater relative contribution vs conventional alternatives due to lower minimum stable generation level and greater availability and flexibility at different times and in different conditions.
Aggregated Generator Unit	1	1	Already contributes to fast frequency response, scope for potential to contribute fast frequency response generally less for non-synchronised generation sources than consumption sources.
Residential Demand Side Response	1	2	Does not yet contribute to fast frequency response but has scope to develop this capability, relative contribution may not be as high as others as may not be main focus vs other system needs and services.
Dispatchable Demand (turn up on-site energy consumption)	1	2	Does not yet contribute to fast frequency response but has scope to develop this capability, relative contribution may not be as high as others as may not be main focus vs other system needs and services.
Implicit Demand Side Response	0	0	By definition, does not take part in explicit arrangements.
Large Energy Users	1	2	Does not yet contribute to fast frequency response but has scope to develop this capability, relative contribution may not be as high as others as may not be main focus vs primary activities.

4.8 Voltage Control / Reactive Power

While consumption and electrical characteristics of demand sites have an impact on, and are impacted by, voltage and reactive power levels, demand sites have not been actively used to manage voltage. It may be physically feasible to develop this capability for demand sites to contribute towards voltage control, and there may be characteristics of demand side response which would be useful for such a service, including the locational diversity of the sites. However, there are a number of aspects which would likely limit the potential for contribution. In particular, changes to reactive power and voltage on the distribution system level would have a smaller impact on the transmission system level. Therefore, the relative value of developing demand side resources to contribute towards this system need versus utilising other resources would need to be considered.

Voltage Control / Reactive Power - Indicative High-Level TSO Assessment			
Technology	**Current**	**Potential**	**Comment**
Industrial and Commercial: Long-run DSU (turn up on-site generator)	1	2	Does not yet contribute to reactive power but has scope to develop this capability through TSO-DSO coordination, relative contribution may not be as high as others due to diminished impact of distribution system voltage / reactive power on transmission system.
Industrial and Commercial: Peaker DSU (turn up on-site generator)	1	2	Does not yet contribute to reactive power but has scope to develop this capability through TSO-DSO coordination, relative contribution may not be as high as others due to diminished impact of distribution system voltage / reactive power on transmission system.
Industrial and Commercial: Peaker DSU (turn down on-site energy consumption)	1	2	Does not yet contribute to reactive power but has scope to develop this capability through TSO-DSO coordination, relative contribution may not be as high as others due to diminished impact of distribution system voltage / reactive power on transmission system.
Aggregated Generator Unit	1	2	Does not yet contribute to reactive power but has scope to develop this capability through TSO-DSO coordination, relative contribution may not be as high as others due to diminished impact of distribution system voltage / reactive power on transmission system.
Residential Demand Side Response	1	2	Does not yet contribute to reactive power but has scope to develop this capability through TSO-DSO coordination, relative contribution may not be as high as others due to diminished impact of distribution system voltage / reactive power on transmission system.
Dispatchable Demand (turn up on-site energy consumption)	1	2	Does not yet contribute to reactive power but has scope to develop this capability through TSO-DSO coordination, relative contribution may not be as high as others due to diminished impact of distribution system voltage / reactive power on transmission system.
Implicit Demand Side Response	0	0	By definition, does not take part in explicit arrangements.
Large Energy Users	1	2	Does not yet contribute to reactive power but has scope to develop this capability through TSO-DSO coordination, relative contribution may not be as high as others due to diminished impact of distribution system voltage / reactive power on transmission system.

4.9 Commentary on additional attributes

There are other attributes which are not included in this analysis, as they would either generally not be considered "TSO power system needs" (although they may affect the value or relative impact of different forms of demand side response providing TSO power system needs), or they may not be considered relevant to demand side response, or they may not be considered within the capabilities of demand side response. The following sections outline some considerations on a few of these additional attributes.

4.9.1 Renewable energy and emissions

Different approaches to demand side response can have a different impact on meeting renewable energy and decarbonisation targets. This relationship may not be simple and clear to establish, as there would be nuances in the different impacts from the direct carbon intensity of the activation of the resources, the operation of these resources for the provision of services over time, and the comparison of this against the operation of alternative or existing options. Factors to consider include:

- Demand Side Response from on-site generation vs on-site consumption;
- If based on on-site generation, if that generation is a renewable vs non-renewable resource;
- Life cycle carbon impacts of development phase vs operating phase;
- Relative operational carbon impact and efficiency of providing energy and / or services vs conventional and lower carbon / renewable alternatives at different times;
- Opportunities to manage / decrease curtailment and surplus of renewables.

Historically, peaker DSUs using on-site generation have tended to use more carbon-intensive fossil fuel generators. Long-run DSUs might use more efficient carbon emitting generators, such as Combined Heat and Power (CHP) gas plants. Approaches which are based on turning down on-site energy consumption result in less energy needing to be generated, meaning that if the generation at that time would have been from carbon-intensive sources then this reduction in energy would help reduce the total amount of carbon emissions on the system. However, these would typically not be able to provide response for longer periods of time compared with the response capable from on-site generation, which may limit their total effectiveness for decarbonisation, even if they are effective in the periods in which they respond.

The ability to turn down long-run DSUs at times of high renewable penetration allows for greater amounts of renewables to generate before requirements for curtailment of renewables arise, which may be a useful resource before suitable dispatchable demand models (turn up of on-site energy consumption) are developed. The effectiveness of this depends on what other changes are needed on the site due to turning down or off the on-site generator, for example if carbon intensive processes are required to replace the outputs of the on-site generator which was turned down.

Turning up demand at times where renewable generation would otherwise be dispatched down may have only a fractional impact on improving renewable and carbon targets in the electricity sector alone. However, it may have the impact of reducing the emissions of the site now consuming this electricity, which may have a positive impact on such targets in other sectors. The potential impact on cross-sectoral emissions could be complex. For example, an overall increase in electricity demand could result in an increase in emissions from the electricity sector if the marginal unit emits carbon. However, if this electricity demand increase represents a decrease in carbon intensive energy consumption in another area, then this could represent an overall cross-sectoral emissions reduction. In the longer term, there could also be value in lower carbon electricity being used to help produce fuel (such as hydrogen) which could help further decarbonise sectors such as transport and industrial processes where current higher carbon fuels could be replaced. The relationship with the primary energy sources across electricity and other sectors will be important in considering the impact on carbon emissions.

