Ireland FuturEnergy

# Response to DECC consultation on Research and Innovation Strategy

16th August 2023

# 1 Contents

# 2 Introduction

FuturEnergy Ireland[1] (FEI) is a Joint Venture Group owned jointly by Coillte and ESB. The Group has been established with the initial high-level ambition of leveraging Coillte's significant landbank and development team to support the deployment of 1GW of onshore wind by 2030 and to deploy storage and solar technologies where these are complimentary to the core onshore wind objective. FEI is one of the largest dedicated developers of onshore wind in Ireland and our mission is to maximise the potential of our national resources and accelerate Ireland's transformation to a low carbon energy economy.

In the context of research and innovation to support the delivery of a decarbonised energy system in Ireland, we would note that most analysis and research to date would, at a very high level, point to the following as the most promising pathway to such a system in Ireland.

**#1 Decarbonise the power system.**

**#2 Leverage a decarbonised power system to decarbonise heat and transport through direct electrification to the fullest extent possible.**

**#3 Utilise biofuels and e-fuels only for hard to abate heat and transport applications, and then, only with due consideration of any potential unintended negative consequences.**

**#4 Implement efficiency measures where economic to do so.**

On Point 4, this should be implemented where the annuitized cost of the efficiency measure is less than the annuitized cost of achieving the same level of decarbonisation with renewable energy solutions and could include capture and utilisation of industrial waste heat, for example through district heating systems.

This very high level / concept level road map informs much of our response below.

The expertise of our team is in primarily in power system decarbonisation and as such, we will provide detailed feedback in relation to research and innovation in this area. We would acknowledge that we may have less expertise in the heat and transport sectors, and so our responses on these topics will be more general. We also may not have full visibility of all research and innovation (R&I) work currently being undertaken by the department and other agencies in these sectors. As such, in relation to heat and transport in particular, please use any feedback that's useful and ignore anything that is not.

[1] https://futurenergyireland.ie/

# 3 Strategic Goals

Our response is focussed on the following strategic goals as noted in the consultation paper:

- Be a recognised leader in climate action
- Transform our energy system for a net zero emissions future.

# 4 Research and Innovation Priorities

As noted in our introduction above, a deeply decarbonised energy system will likely require the delivery of a significantly larger and fully decarbonised electricity system. In this regard, we would suggest that the following topics are worthy of further of prioritisation under the proposed research and innovation strategy (noting some of this work is already in progress).

## 4.1 Delivering a net zero power system

- Research and innovation led by Eirgrid, supported by academic institutions and 3rd party consultants where necessary, to understand what measures are required to be able to operate our power system in a stable manner at 100% system non-synchronous penetration, with 0MW of constrained on fossil fuel generation.
    - What are the most efficient market mechanisms to procure the zero carbon system services needed to maintain system stability.
    - What new operational policy and protocols are required?
- A fully decarbonised power system with wind and solar energy at its heart, will require complimentary new storage and flexibility services to bulk time shift massive amounts of renewable energy from times of excess production to times of low solar and wind output.
    - What existing, new, emerging technologies have the potential to solve this bulk energy time shifting problem in an economic manner?
    - What level of low or no investment flexibility / bulk energy time shifting can be delivered through demand response to short term price signals?
    - What are the locational benefits of this bulk energy time shifting for transmission grids?
    - What innovative policy / regulatory / procurement approaches might be required to incentivise efficient investment and deployment of these technologies on the Irish power system[2].
    - Do we need to develop new sophisticated integrated network and market model tools to co-optimise procurement of renewables and bulk energy time shifting?
- What is the role of additional interconnection to neighbouring power systems

[2] Appendix 1 & 2 includes further details on a specific proposal for an innovative new competitive market based process for procurement of these bulk energy time shifting services.

- How many MW's of interconnection should be developed, connected to which neighbouring power systems?
  - How will the deployment of new generation technologies in these neighbouring power systems impact the cost / benefit of these interconnectors to Ireland?
  - How should investment in these interconnectors be most appropriately incentivised?
  - Where actual consumer costs become more disconnected from wholesale spot prices due to implementation of renewable CfD auctions, are resulting interconnector flows appropriate on a first principles basis. Is there any cross subsidisation of neighbouring jurisdictions? Are bilateral national government level agreements required in order to balance out any unintended cross subsidisation?
- Is there a significant export opportunity to contribute to European power system decarbonisation and how can / should Ireland benefit from this opportunity?

## 4.2 Accommodating power sector growth

Leveraging a deeply decarbonised power sector to support electrification of heat and transport, and to support the sustainable growth of the digital economy in Ireland, requires a transmission and distribution grid capable of accommodating greatly increased levels of electricity demand and generation. A study completed by UCC / MAREI[3] for Wind Energy Ireland indicated that our power sector may need to grow from a level of 30TWh p.a. in 2019 to a level of 84TWh p.a. in 2050. Noting that our transmission and distribution grids are already under some strain, and that timelines for the delivery of significant new transmission and distribution grid assets can run to over a decade, we would suggest that it is important to focus R&I efforts on:

- What level of investment is required in our transmission & distribution system over a time horizon out to 2050?
- What technology tools can be deployed to maximise the utilisation of the grid we have?
- What policy and regulatory measures should be established to incentivise system operators to develop and deliver traditional and innovative grid capacity solutions?
- What competitive market based procurement mechanisms can we develop to incentivise private investment in grid capacity solutions.
- How do we get broad public support for the generation, storage and grid infrastructure required to support the transition?

[3] https://windenergyireland.com/images/files/our-climate-neutral-future-0by50-final-report.pdf

## 4.3 Decarbonising Heat

We would note that while Ireland is a recognised global leader in electricity sector decarbonisation, we have historically been relatively less successful in the decarbonisation of heat. Over the last number of years there appears to have been a substantial amount of quality research done in relation to this sector (Ref SEAI heat study[4]), but perhaps not enough innovation, i.e. we are to date relatively light on the practical implementation of this research. Noting that residential heat emissions in Ireland are a relatively high proportion of overall heat sector emissions, focussing innovation efforts on the decarbonisation of the residential heat sector would now be timely. Noting limited expertise in this field, we'd suggest the topics below would be worthy of further consideration:

- Develop policy to support and expedite the delivery of district heating schemes in main urban centres, in particular Dublin in line with SEAI recommendations.
- Introduce policy innovations to incentivise and expedite a move away from fossil fuel heating in buildings (shifting focus from a fabric first principle – in line with SEAI recommendations).
- This could include the development and deployment of innovative financing / funding solutions to enable efficient private / domestic investment in zero carbon heating solutions, in particular heat pumps, where these have been identified as the best technical solution from a techno-economic perspective. (Critical that this is in tandem with the delivery of a fully decarbonized power grid)
- Expedite policy innovations to support decarbonization of industrial heat sector, prioritising largest emitters first.

The priority in the heat sector now should be building on research done to date, learning also from other countries that are more advanced, in order to innovate the delivery of solutions and enable rapid deployment at scale.

## 4.4 Decarbonisation of Transport

Again noting that our business has had limited engagement with existing research, innovation and policy in relation to transport sector decarbonisation we would suggest the following as areas worthy of further consideration:

- What level of investment is required in public and private charging infrastructure
- What impact does this have on the need for investment in electrical transmission and distribution grids
- How should investment in and delivery of charging infrastructure be best incentivised? Public / Private or combination of both?
- Which elements of the transport sector are unlikely to be amenable to direct electrification? What are the next best alternative solutions for these sectors?

[4] https://www.seai.ie/publications/National-Heat-Study-Summary-Report.pdf

- What policy and regulatory measures will support the switch to zero carbon transport options.
- Alignment with and support of EU policy and research on supply chain security for critical rare earth minerals required to support the transition.

