

Offshore Renewables Surplus Potential WS1 – Market Analysis

A report to the Department for the Environment, Climate and Communications

NOVEMBER 2023

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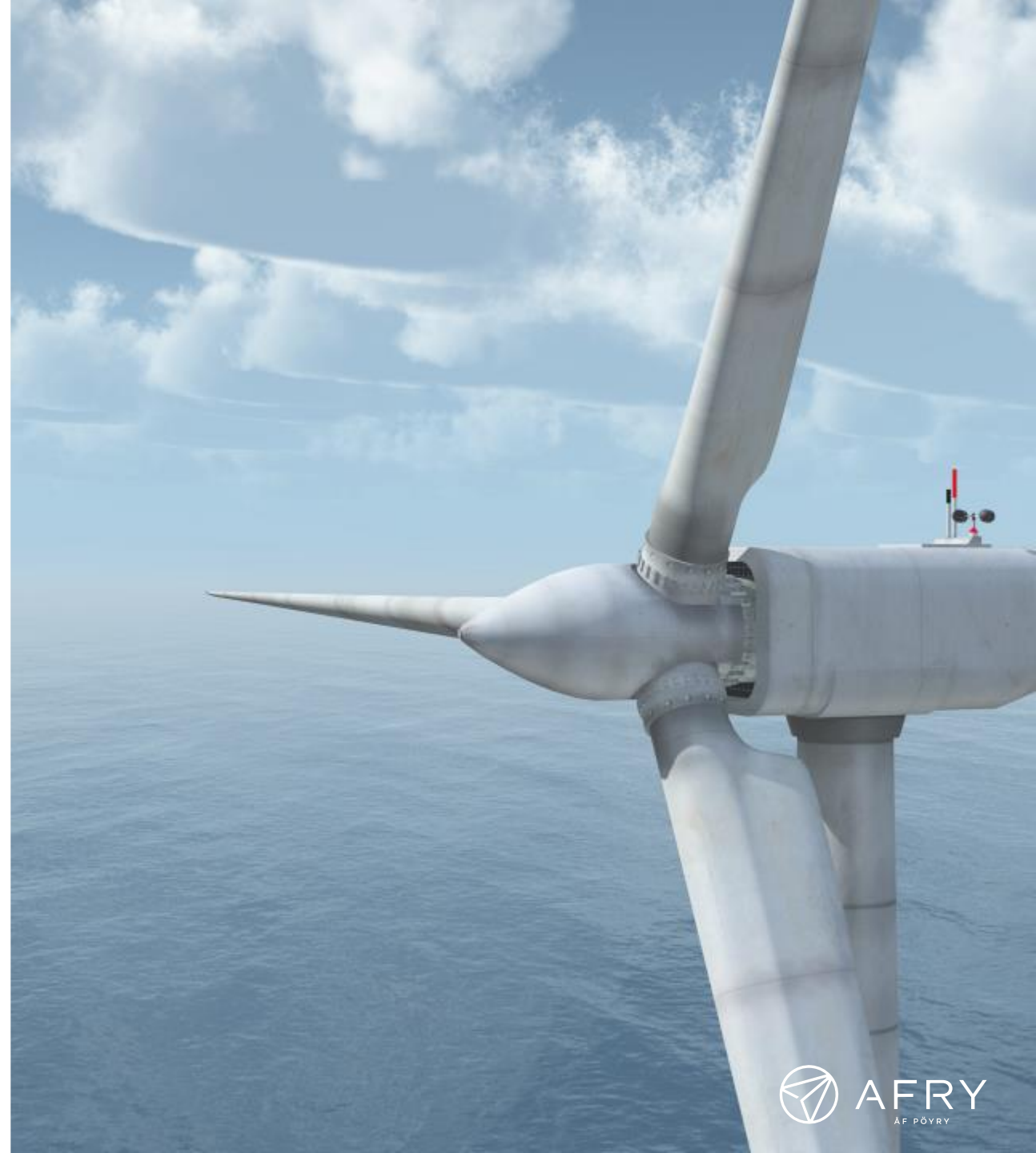
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Table of Contents

1. Key messages	11
2. Introduction	19
3. Modelling approach	24
4. One vision for domestic net zero	29
5. Domestic net zero summary findings	45
6. Impact of pursuing ORE surplus	56



AFRY and BVGA have been commissioned by DECC to provide an economic analysis of the potential for Offshore Renewable Energy (ORE) surplus