It will be important for the various renewable and carbon emission targets that the actual carbon emissions from the operation of demand side response are accurately accounted for. Where appropriate it may also be useful to consider the other carbon emission impacts of demand side response versus the alternatives, including the total impact on cross-sectoral emissions, and the life-cycle emissions impacts including the development phase and the operating phase of these resources.

For both peaking and long-run forms of demand side response with on-site generation, there is a chance that renewable energy and storage could be used, or that less carbon intensive fuel sources could be adopted. If this were possible, this could help improve the capability of these forms of demand side response to improve their potential to contribute overall in meeting TSO power system needs. This could be driven by requirements in the Capacity Market around maximum annual average levels of carbon emissions (driven by EU legislation and state aid requirements), operational considerations arising from Environmental Protection Agency greenhouse gas emission permits, or simply by the price and cost dynamics of operating carbon-intensive sources of demand side response.

4.9.2 Other system requirements

The scope for demand side response meeting other TSO power system needs around system stability and security is limited. Large Energy Users (LEUs) may have some potential to contribute to providing these needs depending on how they develop on-site consumption and on-site generation demand side response in future.

Demand side response approaches would not typically have characteristics which enable them to provide services (other than those presented in the previous tables) related to system stability, system strength, system restoration, or blackstart. Different sources of demand would have an impact on system inertia, in particular when relating to motor-based demand, and short circuit / fault levels, depending on their location in the network topology and in relation to generation sources. However, given the position of these sources as being primarily connected to the distribution system, the variety in the sources of demand in an aggregation in terms of position on the network, and relative size of the individual sites and possible aggregations, there is little scope for control or the provision of services to meet the TSOs' inertia or short circuit / fault level requirements.

LEUs may be the only source of demand side response where there is the potential for growth to meet some of these needs, especially if they are connected to the transmission system. However, currently some LEUs, in particular data centres, are presenting challenges to the resilience and stability of the power system due to their response to power system faults. Many data centres intentionally reduce their power consumption from the grid in response to significant disturbances on the power system before then automatically restoring their consumption after the disturbance has been cleared. The TSOs have established an industry Task Force with data centre customers to assist in the development of solutions to this issue and are planning to propose a modification to the Grid Code that will set out 'Fault Ride-Through' requirements for all Demand Facilities connected to the Transmission System.

In the future, it might be possible that LEUs could potentially provide demand side response with sources that have grid forming capabilities for example, at a scale and in locations which can be more easily controlled and used to meet TSO power system needs.

4.9.3 Relationship with proposed definition of "demand flexibility" from the CRU National Energy Demand Strategy decision

Increased duration and number of potential daily activations can increase demand side response's contribution to the CRU "flexible demand" target. However, it would be important to consider other capabilities in a broader portfolio, including those which are shorter duration, if they are helpful in meeting system needs even if not as impactful in contributing to the "flexible demand" target.

EirGrid generally agrees with the "volume shift" approach to calculating the target which is set out in the CRU's NEDS decision, and the inclusion of energy storage resources alongside demand side response. This definition is based on the volume of energy in MWh that can be flexed up or down compared with the average daily energy consumption in MWh, and therefore considers the daily potential capability of demand flexibility resources. We believe that this approach generally aligns with EirGrid's views of where efforts for flexibility should be focussed (e.g. not just an increase in the MW capability, but also in longer durations of storage or demand response, and a greater number of potential daily activations from demand side response).

This approach to defining the demand flexibility targets appears to align with what would help improve demand side response's capability to meet power system needs. Also, since it is not based on utilisation it does not appear to incentivise additional usage of the resources just to meet the targets – the decisions on when and how to use the resources can be taken in an efficient way considering the need to use those resources. However, since this proposed approach to calculating the target would be based more on capability, it would also be very important to monitor the actual availability and effectively measure the delivered response to ensure that this capability is available and reliable when required to meet a system need.

Demand side response can be important and make an impact contributing to meeting system needs, but as it currently operates it would have less potential to contribute to this demand flexibility target as defined by the CRU proposal. This would be because of typically smaller and limited durations of response when activated, and a limited number of activations possible in a day. However, there is scope to improve this by incentivising longer duration responses from demand, including through the "Dispatchable Demand" upward activation approach through the Dispatchable Consumption Unit – for example, it may be easier to decide to increase electricity consumption for a particular purpose for a longer period of time than it may be to decrease electricity consumption for a particular purpose for a longer period of time.

Higher contribution towards the demand flexibility target also does not necessarily correlate with which resource types would be needed to help with other system needs. For example, when considering what can help accommodate more surplus renewable energy, from analysis EirGrid and SONI carried out for Shaping Our Electricity Future (SOEF) v1.1 analysis, it appears that demand flexibility may have a greater relative impact in this respect. Certain system needs, such as operating reserves, are for shorter durations but can impact on carbon emissions based on the way that resources need to be operated to provide these services. Therefore, it will be important to also consider the need for broad portfolios of capability, including demand side response with shorter durations, that would be impactful in helping meet system needs even if they are not as impactful in contributing to the "demand flexibility" target.

4.9.4 Relationship with DfE Flexibility Plan

It will be important to monitor and engage on plans for demand flexibility in Northern Ireland as they are developed further, in particular the Smart Systems and Flexibility Plan.

It should be noted that while there is currently no explicit target for demand flexibility or similar in Northern Ireland, DfE's consultation paper for the Northern Ireland Smart Systems and Flexibility Plan outlines an intent to develop a mechanism to monitor the development of flexibility[33]. This may be different to the approach considered in Ireland, as it mentions using the GB Smart Systems and Flexibility Plan Monitoring Framework. Developments in this area will therefore be considered as the TSOs formulate their plan to ensure that they remain consistent with the goals set in both jurisdictions.