Again, it is important to note that as we accelerate the electrification of transport, it is critical that we in parallel deliver a deeply decarbonized power grid. Additional electrical demand arising from the electrification of heat and transport, that necessitates ramping output from fossil fuel generation, will have a very limited emissions benefit.

## 4.5 Accelerated Delivery

Noting the aggressive carbon budgets that have been established across electricity, heat and transport, it would be beneficial to focus research and innovation resources on how to accelerate the deployment of carbon solutions across all sectors. For the electricity sector in particular, we would call out:

- What is required to accelerate the consenting of technologies that are critical to the decarbonisation of the power sector including:
    - Onshore wind
    - Offshore wind
    - Solar
    - Electricity storage for both frequency regulation & reserve services (short duration) and bulk energy time shifting (long duration)
    - Zero carbon system services, including synchronous condensers.
- What is required to accelerate the grid connection offer process for these projects
- Noting the sequential nature of planning permission followed by grid connection application, how do we avoid or reduce the need for a 2nd planning application for the grid connection of the original renewable asset.
- What policy / regulatory options are available to reduce project commercialisation and delivery timelines?
- Blue skies research and innovation to assess what other measures could we implement to accelerate project delivery?

## 4.6 Cost Effectiveness

Noting that the transformation of our energy system from a fossil based system to a sustainable renewable energy system will require capital investment running into the many tens of billions of euro over the coming years and decades, it is important to consider the policy and regulatory innovations that will deliver this investment in the most cost effective way. In particular:

- How do we reduce the cost of capital / investment hurdle rates for delivery of these capital projects
- Where private investment is required at the residential level, what low cost / innovative funding mechanisms can be made available?

- How do we ensure complimentary investment in an optimal blend of capital projects. For example:
    - In the power sector, how do we ensure that we are investing in a cost optimal blend of wind, solar, storage and other system assets?
    - How do we ensure that investments in heat and transport solutions are harnessing any available demand side response to enable better integration of renewable energy in the power sector?

## 4.7 Alignment with strategic goals

### 4.7.1 "Be a recognised leader in climate action"

Over the past two decades Ireland has developed significant capacity and expertise in the field of power system decarbonisation. In particular, other countries have taken their lead from Eirgrid in relation to world leading work undertaken as part of their DS3 programme. On the back of this work we are currently able to operate our power system at non-synchronous penetration levels higher than any comparable system globally. There are now two primary opportunities to build on this and retain our place as a global leader in power sector decarbonization.

- Build on the DS3 program and deliver a system capable of operating with no system operational constraints by 2030.
- Deliver a world leading approach to the procurement and delivery of bulk energy time shifting. Very few countries globally are attempting to deliver a fully decarbonised power system in the next 8-10 years. The ones that are, recognise the need to procure these bulk energy time shifting services. In our view, AEMO in New South Wales, Australia represents the current world leading approach to this procurement. We have set out a proposed approach in Appendix 1&2 that if implemented could make Ireland a global leader in how to procure system flexibility on deeply decarbonised grids. DECC should encourage relevant agencies, in particular Eirgrid, to explore and pursue this approach through research and innovation initiatives. We have also included a document in Appendix 3 that provides some context on a specific innovation project that we are developing in this field and we would be happy to discuss this further with you if this is of interest. Please note this Appendix 3 contains commercially sensitive information and should not be published.

In the context of a strategic goal to be a climate leader our simple advice is, lets leverage the expertise we have developed over the last 20 years in Ireland to retake our position as a global leader in power system decarbonisation.

### 4.7.2 "Transform our energy system for a net zero future"

As noted above, while we have been a global leader historically in the decarbonisation of our power system, we have unfortunately been less successful in the decarbonisation of our heat and transport sectors. If we are to sensibly rapidly accelerate the decarbonisation of these sectors we should look to learn from the countries that have been the leaders in these fields. Effectively, we should look at what has already worked elsewhere, confirm that there are no fundamental market differences in Ireland that prevent us implementing it here, and then seek to quickly copy it. For example, countries such as Sweden and Denmark have relatively high utilisation of district heating systems. Can we seek to understand how they have developed and structured these systems technically and commercially to understand how this might be replicated in Ireland?

# 5 Strategic research and innovation gaps

As noted in the introduction we likely have incomplete visibility of all research and innovation activities being undertaken by or supported by the department. With that caveat noted, our high level impression is that the balance between research and innovation is perhaps weighted too heavily towards research and that the transition to a decarbonised energy system might benefit from a greater focus on innovation. i.e. The practical implementation of research and measures to rapidly deploy effective innovations at scale. Ultimately all R&I activities are somewhat academic until they result in cost effective emissions reductions.

# 6 The role of DECC and agencies in the achievement of research and innovation objectives

We would suggest that DECC should:

- Provide direction to all relevant agencies on research & innovation priorities in line with national energy policy. This should include a consultation component with industry and relevant agencies, with support and advice from independent 3rd party consultants where required.
- Build capacity in-house within DECC to actively engage with research and innovation projects carried out by various agencies as they are developed. Our experience (having been involved in several influential studies), is that it is critically important the procurement authority has in-house competencies to be able to robustly challenge and interrogate input assumptions, methodologies and results. This will have the added benefit of creating a deeper understanding of the insights generated from such work within the department.
- Active involvement in provision of funding for research & innovation projects into critical areas supporting national policy. With sufficient in-house competency and

expertise, this could include up to the level of decision making on which projects to fund.

- Lead <u>collaborative</u> research and innovation projects focussed specifically on policy innovations to incentivize delivery of the solutions needed to decarbonize our energy system in a cost acceptable manner.
- Seek to replicate best practise from other jurisdictions. For example the "Pathfinders[5]" approach used by National Grid ESO in Great Britain. More details on this process can be found at the link in the footnote, but at a high level this involves defining the problem you are trying to solve and asking the market to propose solutions. Where effective and economically sensible solutions are offered by market participants they can be procured.

The role of the various agencies should be to support policy set by the Department and Government. This should involve:

- Carrying out research and innovation activities in their relevant areas of responsibility and expertise in priority areas established by the department to support and inform the development of policy.
- Carry out research and innovation activities to support the implementation of policy decisions made by the department and government.
- It should at all times be clear that Government makes the policy decisions. The role of the agencies is to provide advice on policy, with robust quality evidential support and then to support the implementation of ultimate policy decisions made.

# 7 Governance framework & provision of funding

Noting that our current carbon budgets necessitate the rapid decarbonisation of all sectors, we believe there is a need to balance flexibility / agility / speed with governance and value for money. It is also important to recognise the fact that, by their very nature, not all research and innovation projects will have successful outcomes. The level of governance applied to funding of projects should be appropriate for the quantum of funding requested, relative to the potential benefits of the initiative should this be successful. This should be similar to the risk vs reward calculation that a commercial entity would carry out. If the potential benefits of a proposed solution relative to the cost of an R&I project are very significant then there should be an openness to taking more risk to try to accelerate it.

None of this is intended to take from the need for proper and prudent management of public finances. A balanced approach where prudent calculated risks are taken to accelerate critical initiatives should in the medium to long term provide best outcomes for society.

[5] https://www.nationalgrideso.com/industry-information/balancing-services/pathfinders

# 8 Specific consultation questions

## 8.1 What gaps do you see in the Department's current research and innovation activities? How should we address those gaps in the Department Research and Innovation Strategy?