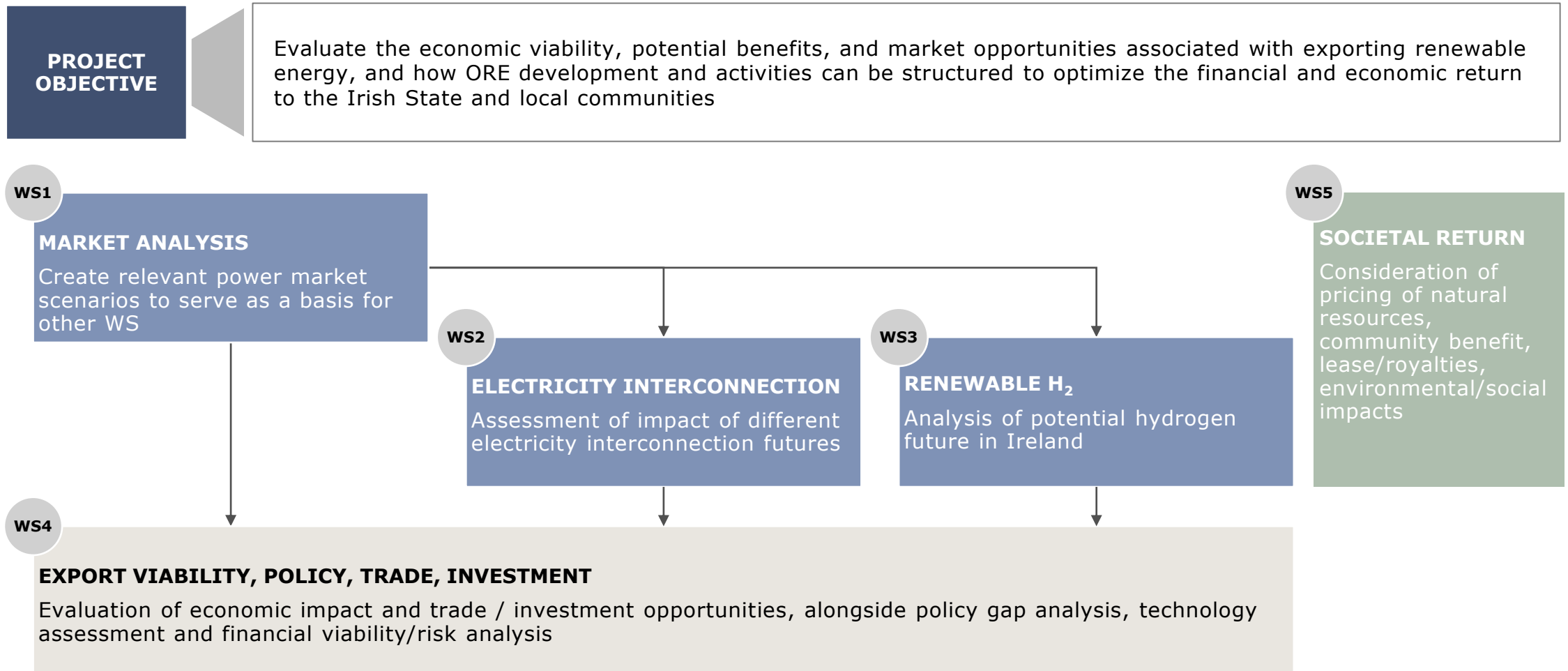
BACKGROUND

- Ireland has ambitious climate action targets for 2030 as well as a legally binding target of achieving net zero emissions by 2050.
- Offshore renewables are expected to play a key role in delivering on 2030 and 2050 targets.
- Furthermore, because of Ireland’s maritime endowment, there is potential to capture significantly more offshore renewable energy (ORE) than would be needed to satisfy domestic energy requirements.
- However, it is uncertain what the optimal use of any ORE surplus might be. More specifically, whether ORE surplus should be exported as electricity, hydrogen (or hydrogen derivative) or if instead it should be ‘refined’ and used to produce new value-added products and services domestically (perhaps data centres or green steel or green aluminium).
- Consequently, the Department of the Environment, Climate and Communications (“DECC” or “the Client”) has requested AFRY Management Consulting Limited (“AFRY”) and BVG Associates Limited (“BVGA”) provide an economic assessment of the potential for ORE surplus.

SCOPE

- The broad scope of work includes the following elements:
 - Market analysis
 - Financial analysis
 - Socioeconomic impact analysis
 - Policy and regulatory analysis
 - Risk analysis
- This will be delivered via 5 Workstreams (WS):
 - WS1 – Market Analysis
 - WS2 – Electricity Interconnection
 - WS3 – Renewable Hydrogen Development
 - WS4 – Export Viability, Policy Considerations, Trade and Investment Opportunities
 - WS5 – Optimised Financial and Economic Return to the State and Local Communities

This study has five discrete but interlinked Workstreams



WS1 is fundamentally concerned with the creation of energy sector scenarios that will form the basis for other Workstreams

BACKGROUND

- The assessments of electricity interconnection, renewable hydrogen and economic impact require a view of the future energy sector both in Ireland and in Europe / Great Britain (GB).
- Areas of uncertainty include:
 - The level of domestic power and hydrogen demand
 - Fuel and carbon prices
 - The evolution of the capacity and generation mix
 - Power prices in the Irish Single Electricity Market (SEM) as well as neighbouring markets
 - Generation economics and the need (or lack thereof) for some form of support.
- Ultimately, the primary focus of WS1 is to create the scenarios of the Irish (and interconnected European) energy market in 2030, 2040 and 2050 that form the basis for analysis in subsequent WS.

SCOPE

- Creation of a baseline energy market scenario (henceforth referred to as the Domestic Net Zero scenario) covering the spot years of 2030, 2040 and 2050 to be used as a counterfactual reference for evaluating alternative views of the evolution of the energy sector.
- Creation of additional scenarios reflecting differing levels of ORE and electricity interconnector deployment.
- Provision of projections under the baseline scenario for:
 - Power / hydrogen demand
 - Fuel / carbon prices
 - Capacity mix
 - Generation mix
 - Wholesale power prices (including renewables capture prices)
 - Price spreads with neighbouring markets
 - Interconnector flows
 - ORE surplus
- Analysis of the impact of varying levels of ORE / electricity interconnector deployment on:
 - Interconnector flows
 - ORE surplus
 - Power prices

There are a number of limitations that readers should be aware of regarding this study

PATHWAY COST OPTIMALITY

The Domestic Net Zero scenario should not be viewed as the lowest cost pathway to achieving net zero in 2050. It is one of many pathways to net zero in 2050 and may or may not be 'cost optimal'.

SECURITY OF SUPPLY

The system is secure under typical weather conditions. This study has not investigated the impacts of weather extremes and sought to ensure the system is robust to these extremes.

SUBSIDIES

The higher deployment ORE and IC pathways should not be assumed to be subsidy-free pathways.



SYSTEM CONSTRAINTS

Network constraints (be they local or system wide) have not been modelled.

NATURAL GAS AVAILABILITY

Natural gas has been assumed to be available when needed, effectively requiring 24/7 supply. This validity of this assumption is likely to be increasingly at risk from 2040 onwards.

CARBON REMOVALS

The economics of carbon removal technologies and specifically bioenergy with CCS (BECCS) has not been evaluated. The study implicitly assumes a positive cost-benefit trade off for carbon removals will justify support if it is required.

Abbreviations

ARA	Amsterdam-Rotterdam-Antwerp	FRA	France	ROI	Republic of Ireland
BBL	Barrel	GB	Great Britain	SEM	Single Electricity Market
BECCS	Bioenergy with CCS	GCS	Generation Capacity Statement	SEMC	SEM Committee
BESS	Battery energy storage system	GHG	Greenhouse gas	SOEF	Shaping Our Electricity Future
BVGA	BVG Associates	GW	Gigawatt	SS	Self-Sustaining (TES 2023 scenario)
CAP	Climate Action Plan	H2	Hydrogen	TES	Tomorrow's Energy Scenario report (published by EirGrid)
CCGT	Combined cycle gas turbine	IC	Electricity interconnector	TSO	Transmission System Operator
CCS	Carbon capture and storage	LCOE	Levelised cost of energy	TYNDP	Ten Year Network Development Plan
CH₄	Methane (i.e. natural gas)	LDES	Long duration energy storage	TWh	Terawatt hour
CHP	Combined heat and power	Li-ion	Lithium ion	V2G	Vehicle to grid
CIF	Cost, insurance and freight	LNG	Liquefied natural gas	WS	Workstream
DAM	Day Ahead Market	MW	Megawatt		
DECC	Department of the Environment, Climate and Communications	MWh	Megawatt hour		
DNZ	Domestic Net Zero	NBP	National Balancing Point		
ENTSO-E	European Network of Transmission System Operators for Electricity	NI	Northern Ireland		
ETS	Emissions Trading Scheme	OCGT	Open cycle gas turbine		
EV	Electric vehicle	Ofgem	Office of Gas and Electricity Markets		
Fe-air	Iron-air	ORE	Offshore renewable energy		
FES	Future Energy Scenario report (published by National Grid ESO)	PHES	Pumped hydro energy storage		
		RES	Renewable electricity generation		

Table of Contents

1. Key messages

11



1 KEY MESSAGES

This study has started with the creation of a Domestic Net Zero scenario that is aligned with EirGrid TES scenarios



SCENARIO BASIS

Fundamentally based on EirGrid / SONI's Self-Sustaining scenario from 2023 TES. This is a progressive, high demand / rapid decarbonisation scenario without high levels of energy exports



WHOLE ECONOMY NET ZERO PATHWAY

The Irish economy pursues electrification as the primary route to decarbonisation of energy consumption, with hydrogen used in hard to abate sectors (e.g. high temperature industrial processes). Net zero is achieved by 2050.