[33] https://www.economy-ni.gov.uk/sites/default/files/consultations/economy/Transitioning-net-zero-energy-system-Consultation-design-considerations.pdf

5 Issues and initiatives to be considered in future work

This section of the White Paper summarises and highlights issues as well as potential initiatives and areas of work to be considered. This includes those raised by the demand side response industry and those highlighted by the TSOs. This is intended to try and provide as full a picture as possible of all of the various potential areas of work to be considered in the future planning work through the development of a high level demand side plan.

5.1 Market trading and settlement across energy, capacity, and system services

The demand side response industry has raised concerns about not being able to fully represent the particular characteristics of their assets and differences in how they operate compared with other unit types across a number of areas. One example is in availability for provision of energy and services, where certainty on these metrics for demand side response would typically come closer to real-time than conventional generators. Demand side response operators have highlighted that the timing of holding ex-ante auctions for System Services would be important in determining the level of volume they could offer. Similarly, more regular shorter-term Capacity Market auctions may also suit demand side response better than longer term auctions multiple years ahead. Arrangements relating to providing incentives to invest in improvements to existing capacity, such as conversion to lower carbon or renewable fuel sources, could also be further considered.

The demand side response industry has offered suggestions for how DSUs could be treated in the Capacity Market in ways they would see as improvements, such as counting multiple DSUs towards the same Capacity Market requirement. This portfolio approach could mean that the composition of the individual DSUs could be optimised for other purposes, such as system services, while also overall being able to meet Capacity Market obligations. Within the Capacity Market, demand side operators have expressed concerns about the de-rating methodology as it applies to DSUs. The methodology has resulted in continually lower values for their marginal de-rating factors. This result is based on assessments of past performance for capacity availability of existing DSUs, the impact of the energy-limited nature of many DSUs, and application of de-rating factors across all DSUs regardless of individual model / approach or performance. Alternative approaches could be considered, such as basing assessment of DSUs on what they could theoretically contribute to reliability on the system rather than based on past capacity availability performance of all units, or considering a different capacity baseline for consideration against availability. However, if the use of these alternative approaches were to be investigated, the potential impact this might have on the capacity requirement, volume adjustments this may require, and therefore the potential impact on the overall amount of capacity procured and consumer cost of this, would need to be further considered and analysed.

The main trigger for the reliability element of the Capacity Market, the Strike Price, has an input parameter representing the average DSU cost which at most times acts as a floor on this price. The value of this parameter, set by the Regulatory Authorities, will also have an influence on both the value of the Capacity Market to DSUs, and their approach to reflecting their costs in trading in the ex-ante energy markets and in offer prices to the balancing market. The demand side response industry has also made a number of suggestions for changes to the Bidding Code of Practice (BCOP) / Balancing Market Principles Code of Practice (BMPCOP) around reflecting their costs.

The approach to charging different aspects of demand for various different network and market charges could also be considered to ensure that the intended locational and market participation incentives are enabled, and to ensure that there are no unintended negative consequences, disincentives, distortionary incentives, or inconsistencies. In particular, it may be worth considering the most appropriate approaches, from market participation and cost charging perspectives, for sites providing demand side response in different kinds of ways. For example, this could consider the relationship and interaction between their contribution towards meeting system needs in the wholesale market arrangements and their payment for this (such as through the capacity market), and the impact this demand side response has on that site's metered wholesale market demand on which market charges are levied (such for the capacity market costs).Demand side response may also play an important role in contributing to congestion management services the DSOs are seeking to procure. There could be potential for the TSOs to consider developing similar services to the DSOs for managing transmission system congestion when the new system services arrangements have been implemented through the FASS programme. The new Network Code for Demand Response is expected to include a number of requirements for how such congestion management services would work, which will need to be considered further when that enters into force.

How such services will operate in the future will need to be developed further through the TSO-DSO Operating Model work separately ongoing with the DSOs in both jurisdictions. This will seek to establish approaches to coordination between the TSOs and DSOs to enable each system operator's solutions to be utilised to manage individual and shared issues, and enable growth in the development of DSO and TSO services, including from demand side response. Doing this in a coordinated way between the TSO and DSO can help maximise the availability of distribution system flexibility and ensure the continued safe, secure and economic operation of the transmission and distribution systems. The future operating model would introduce new arrangements and improve upon the current more static "Instruction Set" arrangements which limit the available response DSUs can provide to the TSOs based on distribution system limitations. For example, ESB Networks are piloting more dynamic approaches to instruction sets, considering the operating conditions on a particular day, which could deliver an ability for the DSO to better facilitate participation of DSUs in providing balancing and system services in congested areas. EirGrid are working with ESB Networks on the TSO-DSO interactions required to enable this. The TSOs will also work with the DSOs on roadmaps for the further development of Residential Demand Side Management.

The approach for settlement of DSUs in the energy markets has been different to other unit types. DSUs currently operate in a model where they must purchase at the wholesale market price the energy that they sell as demand side response, and where their metered quantity is set equal to their dispatch quantity. This has the effect that they do not have full balance responsibility in all scenarios. Typically, the DSU buys the energy, through its Trading Site Supplier Unit, that it sells as demand reduction, and thus pays back the portion of their energy revenue at the market clearing prices, in order to not double-count against the energy revenue impact of the Individual Demand Sites' metering on their Supplier Units. Note that this is not the case during an event where the market reference price for a DSU for its reliability option under the Capacity Market is greater than the Strike Price. The demand side response industry has suggested that if this settlement approach were to change so that DSUs would retain the full energy market revenue that this would help to better incentivise trading and availability in the energy markets.

The SEM Committee made a decision (SEM-22-090) to change the energy settlement approach over two phases. The first of these phases ("Phase 1") would work as an interim solution to ensure DSUs receive / retain full energy market revenues in all periods and not just during periods where the market reference price for a DSU for its reliability option under the Capacity Market is greater than the Strike Price. The second phase ("Phase 2") would look to a fully enduring model where a metered quantity for the actual measured demand response would be incorporated into energy market settlement, both on the DSUs and accounting for the impact on Supplier Units from the response their customers provide to the DSUs. In August 2024 the SEM Committee published a further consultation on a Revised Phase 1 solution energy payments for DSUs[34].