As noted in the body of our response above, there is at least a perception that there is lots of excellent research being undertaken but perhaps insufficient innovation and accelerated scaling of viable solutions. Innovation projects may require a higher level of funding support followed by policy / regulatory / market based incentives to then scale the deployment of these innovations. If the department consider that this perception is not without merit, then an increased focus on innovation in the new strategy would be welcome. Innovation projects by their nature may require a higher level of funding than research projects. On this point, we would also reference our feedback in section 8.10.2 below.

It is also important to understand the difference between excellent research to identify solutions to specific problems that are fundamentally techno-economically viable or optimal, to then developing the innovative incentive or funding mechanisms to deliver these solutions at scale. Research into efficient and effective market incentive mechanisms to unlock the investments required to deploy solutions at scale is at least as important as understanding what these solutions are.

## 8.2 What actions can the department take to identify future trends in the areas under our remit?

Developing a key stakeholder map or database of industry & agency experts and 3rd party consultants with assigned relationship owners within the department could potentially be a useful step to take. The relationship owner could take responsibility for regular periodic engagement with the various identified experts to capture emerging trends and disseminate them to relevant people in the department.

It might also be useful for the department to publish an annual problem statement, identifying what are considered to be key live challenges facing the country as we seek to decarbonise various sectors, and inviting solutions to these issues from all interested stakeholders.

It may also be possible to take learnings from the work of other departments. For example the Department of Further and Higher Education, Research, Innovation and Science included several potentially useful initiatives as part of their "Impact 2030" strategy designed to capture and share knowledge including:

- National Grand Challenges Programme
- Establishment of a new "Evidence for Policy Unit"

- Establishment of an Advisory Forum[6] – a multi stakeholder forum including representatives from key agencies and industry, selected based on their individual knowledge and expertise.

## 8.3 Are there specific thematic areas relevant to the Department's remit which you would like to see more research and innovation activity in? How can this be achieved?

We have set some of these out in more detail in section 4 above, but in summary:

- Efficient and effective procurement of renewable energy and energy time shifting
    - If we are to deliver a net zero power system in Ireland, then the two single biggest components of that system are likely to be the technologies that provide the available renewable energy and the technologies that are capable of bulk time shifting this energy to times where it is needed. The total cost of these technologies on our 2030 – 20035 system (with increased system demand) could be of the order of €7-9billion p.a. Having a procurement process with a level of sophistication appropriate to this level of expenditure will be critical to a cost effective transition to a zero carbon power system.
    - This could be delivered by Eirgrid in consultation with key stakeholders in DECC, CRU and Industry. We have set out initial high level proposals in Appendix 1&2 below. The problem we are identifying is very strongly aligned with similar problems identified in other leading renewable electricity regions globally, including Great Britain and New South Wales (NSW) in Australia. AEMO in NSW have run what we believe to be the current world leading procurement approach which involves very similar procurement principles but with arguably a less transparent and effective execution methodology. As such, implementation of our recommended approach has the potential to help re-establish Ireland as a world leader in power system decarbonisation and renewable integration solutions. We have had significant engagement with Eirgrid on these proposals over the last 8-12months and we understand that they are open to a broader consultation on this topic to explore it further. We have also had constructive and relatively positive engagements with key stakeholders in DECC and CRU.

- Accelerated action
    - How do we move from excellent research, to innovation followed by deployment of new solutions at scale. Research, if not accompanied by innovation and scaling, won't move the dial on emissions. This applies across the electricity, heat and transport sectors. What policy innovations are required to incentivize and enable accelerated delivery of the solutions that work?

[6] Seek to replicate success of Eirgrid's DS3 Advisory Council or the Offshore Wind Industry Council in Great Britain

- Building capacity to translate good research into good policy, innovation and deployment at scale.
    - We would note that as part of their Impact 2030 strategy, published by the Department of Further and Higher Education, Research, Innovation and Science, one of the key initiatives proposed involves the establishment of a "Evidence of Policy Unit". As noted above, we would suggest that it is critically important that the Department of Environment, Climate and Communications builds in house capacity with sufficient bandwidth and expertise to be able to engage with research undertaken by 3rd parties in order to:
        - Set out research priority areas to support evidence based policy development.
        - Test and challenge input assumptions, methodologies and results provided by agencies and 3rd parties undertaking research.
        - Develop quality policy recommendations informed by the best available evidence.
    - In particular, once sensible solutions have been identified it is critical to have increased focus on policy innovations to create appropriate and efficient investment signals (and / or funding supports) to domestic and commercial markets to support scaling of these solutions.

## 8.4 Have you views on the impact of disruptive technologies such as AI, Quantum and 6G as part of the digital transformation agenda and the implications of these technologies for the Department?

This is beyond the area of our current expertise. At a very high level we see significant potential to utilise AI to support efficiencies across a wide array of activities, but we have not yet sufficiently considered the full implications of technology trends in this space, to provide meaningful comment.

## 8.5 How can the Department better communicate its research and innovation needs?

As noted above, it may be useful to set out an annual problem statement with an open invitation for solution proposals? What are the primary problems / challenges currently facing the department?

## 8.6 How can the Department work more effectively to source evidence from the national research and innovation community to support its work in policy development, policy implementation, and the uptake of new technologies?

Our experience of engagement with the department in this space has been good and our sense is that a lot has been done over the last 2-3 years to build capacity. As noted above, we don't think it is necessary for the department to build the in-house capacity to conduct research directly (other than research into policy innovations), but we would suggest it is important that it has sufficient capacity with appropriate technical and commercial expertise to be able to direct various agencies to conduct relevant work, and to be able to deeply interrogate these studies, and be actively involved in them as they are developed. Not all studies are created equal, and some mediocre or poor studies can seem persuasive to untrained eyes. For example, in the electricity sector reports can be sourced with both positive and negative messaging on the merits of gas with carbon capture and storage or new small modular nuclear reactors. These conflicting reports read separately can all seem plausible. The Department needs the in-house technical and commercial skills and expertise to be able to properly interrogate this work in order to develop effective policy in the best interests of the country.

## 8.7 How can the Department engage more effectively with all stakeholders in the national research and innovation system? If you are responding on behalf of an organisation, 4 please state how the Department could more effectively engage with your organisation.

We have found the department excellent to engage with. Any suggestions we have for potential improvements are covered elsewhere in our response.

## 8.8 Should the Department seek to grow its capacity to carry out in-house research? If yes, how can this be achieved?

As noted above, we would suggest it is more important that the department grows its capacity to effectively direct, interrogate, challenge, engage with, and understand the research of others. This requires a strength and depth of technical and commercial expertise and is critical to ensuring quality research that provide robust and reliable insights to inform policy. As noted above, not all reports / research is created equally and at times poor research and reports can create plausible but ultimately misleading results. For the department to be efficient and effective in developing and implementing decarbonisation policies, it is critical that it builds this in-house technical and commercial expertise to be able to fully and properly interrogate the work of others.

We would also suggest that the department should build capacity to support the creation of new policy that supports innovation and scaling of solutions, informed by quality research.

Achieving this requires an appropriate budget and an effective recruitment campaign, supported by competitive salary packages to attract talented people, with expertise across the areas of primary interest.

## 8.9 Are there examples internationally of Government strategies on research and innovation in climate, communications / digital, circular economy, cyber security, energy or environment that we should examine? If so, can you provide details?

We have no deep insights on international research and innovation strategies.

## 8.10 Are there any other matters you wish to raise in relation to the development of the research and innovation strategy?