POWER SECTOR NET ZERO PATHWAY

The power sector generation mix continues its evolution towards ever higher levels of wind (particularly offshore wind) and solar generation. Flexibility is mainly provided by electricity interconnectors, energy storage (batteries, pumped hydro, hydrogen) and electrolysers. The system is backed up by natural gas and hydrogen-fired thermal plant. Power sector net zero is achieved between 2040 and 2050, ahead of whole economy net zero.



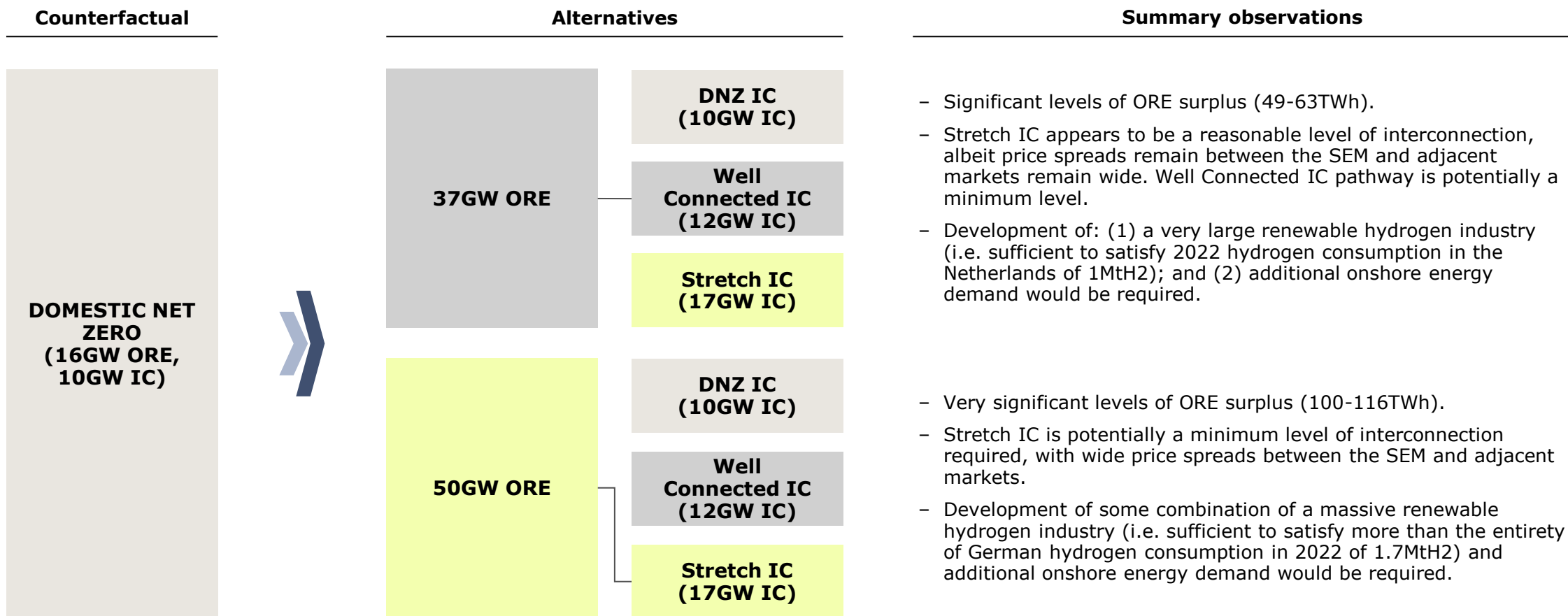
SPECIFIC TECHNOLOGY CONSIDERATIONS

A small amount of bioenergy generation combined with CCS (BECCS) is deployed. This allows for some carbon removals which allows for some residual natural gas-fired generation on the system as well as emissions in other sectors. This approach is consistent with EirGrid's Self-Sustaining scenario as well as similar analyses from other TSOs¹. No nuclear capacity is deployed. The inclusion of hydrogen-fired thermal plant represents the sole key departure from the Self-Sustaining scenario of TES 2023.

1. National Grid ESO, [Future Energy Scenarios 2023](#), July 2023.

1 KEY MESSAGES

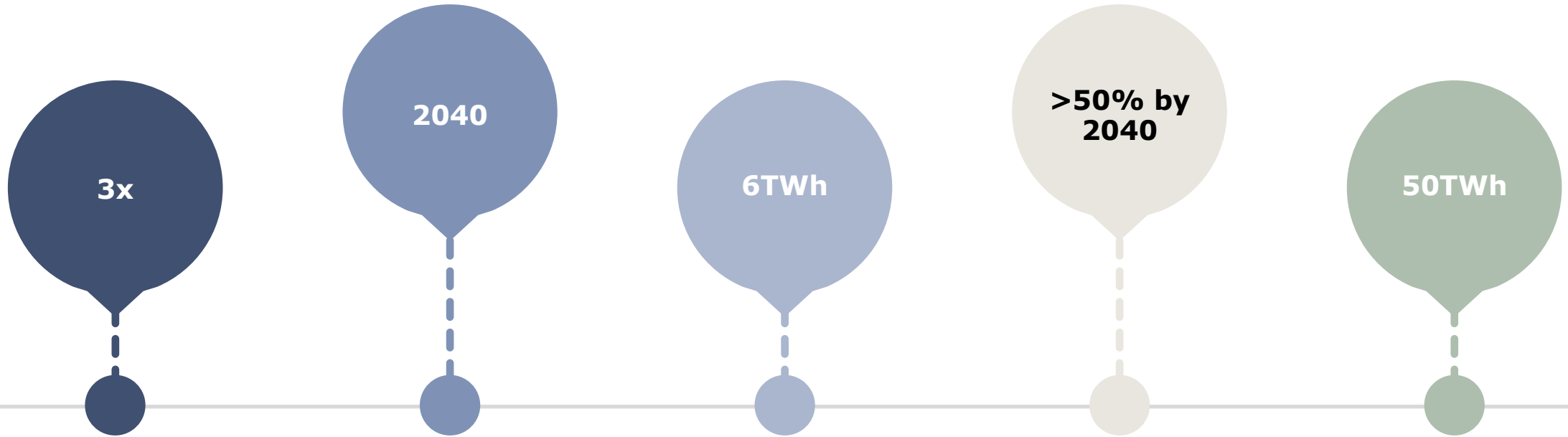
It then explores six other scenarios with varying amounts of ORE capacity and electricity interconnection



Note: Capacities in parentheses indicate 2050 values. Links between ORE and IC pathways indicate the ORE pathway the IC scenario has been sized against.