It is important to recognise that these solutions would not be a straightforward change. The solutions for Phase 1 or Revised Phase 1 would involve additional design and implementation work to central market systems. The changes required for a Phase 2 solution would be much broader. It would be significantly dependent on data systems and transfers that do not exist within the current wholesale market design and systems and will involve significant time and investment to deliver, including interactions with the

[34] https://www.semcommittee.com/files/semcommittee/2024-08/240823%20SEM-24-046%20Consultation%20DSU%20Energy%20Payments.pdf

Supplier Units associated with each IDS, and measuring the delivered demand response, such as through an appropriate baselining methodology. The scale of the changes could potentially result in a multi-year, cross industry implementation project that will fundamentally affect a number of systems, processes and resources.

Given the energy and/or time limited nature of many instances of demand side response in the wholesale energy markets, there could be complex intertemporal effects in the relationship between trading in the ex-ante markets and being available and dispatched when needed in the balancing market. For example, a DSU could trade in the ex-ante markets in ways which appear, with the information available at the time in advance, to be the most beneficial to meeting power system needs. However, when more accurate information is available closer to real-time, it may be that the times for that DSU to be most beneficial to meeting power system needs in the balancing arrangements are later. If the DSU has reached its limits from being dispatched for the original ex-ante market trade, then it may not be available at the later time when it would have been beneficial to meeting power system needs in the balancing arrangements. If the potential contribution towards energy market trading grows in the future, this intertemporal effect will likely need to be explored more, including if there may be suitable mechanisms, such as through incentives or requirements, to help such energy limited instances of demand side response to be available at the times they may provide the most benefit.

Finally, there may be other challenges to developing demand side response markets and products, and approaches to consider in mitigating these challenges, which have not yet been identified or which may arise over time. The CRU has identified in its NEDS decision, and separately the DfE has identified in its Northern Ireland Smart System and Flexibility Plan consultation, a desire to identify such challenges and opportunities to resolve them. EirGrid and SONI support evolving the wholesale market arrangements in ways which would encourage more effective demand flexibility contributing towards meeting system needs. The CRU has also identified in its NEDS decision the possibility for a TSO demand flexibility product to be developed and have requested EirGrid to review the potential options. There may be ways in which products outside of the existing wholesale market arrangements could be more effective in helping deliver and accurately reflecting the capabilities of particular approaches to demand side response to meet particular power system needs. Therefore, the TSOs will review this possibility where it is believed it may be of benefit.

5.2 Demand Side Unit model structure and sources

In addition to the particular suggestions around portfolio approaches to meeting Capacity Market obligations put forward by the demand side response industry, wider concerns and suggestions on the approach required of DSUs in structuring themselves to provide services, capacity, and energy have been raised.

The current arrangements require each demand side aggregation to be represented by the same DSU model, with site-unit relationships aligned across all markets and structures, for capacity, energy, and system services. This could result in those DSUs being optimised for the provision of the more binding of the combined capability and performance standards across capacity, technical characteristics, or service provision, which may result in a restriction in their flexibility. Suggestions have been made to investigate if it would be possible to develop an approach where a DSU could register different units, with different aggregations of sites and technical characteristics, across all of the different market arrangements while being able to separately meet obligations in each of those arrangements. However, requiring alignment of units and technical characteristics across markets and arrangements generally underpins all market arrangements and is important for ensuring consistency in meeting obligations across different arrangements, so considering alternatives would be complex.

The Trading and Settlement code requires that if an Individual Demand Site contributes greater than 10 MW to Demand Side Unit MW Capacity then it cannot form part of an aggregated unit - the DSU can only represent this single site. This matches with the De Minimis requirements for registration of individual Generator Units with a Maximum Export Capacity greater than 10 MW, and requirements for generation stations greater than 10 MW needing to hold a licence. It has been suggested by the demand side response industry that allowing aggregation of sites greater than 10 MW could unlock additional flexibility which is not being made available by larger sites. It may be worth considering other aspects related to Individual Demand Site capacity to provide clarity and maximise benefits. Examples could include the impact of larger response sizes from a single site, whether it would warrant the concept of a maximum capacity from an Individual Demand Site in an aggregation or single-site DSU, the relationship between the level of demand side response (in particular when sourced from on-site generation) and the Maximum Export/Import Capacities of a site, and potentially different approaches where the demand side response is from on-site consumption or on-site generation.

It may be appropriate to consider developing different arrangements for different models of demand side response which have different characteristics, for example in how they operate and their underlying cost structure. Segmentation of different approaches to demand side response into different groupings which have shared characteristics may be a more suitable way to ensure that participants can most accurately reflect their full capabilities, and therefore ensure that their participation can best align with how they can meet power system needs, than maintaining the current one-size-fits-all approach under the DSU model. It could be explored if such segmentation could be done in a more informal way, such as through incentives, or if a more explicitly formal approach such as changes to codes or creation of new kinds of products could be more effective.

There can be very large differences between those DSUs which are based on turning down on-site energy consumption and those which are based on turning up on-site generation, and big differences between those which operate on an “long-run” basis and a “peaker” basis. For those that have on-site generation, it would be useful to consider characteristics such as emissions levels or any operational considerations arising from emissions limits, and other constraints which are not currently reflected in the technical data provided. This information is less relevant to other models of demand side response, and could be useful in helping to encourage the development of lower carbon DSUs. Since the generation can be explicitly and individually metered, this could be used to help with the methodology of calculating the actual amount of response achieved for this model, which may not be possible for models where the response is from turning down on-site consumption.

There may be an important distinction between on-site generation and on-site consumption when interpreting the intent of European and local policies around promoting demand side response. While there are requirements to be technology neutral, demand side response seems to be considered primarily in terms of changing on-site consumption in such policies, with changes in on-site generation seeming to be considered separately as distributed energy resources / distributed generation. It may need to be considered whether on-site generation should be treated more explicitly as a form of aggregated generation, with a different set of arrangements in terms of model structure and requirements, rather than as a form of demand side response alongside other sites with changes in on-site consumption. The Aggregated Generator Unit model is used in Northern Ireland (with similar limits to DSUs established in legislation where only generators less than 10 MW can be included in an aggregation), but there may be gaps in the approach in Ireland which may hinder use of such a model there – changes to address any such gaps could be considered.