### 8.10.1 Policy should leave space for market innovations

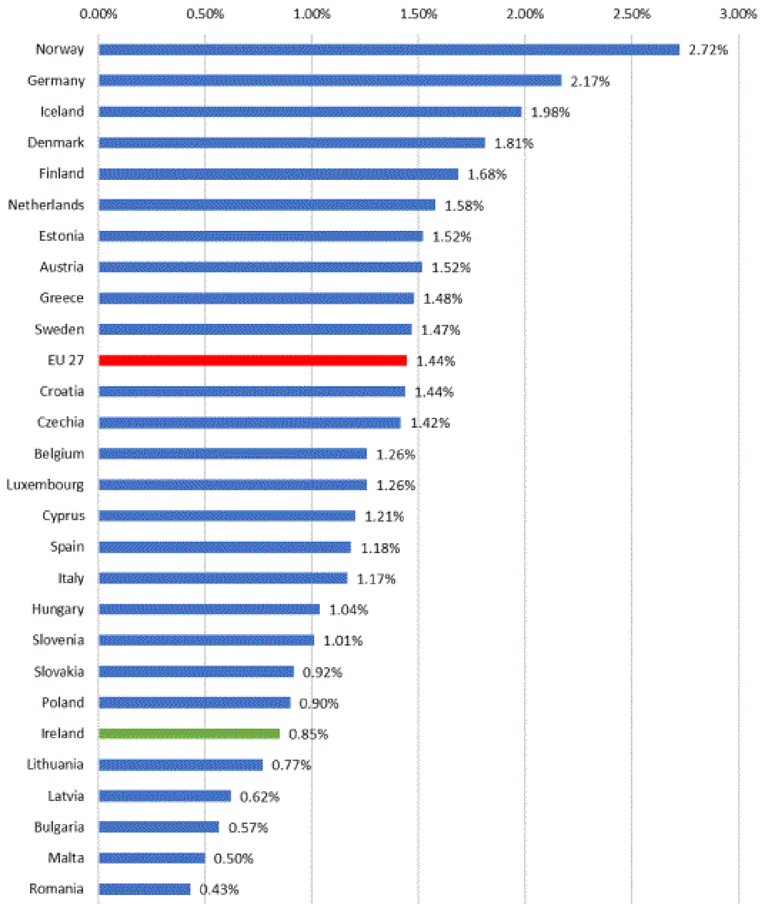
In implementing policy innovations it is often useful to leave space for the market to come up with better solutions. A prime example of this in the electricity sector relates to the procurement of energy storage / flexibility as noted above and set out in more detail in the appendices below. It is possible to do studies that examine a suite of storage technologies, make projections about their cost and determine that we need XMW of a particular storage technology to solve our problems and then run a procurement process to secure this. However such a study will only ever be able to examine a subset of all available technology solutions, and may not have full visibility of all relevant cost and technical data. As such, pre-determining particular solutions and then procuring these solutions may in fact be materially inefficient. This needs to be considered case by case and sector by sector, but at a very high level it may be worth framing it as follows:

- Where simple low cost decarbonisation solutions have been identified and are either clearly lower cost or cost comparable with the status quo, consideration should be given to cost based procurement or incentivisation of specific solutions.
- Where solutions have been identified that require very significant investments, and it is known that a range of potential solutions could exist, then ideally we should utilise technology agnostic value based procurement or incentivisation approaches. i.e. We aren't looking for the cheapest / lowest cost specific solution, we're looking for general solutions that have the biggest differences between value and cost.

## 8.10.2 Irelands research and development budget

We would note that Ireland currently sits close to the bottom of an EU league table in terms of budget allocation towards research and development. It is critical that we allocate an appropriate level of research and development funding if we are to deliver meaningful outcomes and support the delivery of a sustainable and competitive national economy. The figure below is extracted from a report on "The Research and Development Budget 2021 – 2022"[7] which indicates that we are currently ranked #22 within the EU 27 in terms of the % of total government expenditure allocated to research and development, less than half the comparable expenditure in Norway, Germany, Iceland and Denmark. If we wish to be a recognised leader in climate action, we need to be willing to invest meaningfully in the most promising research and innovations to support this.

**Figure 9: International comparison, Civil GBARD, % of Total Government Expenditure, 2020**




**Source: Eurostat. Note Civil GBARD excludes Military R&D.**

For international comparison, data are only available up to 2020. The EU 27 average was 1.44% of total government expenditure spent on R&D while Ireland's percentage was 0.85%, slightly lower than last year's figure of 0.92%.

[7] gov.ie - Research and Development Budget: 2021 to 2022 (www.gov.ie)

# 9 Conclusion

We would like to thank the department for the opportunity to input to this important consultation process and if there is anything further we can do to support, please don't hesitate to get in contact with us.

# 10 Appendix 1 – Future bulk energy time shifting service procurement

## 10.1 Problem statement

### 10.1.1 Changing nature of the system

It is critically important when considering the market framework under which power generation technologies and supporting system services (including storage) are deployed, to consider the changing nature of the system. As we transition to 80% RES-E and beyond, we are moving from a system on which the largest cost component is fuel, to one where the largest cost component is capital infrastructure. Figure 2 & 3 below provides a crude illustration of the potential change in the underlying cost of providing sufficient generation capacity and fuel to meet demand in a 2035 power system – figure 2 illustrates cost breakdowns for a 35% RES-E system, Figure 3 illustrates how this changes on a system trending towards net zero. It is noteworthy that only the fuel and carbon elements of these costs are capable of responding in an economic way to short term energy market price signals i.e. through the burning of more or less fuel. The capital infrastructure component is incapable of responding to these signals economically after it has built.

On the basis that the clear global and national imperative is to decarbonise the grid as quickly as possible and at least cost, the following key questions emerge:

- Which technologies should be deployed?
- What market framework / process should they be deployed under?

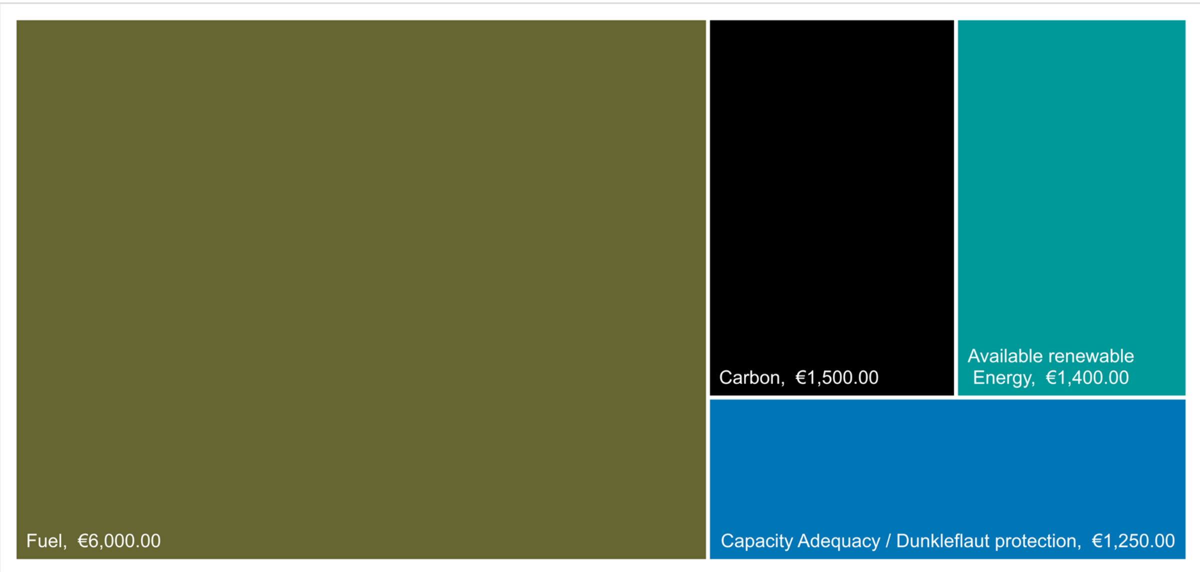



*Figure 2: Illustration of approximate fundamental underlying annuitized capex, opex, fuel and carbon cost on an all island power system at 35% RES-E in 2035 , Costs in €m p.a.*