1. When comparing the difference in annual average baseload wholesale price across markets.

Five key messages to take away from this report



DEMAND GROWTH 2022-50

Power sector demand triples vs. 2022 as a result of significant electrification of heat and transport and growing utilisation of electrolysers to produce hydrogen.

POWER SECTOR NET ZERO

The Domestic Net Zero scenario achieves power sector net zero in 2040, with BECCS generation allowing the power sector to provide net carbon removals that can support other sectors.

2050 ORE SURPLUS IN DNZ SCENARIO

There is 6TWh of ORE surplus in Ireland in the Domestic Net Zero scenario in 2050, equivalent to oversupply of c.8%. Across all wind and solar in the SEM, there is 14TWh of surplus renewables generation.

RES COST REDUCTIONS TO AVOID SUPPORT

Levelised costs of wind / solar must fall by more than 50% from current levels (as evidenced by RESS/ORESS strike prices) by 2040 in order for these technologies to be deployed without support in the Domestic Net Zero scenario.

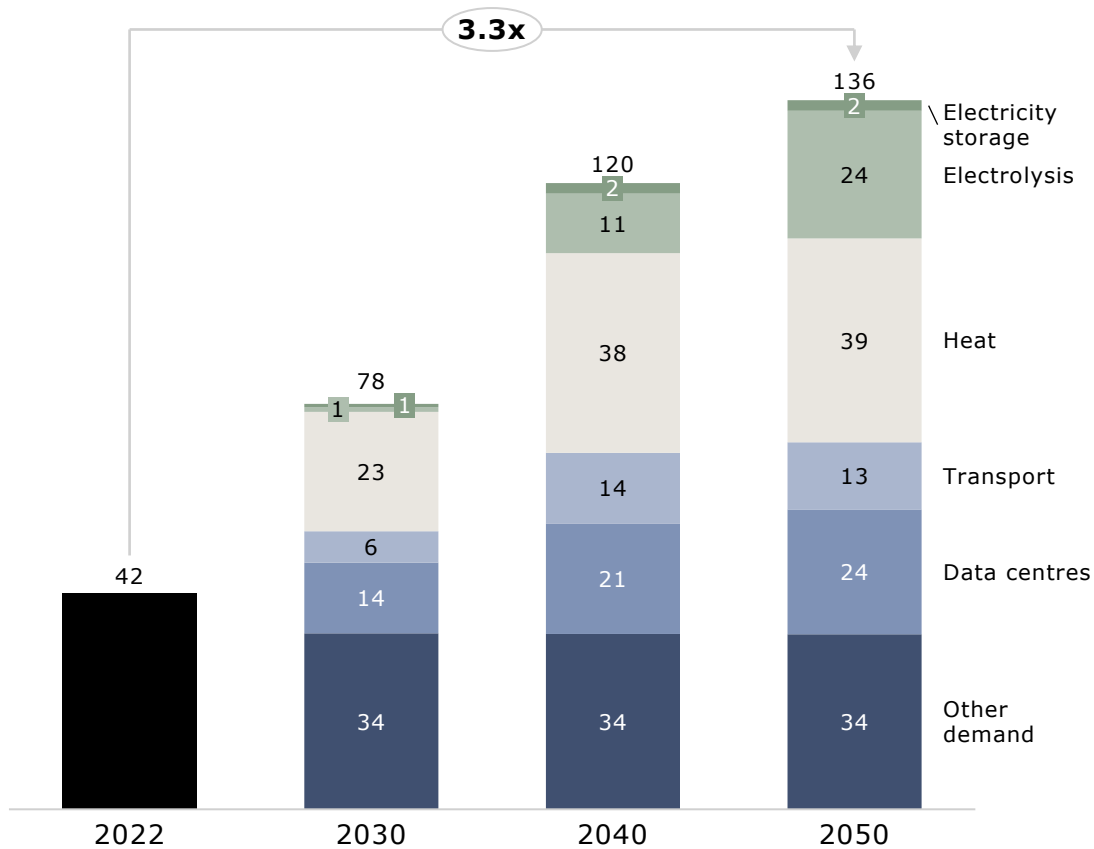
2050 ORE SURPLUS IN A 37GW WORLD

Including generation from off-grid offshore wind, ORE surplus in Ireland is almost an order of magnitude higher in a 37GW ORE world vs. Domestic Net Zero. 50TWh is almost 50% more than all of the power consumed in Ireland in 2022.

1 KEY MESSAGES

1. Power demand more than triples between 2022 and 2050

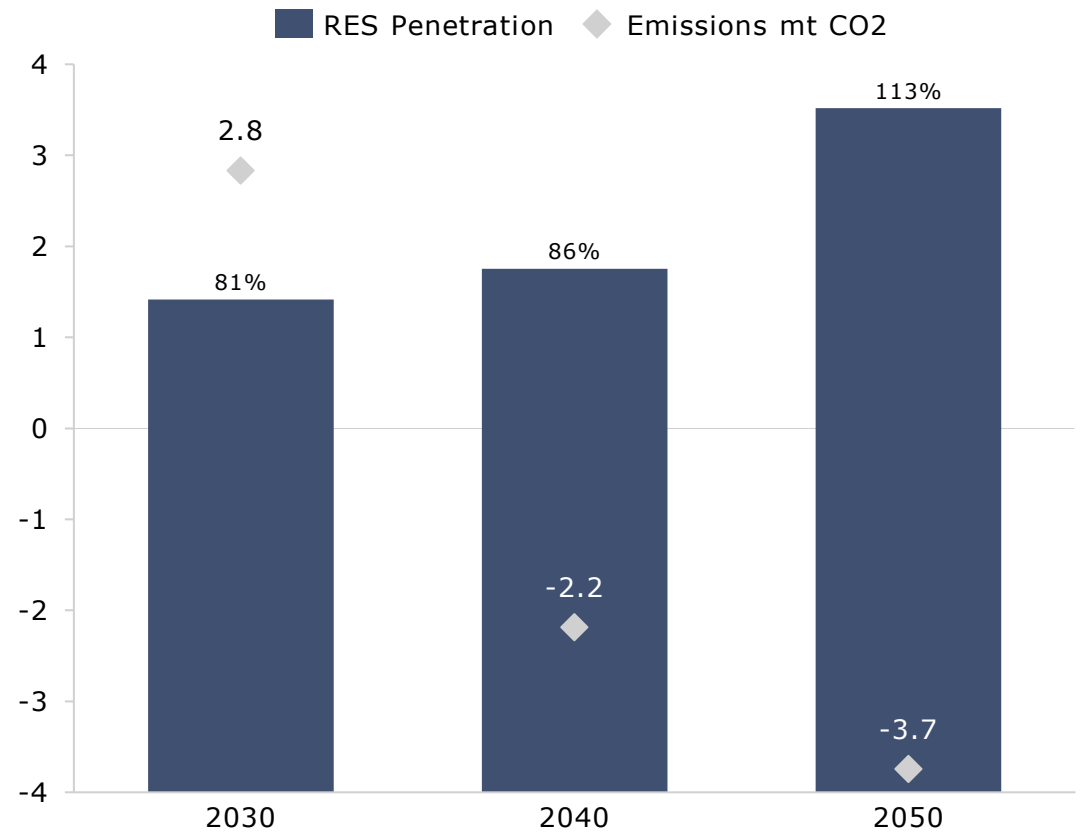
SEM POWER DEMAND (TWh_e)



Note: Electricity storage consumption reflects the impact of round-trip efficiency losses. Other demand, Data centres, Transport and Heat are input assumptions of the study.