For demand side response based on changes in on-site consumption, it would be useful to capture additional characteristics in the technical data provided, such as limits in the amount of energy, amount of time, or number of instructions for which the response is available. These limits could be due to reasons such as meeting physical or safety requirements or commercial impacts for the main activities of the site, which may feed into agreed availability levels between the site operator and the aggregator.

Some demand side response providers may wish to concentrate on certain market arrangements over others (e.g. provision of system services but not provision of capacity adequacy or energy balancing capability) while others may wish to participate in multiple or all market arrangements. Since the various market arrangements have different requirements and focus on different operational and commercial characteristics, it may be appropriate to have different arrangements to enable a provider to more accurately reflect its optimal individual capabilities. This could be an improvement over one-size-fits-all approaches where providers need to be able to meet all requirements, or where the limited capabilities of one model may disadvantage the opportunities of another model (for example where the characteristics of less flexible DSUs could limit the opportunities for those DSUs which have more flexible characteristics).

Suggestions have been made to investigate the potential for more complex bid structures or dispatch instructions to take into account greater flexibility in characteristics, such as different notice times, durations of response, and ramp rates depending on the levels of dispatch and the different services being activated.

While the TSOs do not currently consider the locations of individual sites in demand side response aggregations, this may be an area of interest to develop in the future to enable co-ordination with the DSOs, and to enable demand side response for location-specific services such as congestion management. The locational aspects of demand side response are likely to become more important in the future in enabling other services, where congestion issues and limits in certain locations (such as those managed by DSO "instruction sets" today) may reduce the effectiveness of a unit in aggregate meeting a more general system need such as energy balancing or reserves. Since demand side participation in DSO services is expected to grow, it will also be important to ensure definitions and approaches work together between the DSOs and TSOs.

5.3 Performance of Demand Side Units

Concerns have been raised about the level of availability (forecasted and real-time) DSUs have provided compared with their capacity, where it is lower than expected by the TSOs compared with other Capacity Market Unit types. There has also been a number of individual DSUs whose actual response when dispatched has not aligned with expectations. Some units reduce their availability at short notice, in particular after being issued a dispatch instruction, and some units appear not to be operationally available to meet certain Grid Code requirements after passing tests which showed them to be capable of meeting these requirements, e.g. the 2hr maximum down time requirement.

Some of these concerns may be addressed by clarifying and better defining the expected performance of DSUs, in particular for capacity availability, and redefining the metrics to input into that process in a way which better reflects the differences in DSUs against other unit types. For example, if Operational Certificate capacity testing were to better reflect the portfolio nature of a DSU's operational availability across its sites, and that metric were reflected in the market participation and capacity availability performance expectation, then this may help align market volumes, expected performance, and actual performance. It has also been suggested by the demand side response industry that changes to energy settlement could incentivise increased capacity availability from DSUs.

Concerns have also been raised about other submissions, declarations, and actions by a number of individual DSUs, including to minimum stable generation levels and Physical Notifications (PNs). Some DSUs have been found to trade in the energy markets and submit PNs in a way which is not consistent, such as trading in the ex-ante energy markets to a level matching their capacity, while their PNs may be much lower than this, sometimes reflecting availability being lower than the traded level. This is not behaviour the TSOs would expect from such units, as Final PNs should reflect ex-ante market trading positions to the extent possible to comply with SEM Committee decision SEM-15-065, and in general efforts should be made to trade only up to the level for which a unit knows they will be available. Some DSUs also submit PNs which are inconsistent with their Technical Offer Data, which is not compliant with the requirement in Trading and Settlement Code paragraph D.7.1.4.

Normally exposure to imbalances provides a financial incentive against such trading behaviour, but DSUs do not currently have this exposure to imbalances. The TSOs will continue to work alongside the Market Monitoring Unit of the Regulatory Authorities in raising and managing issues of market data submission, trading, and performance in availability levels and actual response against dispatch. Inclusion in Generator Performance Incentives and Uninstructed Imbalances could also help with better matching actual response to dispatched levels and to reduce the impact of DSU submissions to the system (e.g. reducing availability at short notice). More effective measurement of the demand response delivered when called upon by the TSOs, for use in settlement as considered by SEM Committee in their consultations on enduring energy settlement arrangements, will also be important for measuring improved performance and ensuring balance responsibility for DSUs in all scenarios through exposure to imbalances.

5.4 Implicit demand side response

Over the next decade, there will be a drive towards increased electrification of heat and transport, the completion of smart meter rollout in Ireland, and the expected start of smart meter rollout in Northern Ireland[35]. Consumers can be more greatly empowered to change their consumption patterns and behaviours in ways beneficial to themselves and to the system, either directly or through smart home devices and services.

A number of recent documents have outlined the intention and potential benefits and other considerations around the development of smart meters and other aspects relevant to enabling and encouraging effective implicit demand side management in Northern Ireland. These include the cost benefit analysis on the implementation of smart meters[36] (following which it was announced that a plan for the implementation of electricity smart meters and systems would be developed), and the consultation on the Smart Systems and Flexibility Plan[37]. This consultation considers the potential benefits to customers and the power system of implicit demand side response and demand flexibility enabled through smart meters, and ways to encourage it including through time of use tariffs and different ways of engaging different types. Work by Ulster University, commissioned by DfE, also considers different aspects relating to the potential benefits of smart meters and demand side response, and ways to help enable demand flexibility[38].

All electricity retail suppliers in Ireland have started offering “smart tariff” pricing structures with changes in prices for different times of day. These include daytime, peak time, and nighttime rates, and some also offer specific rates for charging electric vehicles or boosting heat pumps, and free or discounted rates at certain periods of the night or the weekends. As part of the Climate Action Plan 2023[39], more dynamic “green” tariffs are intended to be developed to incentivise shifting of demand to times of high wind and solar output. There may not need to be specific changes proposed to the wholesale market arrangements to enable implicit demand side response. It will be important to ensure that there is an appropriate linkage between what is happening in the wholesale market with what the suppliers can offer in the retail electricity market.