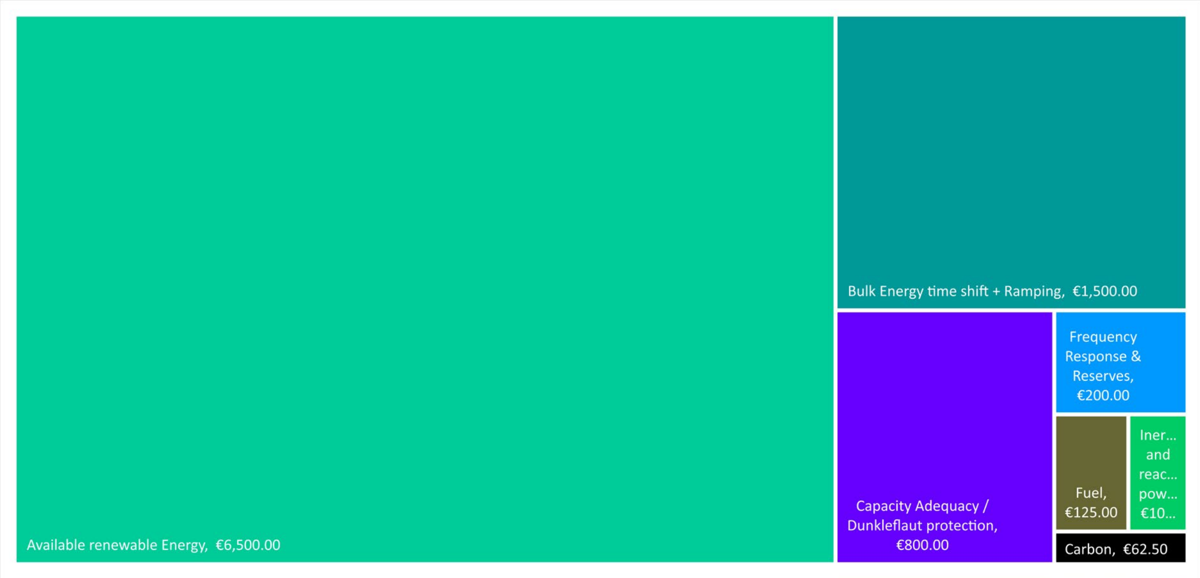



*Figure 3: Illustration of approximate fundamental underlying annuitized capex, opex, fuel and carbon cost on an all island power system trending towards net zero in 2035. Costs in €m p.a.*

Existing short term energy and system service markets are primarily focused on minimising short run operating costs, i.e. to ensure efficient operation of existing assets. Delivering a net zero power system requires market mechanisms that ensure efficient investment in an optimal blend of zero carbon technologies. The largest components of underlying costs of a net zero power system will be the technologies to provide available renewable energy and the technologies needed to bulk time shift that energy. Endless complexity is being brought to bear on future system service arrangements and wholesale energy markets to achieve optimal dispatch and minimise short run marginal operating costs. These costs will be a very small portion of our future system costs. As we transition to a net zero power system capital costs dominate. Delivering such a system cost effectively requires much greater consideration of how we lower the cost of capital through provision of long term revenue certainty and greater sophistication in how we incentivise investment in an efficient technology mix.

### 10.1.2 How to Compare Different Storage Technologies at a System Level?

Existing and new LDES and demand side response technologies have very different combinations of energy capacity, duration, return trip efficiency (RTE), asset lives, capital costs and fixed operating costs. Each technology has a different floor revenue requirement in order to meet a reasonable investment hurdle rate. Under any new storage procurement framework how do policy makers compare these technologies and decide which should clear? e.g. Technology A can provide 24hr discharge, 65% RTE, and is located in a region with existing network constraints of 9% and requires a guaranteed floor revenue of €50k per MW per annum to build. Technology B can provide 6hr duration, 80% RTE, is located in an area with network constraints of 3% and requires €40k per MW per annum to build. Which of these two technologies should be procured? On what basis do you make that decision?

### 10.1.3 How should Locational Benefits & Interactions with Renewable Generation and Demand be Considered?

Intuitively there are interactions between the cost of available renewable energy in different locations, the level of network constraints and the value of storage services of different durations. For example, if there is a renewable generation resource with a very low cost of available energy but facing high network constraints, it is likely that longer duration storage services deployed in that location will provide greater system value, compared with the same storage technology deployed in an area facing demand side congestion issues, or in areas with low renewable constraints. Should policy makers be willing to procure LDES at a different price in areas of high renewable transmission constraints? If so, what should inform that decision? For example, consented wind energy projects exist with an underlying LCoE based on availability of €50.00 in the same region as technology A above. Wind energy projects in the same region as technology B have an LCoE based on available energy of €80.00. How should these interact with the storage procurement process?

Similarly, there are likely to be interactions with locational applications. E.g. In areas of high demand (Dublin), the demand side transmission congestion issues are likely to be of shorter duration. In these locations, intuitively, storage technologies of shorter durations and higher efficiencies are likely to be more optimal. Again, how should policy makers compare bids and decide what clears where?

### 10.1.4 Remuneration Gaps / Revenue Certainty

Existing market systems do not fully remunerate storage for the services that they provide. Some examples include:

- Network congestion management– no product or incentive exists.
- Carbon abatement (energy storage is a source of clean dispatchable capacity that displaces fossil fuels)
- Managing renewable oversupply and contributing to RES-E targets.

With the exception of capacity market revenues, the majority of available revenues come with limited medium to long term certainty:

- DS3 tariff arrangements will transition to an enduring, competitive arrangement (currently targeted at 2026 ). No detailed design yet on future arrangements but short-term auctions are a key feature. Opportunities for long-term revenue certainty may be limited;
- Energy Arbitrage – energy market revenues are volatile and difficult to forecast with accuracy;
- Capacity - does allow for 10-year contracts but structural issues disadvantage long duration storage e.g. de-rating factors do not recognize LDES and price caps are based on new fossil fuel plant. The Capacity Market, as currently structured, will not make up the 'missing money' needed to drive investment in LDES.

These uncertainties result in higher investment hurdle rates and make it very challenging to develop an investable business case for LDES assets or demand side response assets that require material capital investments.

### 10.1.5 Operational Signals vs Investment Signals

Existing market structures are reasonably good at incentivizing appropriate / optimal operation of constructed assets but are not good at sending investment signals to the new low to zero marginal cost assets needed to decarbonize the power system.

How should policy makers provide the needed revenue certainty to new LDES assets without removing / reducing the effectiveness of short-term price signals driving optimal operation of assets? E.g. If you provide LDES with a simple Contract for Difference structure, where is the incentive to trade optimally when any revenue above the strike price will be handed back?