2. Power sector emissions are net negative from 2040

SEM EMISSIONS AND RENEWABLES PENETRATION (MTCO₂, % OF ANNUAL DEMAND)

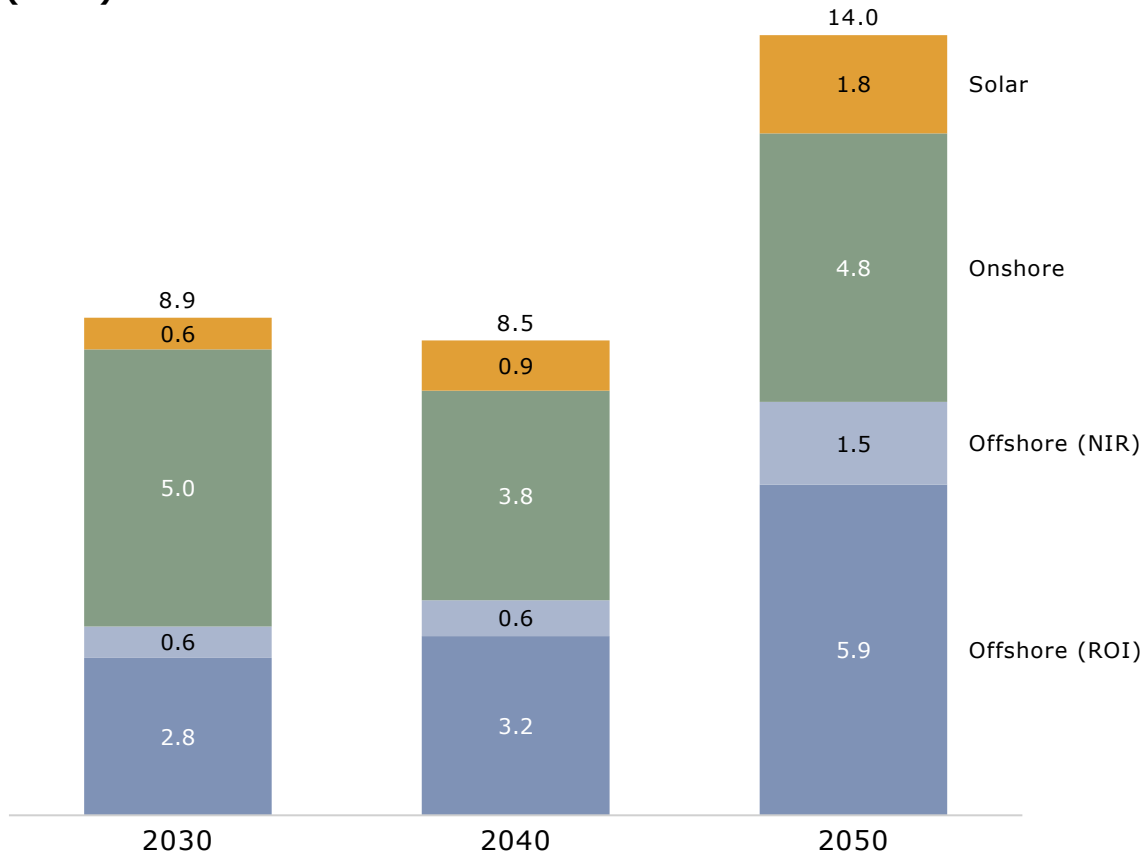


Note: Renewables include, wind, solar and hydro. Biomass is not included.

1 KEY MESSAGES

3. Ireland ORE surplus reaches 6TWh in the Domestic Net Zero scenario

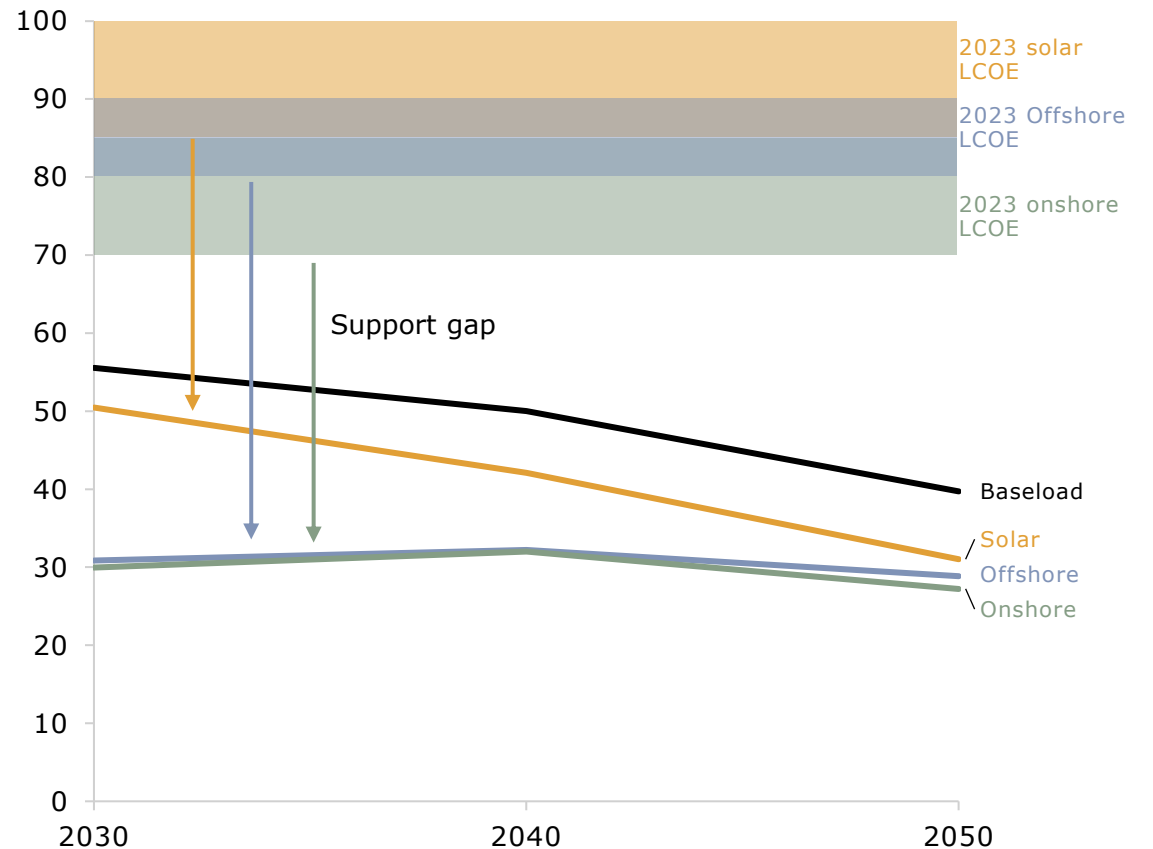
SEM RENEWABLES SURPLUS (TWH)



Note: Renewables surplus is equivalent to renewables oversupply in the Day Ahead Market.