Dynamic tariffs reflecting the wholesale market prices could be helpful, encouraging customers to respond to the operational signals which exist in the wholesale markets. Dynamic tariffs would also ensure that less flexible demand is contributing appropriately to the cost of the system meeting their needs, e.g. ensuring there is sufficient generation on the system. For customers unable to respond and benefit from this it would be useful to have a price signal which feeds through the wholesale market price signals, which are reflecting the operational situation of the power system in a period. However, care needs to be taken in understanding the extent to which these signals can be provided through such tariffs to ensure that assumptions for these developments and expectations for their potential impacts are correct.

There is the potential for smart meters to have even greater impact, including through innovation in the time-of-use tariffs, offering of “smart services” in addition to “smart tariffs”, and improved provision of data and learnings to consumers. Suppliers could provide implicit demand side response if customers sign up to such “smart services”, where suppliers help to manage aspects of their customers’ electricity demand to maximise the benefits to themselves, the system, and the customer. An example of this could be automation in managing the timing of charging electric vehicles in ways which align with system conditions and needs (e.g. higher renewables, lower emissions, network congestion), and using higher and lower priced tariffs to reflect these conditions. While there will be consumers who might wish to invest in equipment to enable them to provide demand side response, service providers including suppliers could

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35 https://www.economy-ni.gov.uk/articles/smart-meters-update
36 https://www.economy-ni.gov.uk/sites/default/files/publications/economy/smart-meters-cba-report.pdf
37 https://www.economy-ni.gov.uk/sites/default/files/consultations/economy/Transitioning-net-zero-energy-system-Consultation-design-considerations.pdf
38 https://pure.ulster.ac.uk/ws/portalfiles/portal/92995938/smart_meters_and_flexibility_report_final.pdf
39 https://www.gov.ie/pdf/?file=https://assets.gov.ie/243585/9942d689-2490-4ccf-9dc8-f50166bab0e7.pdf#page=null

also provide such equipment as part of their offering, which could help further reduce barriers to providing demand side response.

It will be important to consider the most effective approach to engaging different types of consumers, and if different opportunities can be made available depending on preferences and impact. For example, some consumers might wish to participate in schemes where they respond to explicit messages requesting action, while others might more effectively respond to price signals. Others may not wish to respond directly, but rather rely on other approaches, such as algorithmic approaches, setting parameters on automated smart home devices (e.g. energy management systems / home management systems). There are multiple potential approaches to this, which could be as simple as the consumer receiving a message requesting a change in consumption, or as complex as automated changes through connection with smart devices. The TSOs may be able to enhance communication of information which is available to it and which could be important to making decisions in different timeframes about demand flexibility, such as reporting of emissions, system alerts, and available network capacity.

The interactions between implicit and explicit incentives and signals for demand side response require further consideration to understand the potential impacts, and to determine if any arrangements should be considered to coordinate between them. Some consumers may be primarily or only incentivised by either implicit signals or explicit signals, in which case it will be the total effect across the market which would need to be considered (e.g. if response to implicit signals removes the need for explicit signals, if explicit signals were issued and responded to but then implicit signals resulted in "overshooting" the desired total response). However, many consumers may be responding to both implicit and explicit signals, in which case the effect on each single consumer may need to be considered. For example, if a consumer responds to an implicit retail tariff price signal by reducing demand, it may not be able to provide this demand reduction availability for the aggregator who intends to use it to provide explicit demand side response services. However, if the site leaves itself available for providing explicit demand side response services, it may not avail of the full cost saving opportunities from responding to the retail tariff prices. It will be important that the potential impacts of multiple interacting incentives on the same resources are considered to ensure the most efficient and effective outcome.

The cost impact of a move to "smart tariffs" will also not be the same for every consumer, and so this would need to be carefully managed. Some of the proposed changes in EU electricity market design are aimed at protecting consumers from the potential negative effects of dynamic wholesale market prices, and therefore may reduce the impact and incentives from more dynamic retail electricity market prices. While the proposals do allow for real-time tariffs to incentivise demand flexibility, the main intent of the proposals is about access to fixed prices in the long term markets. The proposals are largely focused on ensuring there are appropriate and liquid forwards markets, where suppliers will be under obligations to engage in hedging, to allow retail electricity market suppliers fix prices for their consumers on a long term basis to protect them from the wholesale market price shocks that have been experienced in recent years. This may mean that retail electricity market tariffs offered to consumers become focused on price-certainty, which could reduce the potential for implicit demand side response.

Any such change in energy consumption behaviour would naturally have an impact on the demand consumption profile, and therefore the operation and planning of the power system. The intended positive impacts of such a change would include reduced net demand peaks and troughs, better alignment of energy consumption with times of high renewable energy output, and decreased surplus renewables and curtailment of renewables. The level of impact that demand behavioural changes could have on system operations and planning is not yet fully proven, and care is needed to ensure incentives would not result in issues and unintended negative consequences. For example, there is a risk of more systematic consumption profiles developing with a diminished diversity of loads in some areas, which may lead to unintended consequences or additional challenges for system operations.

New consumption patterns might be difficult to forecast given the limited experience and availability of data. The nature of the relationship between this demand behaviour and other forecastable metrics is not as well defined as it is for the largely well-known current major drivers of consumption patterns, such as day of the week and temperature. This could be further complicated with development of consumer-level solar and storage, which can follow different patterns impacting net consumption from the grid. More work is required to understand changes that should be made to the demand forecasting process to account for implicit demand side response.

Where aggregating demand side response is done in a market context, the TSOs have arrangements for control and set out requirements for the operation of the aggregation, e.g. ramp rates. Where such aggregation is done outside of such market contexts, there may be concerns about the lack of rules for how this aggregation could be activated. There are few arrangements for how this is to work set out in the Grid Codes and Distribution Codes for normal operations (although some more control capability may be possible in emergency situations). This may be acceptable at smaller scales of such aggregation, but as the scale grows there would be greater concerns about how such large MW movements could impact the operation of the power system. This could be from intentional activation, or from mistakes being made in the absence of standards and obligations being set.