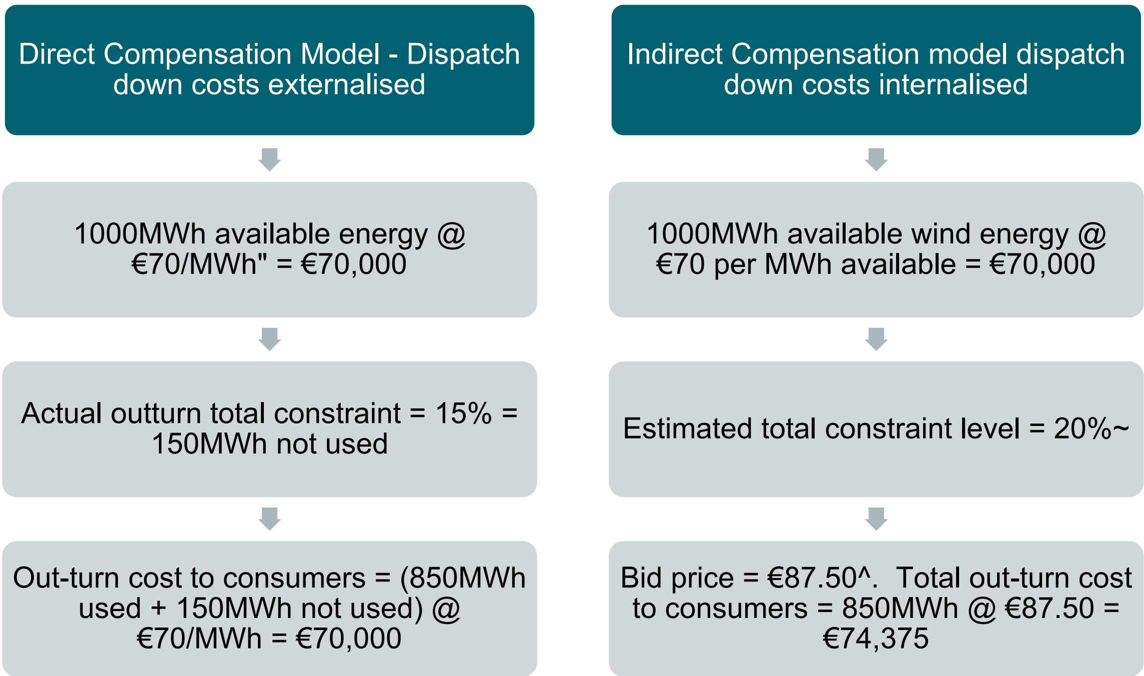
### 10.1.6 Existing Operational Issues

Today storage projects cannot be scheduled and dispatched (S&D) effectively for energy. We understand that the TSO have an active workstream in place to enable scheduling and dispatch for energy and that this should be implemented by 2024. However, based on engagement with the TSO, the scope of this initial S&D project does not include dispatching storage or demand side response to address network constraints. If storage and demand side response assets are to provide network congestion solutions it is critical that they can be dispatched to charge at or close to zero cost to resolve a network constraint (or at a minimum compete against each other for the right to charge using this surplus renewable energy). Our understanding is that once the current workstream is complete, storage will be able to trade *ex ante*, secure a market position and have a reasonable expectation of being dispatched to its nominated position, but this would be based on *ex ante* market pricing. Times of network constraints are often not coincident with times of zero price *ex ante*. As such, it may not make economic sense operationally for a particular storage asset to charge even if this results in the loss of renewable energy that the storage asset would have been happy to absorb if the price was at or close to zero.

### 10.1.7 Interactions with RESS auctions and Renewable Generation Procurement

Under existing RESS auction design, constraint, curtailment and oversupply risk are principally with the generator (noting that a proposal to address curtailment and oversupply risk has been put forward in O-RESS1 and RESS 3, subject to state aid approval, no current proposal to address constraint risk). This means that generators will price in a certain level of dispatch / re-dispatch into their bids. This in turn means that subsequent storage deployments that serve to reduce levels of dispatch down will increase revenues to RESS generators and not create consumer cost savings to the extent that would otherwise be the case. This diminishes the level of incentive for regulators acting on behalf of consumers to support storage deployments as high re-dispatch and oversupply costs are baked in for the period of support.

This is illustrated in more detail below. The first figure below compares costs to consumers for renewable energy in a model where network constraint risk is taken by consumers (Direct compensation model) vs a model where this risk is assigned to generators (Indirect compensation model). As a generator has almost no ability to manage this risk a prudent bidder will tend to incorporate reasonably conservative assumptions in their financial models. In the simple illustration below this has the effect of increasing costs to consumers by 6.25%. i.e. Even before storage interactions are considered we would suggest that this is already an inefficient procurement approach.

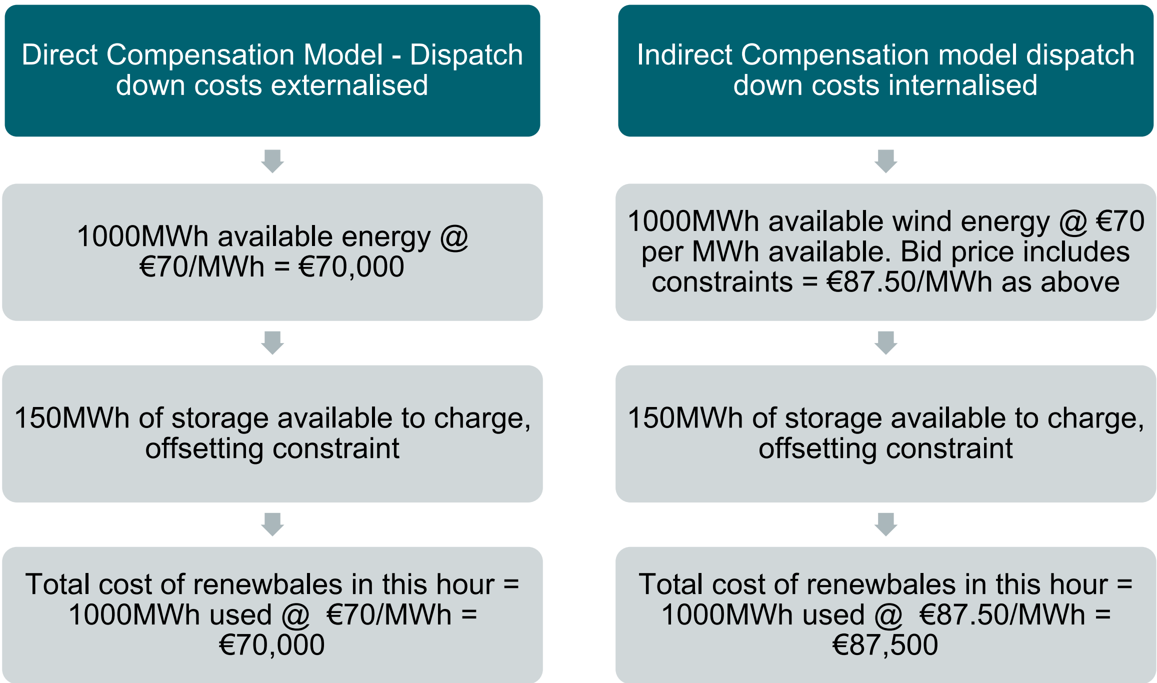



“ If constraint costs are externalised then the auction bid price should reflect the actual cost of the available energy. In this illustration we're assuming that this is at a level of €70/MWh

~ Based on very high uncertainty in forward forecasts of dispatch down levels, the assumption is that auction bidders need to be somewhat conservative and make a constraint assumption that is somewhat larger than the most likely / probable out-turn level. Obviously it is possible that the actual out-turn levels might exceed even a prudent bidders assumption, in which case consumers would benefit, but this is the less probable outcome.

^ simple illustration only – actual impact of constraints on bid prices also interacts with RESS tenor + assumed merchant tail revenues

If we now consider the impact of a future deployment of some new long duration storage technology and how this interacts with the direct and indirect compensation models:




In this scenario, inappropriate risk allocation in the RESS auction results in costs to consumers (and revenue to RESS generators!) that are 25% higher than they need to be. This inappropriate risk allocation results in these potential consumer cost savings becoming inaccessible to storage & DSR and makes it more difficult to develop a cost benefit analysis that supports a case to provide storage with sufficient long term revenue certainty.