4. RES LCOE has to fall by >50% if capacity is to be built without support

SEM DAY AHEAD MARKET POWER PRICES (€/MWH, REAL 2022 PRICES)

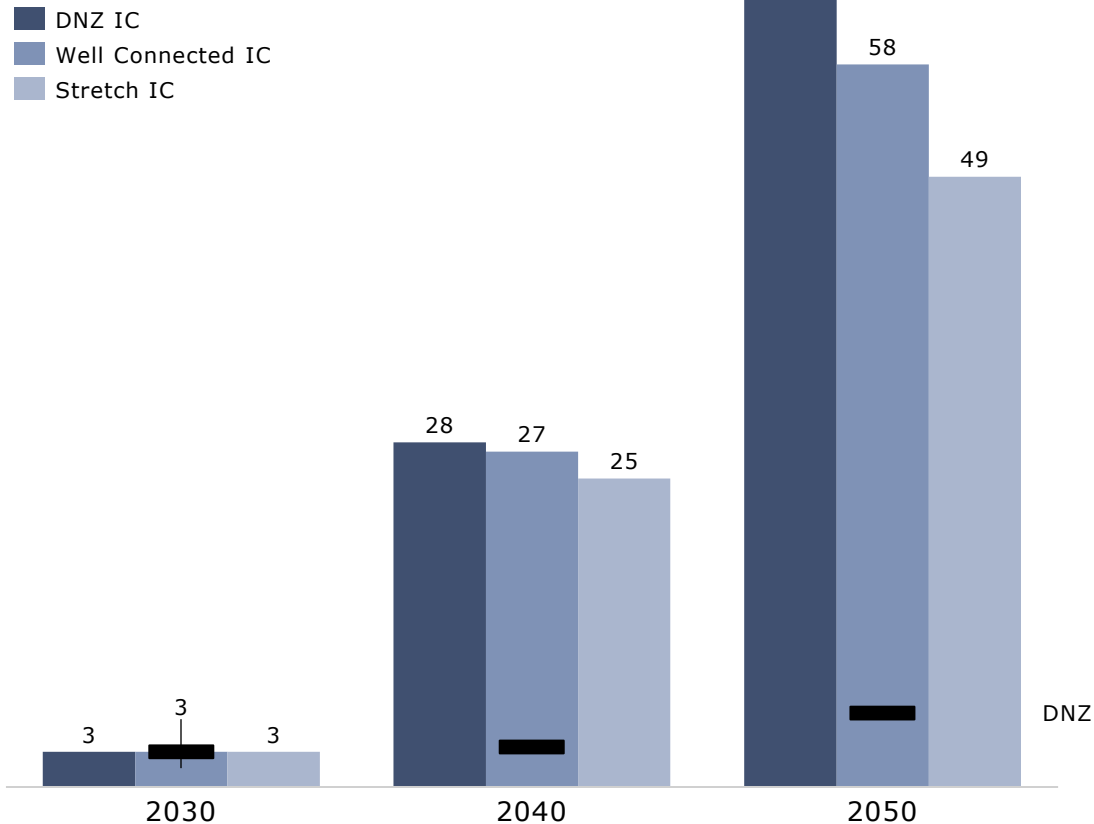


Note: LCOE ranges are illustrative and inferred from recent RESS / ORESS auctions.

1 KEY MESSAGES

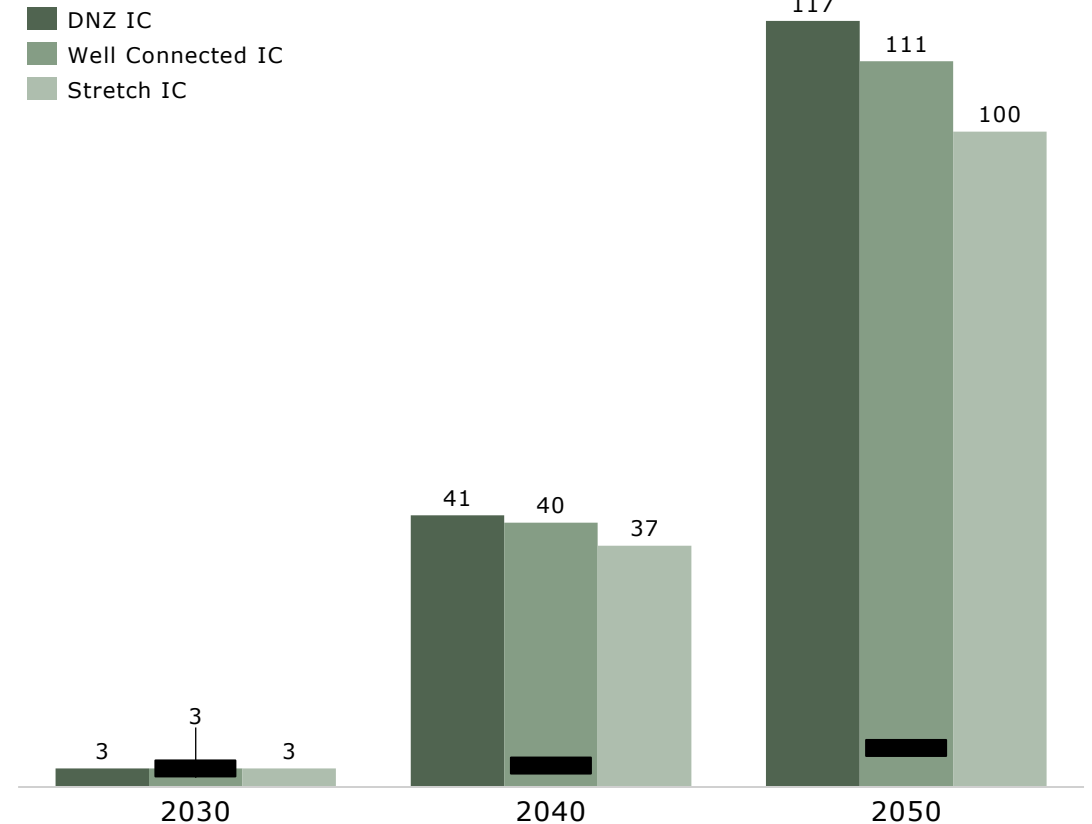
5. ORE surplus reaches >50TWh in the 37GW ORE pathway...