It needs to be considered if there may be a need to set requirements for how such an aggregator with control over large amounts of power outside of the market arrangements is expected to operate. This could start through developing bilateral relationships with the aggregators which are identified as having the potential to aggregate a large MW quantity, developing specific agreements and requirements with each of them. Then there is the potential to use the learnings from this to develop more general requirements under the relevant codes. It should also be considered if developing requirements to provide greater transparency in sharing information on implicit demand side response from suppliers, the DSOs, or end-users as relevant and as such information may be available, could be helpful for power system operations and planning. For example, it may be important to have information from suppliers on the level of electricity demand they intend to purchase when they are offering services which equate to implicit demand response.

5.5 Potential new models for explicit demand side response

In addition to the existing forms of explicit demand side response, a number of potential new models have been suggested.

Residential Demand Side Management (RDSM or ResDem) is often identified as a new potential source of a large volume of demand side response. Third-party aggregators and electricity suppliers could both have a role in providing ResDem. Retail electricity market suppliers have a key role to play in enabling, providing, and benefiting from ResDem, where “smart tariffs” will likely be a large driver. Suppliers could decide to provide explicit, rather than implicit, demand side response if their customers sign up to “smart services” in addition to smart tariffs, where they help to manage aspects of their customers’ electricity demand to help maximise the benefits to themselves, the system, and their customers. An example of this could be the provision of short-term reserves, response for network congestion, or energy balancing capability (in particular over peak demand periods).

This could have additional benefits to the supplier and customer on top of reduced costs from tariff charges, by being remunerated through the wholesale market arrangements. This highlights potential for suppliers to innovate their offerings in the retail electricity market to help better enable ResDem. However, the current arrangements for participation of demand side response in the wholesale electricity markets (energy, capacity, or system services) includes particular requirements around market participant entity models (e.g. DSUs) and different licence requirements in each jurisdiction (supplier licence in Ireland, shortened supplier and generator licence combination in Northern Ireland) which would need to be taken into account.

In the wholesale market and transmission system arrangements, there is currently no clear path for the development of ResDem, and changes to the wholesale electricity market arrangements may be required to enable ResDem. A number of smaller scale trials involving ResDem have been carried out in recent years, including those through the TSOs’ Qualification Trial Process (QTP). EirGrid is working with ESB Networks on the development of roadmaps and trials for the procurement of both DSO and TSO services in ways which enable ResDem to participate fully in the system and markets. SONI will engage further with NIE Networks to outline in more detail the vision and direction for this sector in Northern Ireland.

The installation of customer-side technology which can facilitate active customers to manage their demand in coordination with system operators is key to enabling ResDem. Standardisation will be important to ensure interoperability of customer technology. Setting standards at an earlier stage can help ensure that installations of the relevant technologies happening in homes prior to their use for ResDem would be ready when such use is developed. In addition, it could be considered whether there should be cases where the capability or activation of demand flexibility should become a requirement rather than something which is encouraged, for example in technology standards for System Operator controllability and communications. This may enable a reduction in barriers to participation in explicit demand side response, and potentially provide a mandatory backup from implicit demand side response in particular circumstances if the explicit arrangements are not sufficient to manage issues.

There is a large growth in demand from LEUs, which provides both a challenge whose impact needs to be accounted for, and an opportunity to engage with these users to explore opportunities to provide flexibility through demand side response in existing or new arrangements, either explicitly or implicitly. There is scope for exploring the development of capability for demand flexibility through incentives or through requirements. If there are arrangements and incentives in place, new types of LEUs, such as sources of electrified industrial heat demand, may be developed in ways such that they can provide demand side response capability, while existing types of LEUs could look to ways they could introduce changes or redevelopments to provide such demand side response capability.

Arrangements with enhanced reporting/certification and granular matching of demand consumption with renewable energy generation, and hybrid and/or non-firm demand connections, may help provide incentives for such flexibility. The role of the production of “green hydrogen” as a Large Energy User, and in particular its relationship with offshore wind connections, the 2GW offshore wind intended for “green hydrogen”, and production from “surplus” renewable electricity, as considered under the Climate Action Plan, also need to be fully considered. They have the potential to become a source of demand flexibility, which should be further explored.

Finally, a new model for demand side response focused on turning up demand on a site above its baseline in response to wholesale market prices (including dispatch by the TSOs) has been put forward in recent years. This could help manage issues with surplus renewables and curtailment of renewable electricity, while decarbonising other industrial sectors. It would be important to ensure that such demand increases are for productive and useful reasons, such as productive end uses which otherwise would not have happened, reducing corresponding amount of electricity consumption at other times which would have been more carbon intensive, or replacing more carbon intensive non-electricity energy consumption which otherwise would have been used at the time.

However, the existing rules, systems, market and system operational models do not allow for the operation of such a unit in the way intended. The potential impacts of developing such capability and ways in which to develop it would need to be investigated further. In particular, it may be important to consider requirements on which kinds of demand sites could provide this kind of demand turn-up solution, and to consider the prices at which such demand turn-up could be accommodated to ensure that there are no opportunities for exercising market power or gaming. This is currently being considered under the “dispatchable consumption” initiative in the Strategic Markets Programme being developed by the TSOs.

5.6 Technical and code requirements in systems and operations

Some demand side response operators have raised a number of specific issues related to the technical requirements and characteristics with which they are expected to comply, which they believe restrict the level of flexibility and therefore value they can provide, in particular related to system services. The TSOs and MO also have a number of limitations and considerations for how they operate DSUs, primarily related to the processes and systems used, the need to use more manual processes or workarounds where systems cannot accommodate the DSUs operationally in the same way as other unit types, and the larger scale of data related to DSUs (including the number of such units and the number of underlying Individual Demand Sites).

The demand side response industry has suggested making changes to the Grid Codes, in particular around changing the minimum size of an aggregation from 4 MW to 1 MW and removing a requirement for having a Maximum Down Time of at least two hours. It is suggested that these changes would result in greater volumes of availability for shorter term reserve products and unlock capability from some demand sites which would not be able to comply with the current Grid Code requirements. However, both proposed changes would also have an impact on the power system from a number of perspectives.