## 10.2 Proposed principles for an effective flexibility procurement mechanism

We propose the following principles for a storage / flexibility procurement Framework

- The procurement process should be technology agnostic and support investment in an appropriate broad portfolio of storage technologies and capabilities that meet the needs of the system and national decarbonisation objectives.
- The procurement process should maximise long term certainty for a floor revenue for winning technologies. This will reduce investment hurdle rates enabling easier, greater and more cost effective deployment.
- The procurement should be based on an estimation of overall system value vs cost taking account of any locational benefits.
- The selection of "winning" technologies needs to be based on a transparent full system & network model[8] that bidders can understand and replicate. This doesn't have to be perfectly optimized, but it is critical that it is consulted on and is transparent / replicable. The process should clear projects with the highest deltas

[8] Note there is some precedent for this approach. ECF's in RESS differentiate between the expected system value of technologies, the calculation of these ECF's had to be based on system modelling. Similarly locational scalars are considered in system service and capacity markets based on different locational values of technology deployment. This proposal would make this process more transparent in the context of storage technology procurement.

between overall system value and bid cost first. We note that, as part of the LCIS consultation, EirGrid has modelled the value of zero carbon inertia to the system, which demonstrates that the concept of modelling value to the system is now present in Ireland;

- The process should be designed in a manner that recognises the hedging value of storage. LDES investment will be Capex driven rather than Opex which means more stable pricing and less exposure to gas price volatility.

FuturEnergy Ireland have been working with a 3rd party modelling provider to develop an integrated network and market model capable of being used to clear the auction process envisaged above. A slide deck is attached in Appendix 2 that sets this out in more detail. This appendix should be treated as confidential / commercially sensitive and is flagged as such.

## 10.3 High-Level Design of a Potential Procurement Framework

### 10.3.1 Revenue Floor with Shared Upside

Bidders could bid in a required revenue floor with any upside on actual aggregated market revenues shared proportionately with consumers for the length of the contract. “Floor” revenues to be bid and cleared based on the system Cost Benefit Analysis (CBA) at the bid floor price using a full system model as envisaged above. The objective shouldn’t be to minimise the gap between revenues earned under existing market arrangements and the floor price, rather to maximise the projected net system value that the LDES asset can deliver. The existing/new system services and energy markets should just be used in conjunction with the broader long-term procurement to ensure efficient near-term operation of assets.

A cap and floor mechanism has been proposed in Great Britain to incentivise long-duration storage. This is a regulated long-term contract framework, used to incentivise investment in interconnectors, which provides a guaranteed floor price, supported via Use of System charges where project revenues fall below the floor, and a cap above which excess revenues are handed back to end consumers. This type of framework could be feasible for LDES but the downside of this is that assets are only incentivised to trade optimally and manage near-term operation up to the cap. The incentive to gain more revenue and add more value to the system is lost beyond this. A floor and shared upside mechanism does not set a fixed cap but a fixed proportion of revenues above the floor price that would be shared with consumers so the incentive remains for assets to trade optimally and try to maximise revenues from existing and new services, and in doing so maximising consumer savings.

We also think there is merit in discussing whether such a system could be added to existing RESS auctions (noting that storage would be floor + shared upside rather than CfD) and allow all zero carbon energy service technologies to clear based on the marginal system value vs cost (both generation and flexibility)

### 10.3.2 New Services

New services, in addition to existing DS3 services, energy arbitrage and capacity market contracts, should be introduced to incentivize locational/strategic deployment and optimal operation of LDES. For instance:

- Congestion management service: Where technologies are being deployed as network congestion solutions, they should not be paying any TUoS charges and instead should be receiving TUoS payments based on the space they create for new renewable project connections.

Auctions for long term revenue floors would allow new storage assets to be deployed with relatively low cost of capital. The addition of new services combined with the continued operation of existing market structures will ensure that these newly deployed assets are operated in a way that maximizes their overall system value. Where revenues exceed the floor price, consumers would share in this upside as a reward for providing the floor.

### 10.3.3 Interactions with Existing Market Structures

- **RESS:** Storage and RESS procurement processes should be complementary. – e.g. Assigning very significant re-dispatch risks to RESS bidders and driving up RESS prices, and then fixing the problem with a storage procurement after the RESS assets have built, is not efficient or in consumers interests. Likewise, assigning that risk to System Operators who then pass it on to consumers is certainly not in the consumer interest. Separately, iA combined auction model that allows for the most efficiect clearing of both RESS projects and storage can resolve this problem. If we have a system model for storage procurement, should or could this be used to determine appropriate ECF's for RESS clearing. Could this involve moving to a system where bidders bid in based on availability and locational ECF's are determined that account for expected levels of re-dispatch compensation (noted that this could interact with EU energy policy and this could be very challenging)

- **Firm Access:** Storage deployment can result in the creation of new "firm" capacity for renewable generators without the need to build any new grid infrastructure. As a result, storage should not pay network charges and, in fact, should be paid out of the Use of System Charges pot for the grid capacity created.

- **Energy Market:** Existing market structures will incentivise optimal near-term operation of LDES assets.

- **System Services:** Existing and new system services will incentivise optimal near-term operation of LDES assets.

- **Capacity Market:** It is worth considering whether a storage technology that has cleared for a revenue floor in the LDES auction be required to be a price taker in capacity auctions?

### 10.3.4 The problem with central specification of MW / MWh capacities and locations

**Key Point:**

**An alternative approach whereby storage MW and MWh capacities are centrally defined with a view to supporting broader renewable integration and decarbonisation objectives, has the potential to be extremely inefficient and wasteful of consumers money.**

- Central definition of storage requirements would have to be informed by some technoeconomic analysis in advance of an auction in order to determine the auction sizing. This would always be limited to a subset of the available technologies and would require the auction designer to make assumptions about the bid prices from these technologies in advance of seeing the actual costs. This creates two material inefficiencies:

    - There may be other technologies not considered that could add more system value and if they were considered, might materially change the MW / MWh and locational specifications in the auction.
    - The assumed costs for the technologies that are considered may be wrong.
    - Central definition of MW / MWh ratios would immediately exclude many technologies from participating. This could reduce auction competition and might exclude the technologies that provide the greatest system benefits from participating.

- If you specify the MW / MWh ratio, it would seem likely that you would also need to specify the return trip efficiency in order to make a fair simple cost comparison between different bidders. Otherwise, the question would arise as to how you should differentiate between two bids for the same MW's and MWh's but different efficiencies. The less efficient technology may be materially cheaper but what is the appropriate trade off between cost and efficiency? This effectively means that the auction might be limited to a single technology. If an auction design specifies both the duration and the efficiency of the storage technologies to be procured, the majority of these technologies would from a practical perspective, be ineligible to compete.

- Noting the significant inefficiencies already in pre-determining technologies, if you assume a specific duration and a specific return trip efficiency, there is still the potential for different system values associated with different locations. The auction might specify where they want the technologies but some locations may still have more value than others.

    Depending on the nature of the analysis undertaken in advance of determining requirements centrally, there is a material risk that a solution is procured that costs more than the problem it is solving. The single central objective function that the SO's / RA's should be solving for is to deliver a decarbonised system (in accordance with legally binding sectoral emissions ceilings) at least cost. There is always an option to reach decarbonisation targets by overbuilding the renewable and taking and absorbing the cost of the additional constraint / curtailment / oversupply. If storage requirements are centrally defined with:

- o An incomplete picture of the available storage technology solutions
- o Inaccurate cost estimates for the storage technologies that are considered
- o Limited / no techno-economic assessments to determine the appropriate economic trade off between higher dispatch down levels or more storage / flexibility deployments;

Then the risk of the process delivering extremely inefficient or worse still, actively wasteful outcomes would be high.