IRELAND ORE SURPLUS IN 37GW ORE PATHWAY (TWH)



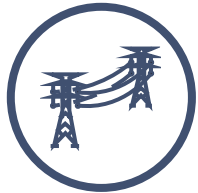
...and >100TWh in the 50GW ORE pathway

IRELAND ORE SURPLUS IN 50GW ORE PATHWAY (TWH)



Note: Contribution of off-grid ORE is included above.

Three emerging findings to consider in future work



**Electricity IC
can only be
part of the
solution**

With >33x current IC capacity by 2050 (i.e. 16.7GW vs. 500MW today), IC utilisation appears to be almost as high as it practically can be in the 37GW ORE | Stretch IC scenario. It is unclear whether building more IC capacity than this is really feasible.



**Support
costs could
be very high**

After accounting for savings in the wholesale cost of power demand, optimistic assumptions around offshore wind LCOE suggest household bills could increase by €750/yr in the 37GW ORE pathway as compared to the DNZ scenario. This c.€1.5B/yr cost represents the amount that should be made up by some combination of the renewable hydrogen industry or the development of new onshore industries.

**Making productive use of 37GW of ORE will
require a multi-faceted approach**

In order to deliver a functioning energy system with 37GW+ of ORE capacity by 2050, some combination of the following will likely be needed:

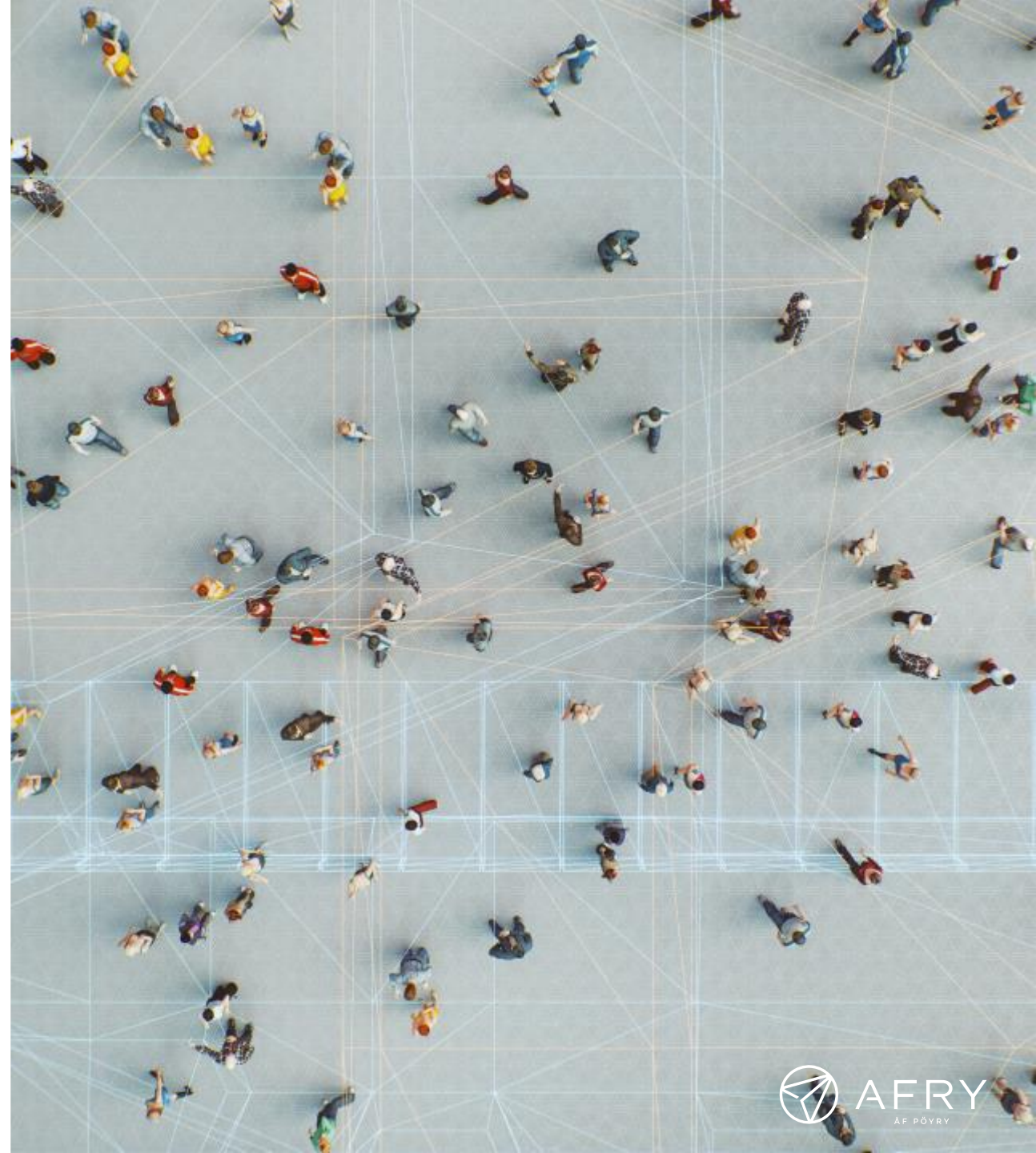
1. Electricity interconnection needs to increase significantly vs. today.
2. A renewable hydrogen economy big enough to satisfy current hydrogen demand in a country such as GB or France would need to be developed and be commercially viable.
3. New industrial demand capable of offtaking low single digit GW of power (ideally flexibly) would need to be developed and be willing to support the costs of developing new offshore wind generation.

If any of the above happen in isolation, the magnitude of what is required from any given approach could increase beyond levels that are practical.