One potential impact is an increased incentive for the operational characteristics of DSUs to become more focused on the provision of reserve system services (and their shorter timeframes) than capacity adequacy (and its longer timeframes). While this may be beneficial for system services, careful consideration is needed as to whether it could be accommodated in the shorter term while the power system is experiencing its current security of supply issues related to capacity adequacy, while generally not having similar issues around reserve system services. Other concerns include the complexity, practicality, and certainty in the processes and systems for scheduling and dispatching units, which would further exacerbate security of supply issues. The potential impacts in the areas concerned would need to be better understood to determine the level of changes which would be required, and when it may be possible to consider accommodating these proposals in the context of system issues. Following a direction from the CRU, EirGrid has established a working group under the Grid Code Review Panel to engage on these proposals with the demand side response industry. Depending on the outcome of that process, this may require further work including potential alignment in the Northern Ireland Grid Code, and the different wholesale market codes.

Separately, there is a need to consider more broadly what the most appropriate approaches would be for standards, data, equipment, communications, monitoring, and metering approaches for different forms of demand side response. This could consider if there are ways to sufficiently meet TSO and MO needs which reduce the potential for barriers to development, or which could incentivise further growth and improvements in performance. More simplified approaches to prequalification, testing, data provision, and monitoring may be required under the future Network Code for Demand Response, with the aim of reducing such barriers. This general approach could be applied to some existing models of demand side response, but could be even more effective for newer models, such as ResDem.

From a systems and process perspective, the TSOs and MO currently need to carry out manually intensive work to accommodate DSUs, which can also prove to be onerous for the DSU operators themselves. This can include considering IDSs in registration, changes to IDSs registered to each DSU and switching between DSUs over time, performance monitoring, and testing. If the scale of demand side response grows into the future, more automation and alignment of systems and processes would be needed to help accommodate this, to maintain or reduce the level of manual work. It may be worth considering how more portfolio-based approaches looking at the overall impacts, rather than individual site-based impacts, could contribute to such improvements. The relationship between the TSOs and DSOs in managing the registration of sites and service providers for the provision of local and wholesale market services will also need to be considered further, including the context of potential future requirements under a new Network Code for Demand Response.

In real-time operations, the scheduling systems currently have limitations in how they represent the provision of services from DSUs, which require relatively onerous manual work to be able to represent this volume of service provision through the Interruptible Load parameter. Improvements in the scheduling of reserves for DSUs could be considered to help remove the need for this manual work and to better reflect the dynamic provision of reserve over time. For instance, this could include considering reserve curve characteristics in a similar way to conventional units (but enabling the counting of reserve from a position of 0MW rather than needing to be synchronised to a minimum stable generation level >0MW), and in general a more robust approach to providing real-time and forecast reserve provision data through EMS, EDIL, and the relationship between energy availability and service availability.

6 Next steps

This Demand Side White Paper has outlined the current high-level views and vision of the TSOs for the development of demand side response to meet the TSO power system needs for power system operations. It will be important to ensure that an achievable plan is developed to enable demand side response to further develop. To do this, the TSOs intend to carry out the next steps as set out in Sections 6.1and 6.2, including development of a demand side plan. Delivery of future initiatives, identified as part of the planning process, are subject to future funding requests and regulatory authority approval of same.

6.1 Demand Side plan

To enable demand side response to develop to provide maximum value, there are multiple issues to be resolved and initiatives to be undertaken. While this White Paper has outlined potential areas of work to consider in the future, work will be required on identifying and understanding these issues and initiatives in more detail. In considering these issues and initiatives, it will be important to balance between those issues which the demand side response industry have raised as barriers to development, and the issues experienced by the TSOs with demand side response to date (for example with the performance and operation of Demand Side Units).

Also, due to the overall scale of work required to meet the policy goals to 2030, the priority areas of this work to resolve issues and undertake initiatives need to be determined in a holistic way within the overall SOEF roadmap. These priority areas should focus on those changes which would be the most impactful to helping meet the 2030 goals, while also being the most achievable.

Therefore, after the potential issues and initiatives have been identified in detail, the TSOs intend to create a demand side plan. Some work on demand side response matters has already been identified and is already currently underway, or there are plans to carry it out in parallel. The plan would intend to take this into account alongside the other work identified when considering the priorities. The TSOs will also need to consider the importance of ensuring the safe and secure operation of the power system, and therefore the initiatives which can be included and prioritised in the plan will be within this context.

6.2 Engagement with stakeholders

As it is intended in these next steps to identify issues, initiatives, trials, and develop a feasible demand side plan in a way which has the greatest impact in enabling demand side response to provide maximum value, we intend to initiate and continue engagement with the DSOs, RAs, demand side response industry, and retail electricity market suppliers. This will be particularly important in discussing the relative priorities of these issues and initiatives, and the sequencing of when work can be carried out in those areas. This will need to be considered alongside all other changes, as part of the SOEF programme, and therefore engagement with stakeholders in that programme will also be required. EirGrid will also continue to engage with the CRU on the development of its National Energy Demand Strategy, and SONI will work with the DfE and UR on demand flexibility plans including through the Smart Services and Flexibility Plan, ensuring that the TSOs' demand side plan is cognisant of these developments where needed.

It is likely that there will be further discussion required on the funding and regulatory aspects where the initiatives being planned have impacts on capital and operational expenditure in ways which have not yet been reflected in the price controls for EirGrid, SONI, or SEMO. As is clear from the discussions in this White Paper, there will also be aspects which are dependent on, or led by, parties other than the TSOs or MO, including the RAs, DSOs, and retail electricity market suppliers, which will require ongoing engagement.

EirGrid and SONI would welcome any comments from interested parties on this White Paper. If desired, they can be submitted via email to SOEF@Eirgrid.com or SOEF@soni.ltd.uk with the email titled "TSO Demand Side White Paper". This White Paper and comments received about it will help to inform the development of the demand side plan. The work on this plan is intended to begin upon publication of this White Paper.