Below are a series of simple examples that are deliberately extreme / hypothetical to illustrate the problem of centrally defining storage requirements:

- Take a scenario with an auction running for 4hr storage. Technology A can provide 4hr storage for €1m p.a. Technology B is designed to be able to provide 24h storage but costs €2m p.a. So the cost is 2x but energy capacity is 6x, so it is capable of solving roughly 6 times the problem (this is an over-simplification but it should be clear that presented with these two choices, the system should be procuring Technology B);
- Now take a new scenario with two different 4 hr technologies – Technology A costs €1m p.a. and has an efficiency of 80%, Technology B costs €0.75m p.a. but has an efficiency of 40%. So technology B is 25% cheaper but would recover 50% less energy than Technology A. On a simple cost comparison technology B would win but would very likely provide much less value for money.
- If we attempt to solve this by also specifying an efficiency you have a new problem. Consider a (third) scenario involving an auction for 4hr storage with an 80% efficiency requirement. Technology A can provide 4hrs, 80% efficiency for €1m p.a. Technology B can provide 4hr storage, has an efficiency of 78% and costs €0.5m p.a. Technology B would almost certainly provide better value for money but would be ineligible to compete in a simple duration specific / efficiency specific auction.
- Last example (scenario 4): Only consider technology A, but one is located at a node X where there is a lot of renewable constraints, with a second another is located at node Y where there is no constraint. So the technology at node X would have more "surplus" renewable energy to absorb vs the same tech at the node with no constraints. As such it is likely that the tech at node X should clear ahead of the tech at node Y. A simple 4hr procurement would not differentiate between these things.
- These are all deliberately extreme scenarios to highlight the issues, but there are real world versions of this, where real technologies have much longer durations, much lower capex per MWh and often lower efficiencies, and it is complicated to know which of these represents better value for money for consumers. Anywhere that you attempt to draw crude lines can cause material inefficiencies. Any storage or flexibility procurement process that is not capable of making a fair comparison between different technologies with different efficiencies, different energy capacities, different associated costs and located at different nodes, risks being extremely inefficient.

- Just to illustrate the challenge let's ask a more complex question: Let's consider you have technology A located at a node with 10% constraints, it has an energy capacity of 24hrs and an efficiency of 55% and requires €1m p.a. to build, Technology B is located at a node with 5% constraints, has an energy capacity of 12hrs, an efficiency of 70% and requires €1.2m p.a. to build. It is very likely that one of these technologies provides significantly more value than the other but which one would you choose to clear if you could only pick one? How would you decide?

### 10.3.5 International Context – AEMO Auctions, NSW Australia

Key Point:

**Other markets globally seeking to decarbonise the power systems are moving towards a value based approached to clearing storage / flexibility auctions, though there is room to improve considerably on the detailed execution methodologies. If we can do this properly in Ireland, we have a chance to re-establish ourselves as a global leader in decarbonisation of our power systems.**

AEMO have already held their first long duration energy storage auctions with further rounds anticipated over the next 2-3 years. The approach taken in this auction was relatively technology agnostic, with a minimum duration of 8 hrs specified as a pre-qualification requirement, but no maximum duration and no specific return trip efficiency requirements. Bids were assessed against both quantitative and qualitative criteria designed to take account of the holistic system value of the bidders projects. The merit criteria considered included an assessment of the overall impact of the project on the electricity system. Bidders were required to submit their own curtailment studies and network benefits studies, prepared by approved / reputable providers, to highlight the broader system benefits of their bids. Projects were expected to deliver reduced wholesale energy costs, reduce the levels of renewable constraint / curtailment and reduce the levels of unserved energy (i.e. make a contribution to generation adequacy). The bid cost parameters were assessed alongside the project's technical characteristics across multiple future scenarios. In terms of the pros and cons of this approach:

- Arguably this procurement is world leading insofar as it is the first procurement globally that we are aware of that attempts to procure storage based on a holistic assessment of the future system value of bidder's projects.
- This has the immediate benefit of signalling the market to start developing the technologies that will maximise system benefits and minimise system costs.
- However, participants in this auction commented on the lack of transparency in relation to some of the non-price criteria.
- Also the decision to allow individual bidders to effectively submit their own system cost benefit analysis creates a risk that modest differences in modelling approaches and assumptions within these CBA's could distort the results.

The proposed high level design outlined above addresses both of these concerns with a single centralised model being used to compare all technologies on equitable basis, based on the value that they are adding to the system

### 10.3.6 Detailed auction design considerations

Should the SO's / RA's / DECC be minded to support the high level design approach put forward in this paper, we would suggest that the following topics should be consulted on further to develop a detailed design:

- What is the most appropriate modelling tool / (integrated network and market model) to be able to determine and compare the holistic system value of different bidding projects and technologies and should this seek to co-optimise an optimal blend of bidder's projects or compare each bidders project individually to a base case system?
- Can an open-source version of this model be made available to the market well in advance of an auction to allow bidders to enter technical and cost parameters and provide the estimated system value of their projects? This could serve as a strong signal to the market to develop optimal technologies in optimal locations and would reduce the amount of wasted development effort.
- What network scenarios should be assessed? Should this be based on a single study year or multiple study years with different future transmission network assumptions?
- Should new grid reinforcement projects be participating in the process, (i.e. so that we are making optimal decisions to build more grid vs sweat the grid we have, considering realistic timelines for the delivery of storage vs grid projects?
- What is the appropriate contract duration, and does it vary by technology?
- What technical and cost parameters should bidders be including, e.g.
    - Floor revenue p.a. (indexed or not indexed)
    - MEC
    - MIC
    - Return trip efficiency and any expected degradation of efficiency over time, how should penalties be applied.
    - Energy capacity (Duration) and any expected degradation in performance over time.
    - Connection node
    - Other? E.g How would storage technologies that interact with other sectors be treated (e.g. thermal storage technologies interacting with a neighbouring heat source or sink, hydrogen storage interacting with other end use demands for hydrogen)
- What pre-qualification requirements should be:
    - Planning grant
    - Grid offer
    - Technological readiness levels (TRL's). Should there be a cap on volumes procured for technologies with TRL's below a defined threshold value?

## 10.4 In summary:

- Moving to a net zero power system means moving from a system where short run marginal operating costs dominate to one where annuitized capital costs dominate

- Delivering capital intensive projects at least cost requires providing a high degree of revenue certainty.

- Delivering a net zero power system at least cost requires providing this revenue certainty to an optimal blend of technologies

- Determining an optimal blend of technologies over time requires long term auctions which clear projects / technologies based on a detailed assessment of their holistic system value.

- This implies that we need to utilise integrated network and market models to determine the expected marginal system value of new technology deployments, taking account of the projects technical characteristics in addition to their locations on physical grid systems.

- Co-optimising the procurement of variable renewable energy technologies with flexibility service technologies including LDES based on marginal system value will deliver the most efficient net zero systems. At a minimum we need to ensure generation and flexibility procurement is complimentary

- This is complex but not as complex as existing short-term markets, and the complexity is justified on the basis that these new markets would be addressing the largest part of our new net zero system.

# 11 Appendix 2 - Example integrated network and market model for auction clearing

Attached separately – COMMERCIALLY SENSITIVE NOT FOR PUBLICATION

# 12 Appendix 3 – Preliminary discussion document for a long duration energy storage innovation project

Attached separately – COMMERCIALLY SENSITIVE NOT FOR PUBLICATION