Table of Contents

2. Introduction

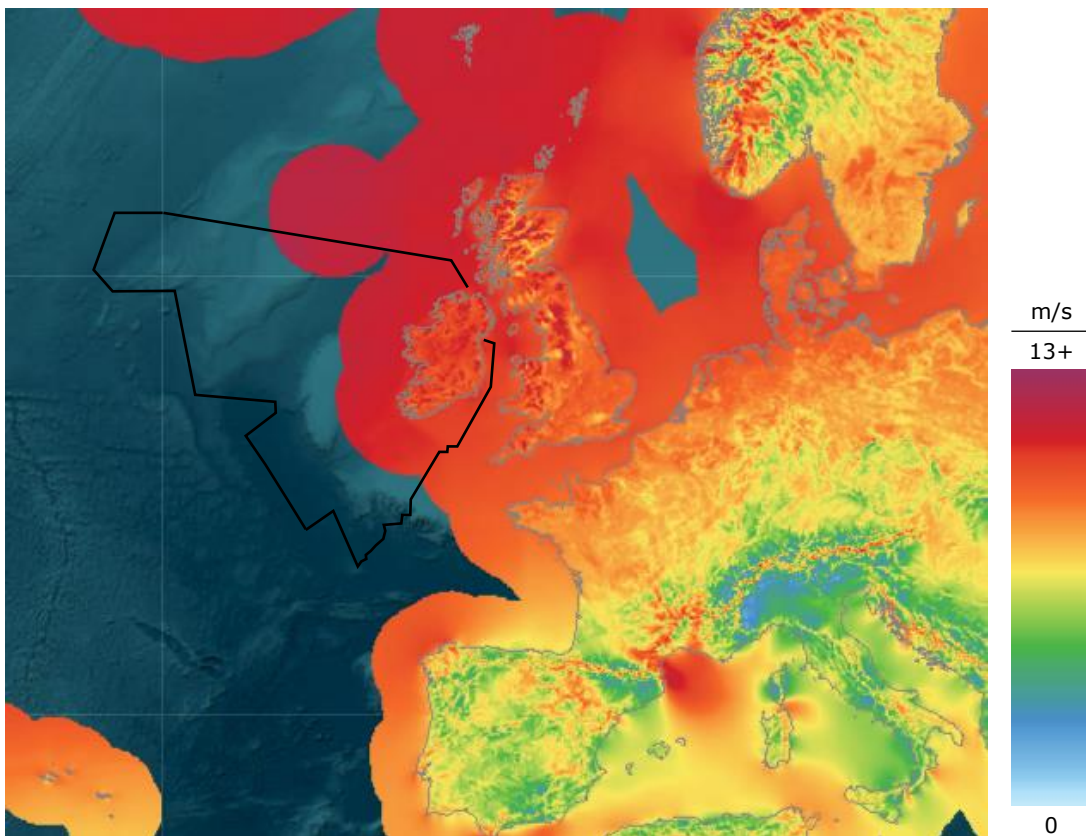
19



2 INTRODUCTION

Ireland has an exceptional wind resource stemming from a combination of its position next to the Atlantic ocean and a large marine territory

WIND SPEEDS AT 150M ALTITUDE (M/S)

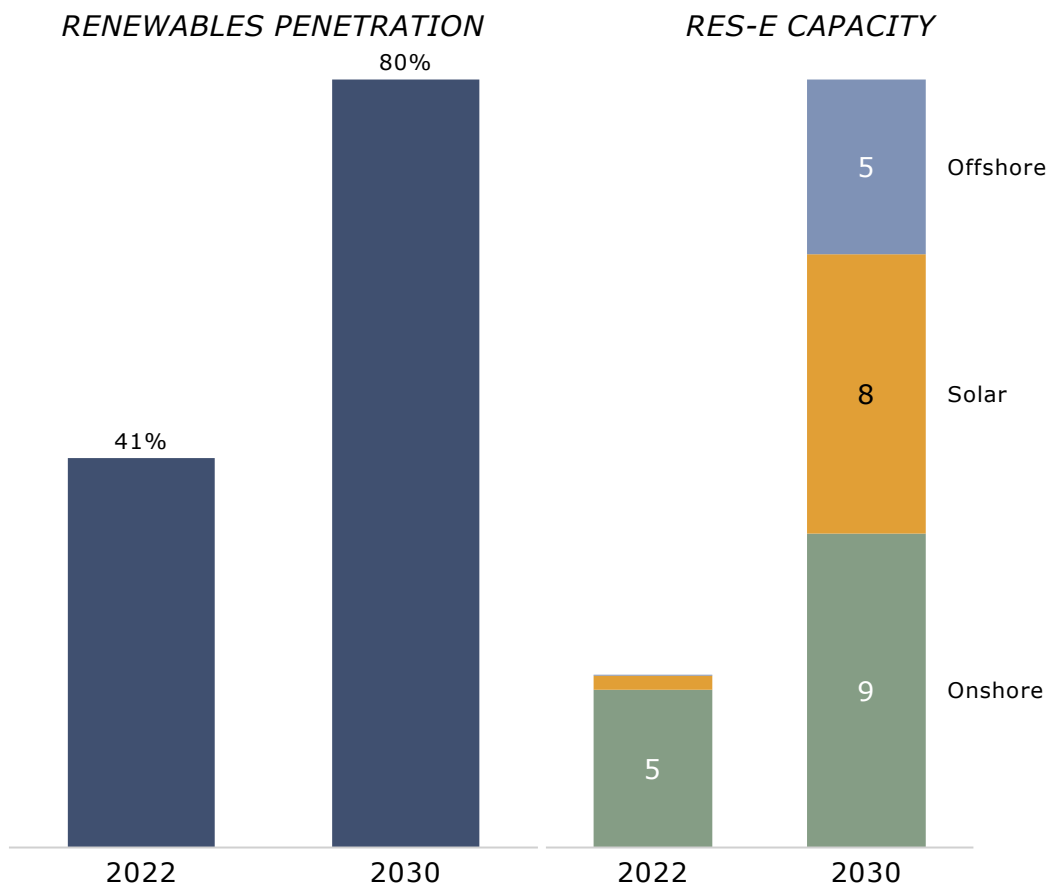


Note: Ireland's approximate marine territory is denoted by the black line.
Source: [Global Wind Atlas](#).

- Ireland's wind resource is perhaps the best in Europe. Its position on the far west of the continent next to the Atlantic Ocean ensures high average wind speeds across the country (and particularly off the west coast), whilst it also has a large marine territory extending far from shore.
- With that said, Ireland is not alone in enjoying a significant offshore wind resource with all of the countries of the North Sea basin (e.g. Great Britain, Netherlands, Germany, Denmark, etc.) having coastlines / marine territories amenable to significant offshore development.
- Consequently, there isn't an obvious answer to the question: should Ireland pursue a surplus-led offshore energy strategy?
 - On the one hand, Ireland has an undeniable offshore energy resource that could be amongst the cheapest sources of energy in Europe. It could also support additional domestic uses of energy (e.g. data centres, green steel, green aluminium, etc.).
 - On the other hand, producing a material offshore energy surplus requires considerable infrastructure (both electrical and for hydrogen and / or its derivatives) and a number of other countries are considering similar strategies (e.g. the Netherlands).

Offshore wind will be required to play a central role in achieving Ireland’s 2030 targets and will be a key enabler of net zero by 2050

KEY CLIMATE ACTION PLAN TARGETS FOR THE POWER SECTOR



Source: DECC, EirGrid.

- The Climate Action Plan (CAP) 2023¹ and accompanying legislation require Ireland to reduce greenhouse gas (GHG) emissions by 51% between 2021 and 2030 and achieve whole economy net zero emissions by 2050.
- As part of the plan to achieve the 2030 targets, it is expected that 5GW of grid-connected offshore wind will be required, effectively creating a new power generation technology class and associated supply chain (current offshore wind capacity is limited to the 25MW Arklow Bank Phase 1 project).
- Beyond 2030, there are targets for 20GW of offshore wind by 2040 and 37GW by 2050².

1. DECC, [Climate Action Plan 2023](#), 7 March 2023
 2. DECC, [Accelerating Ireland’s Offshore Energy Programme – Policy Statement on the Framework for Phase Two Offshore Wind](#), 10 March 2023.

This study examines the economic potential for ORE surplus via counterfactual analysis

COUNTERFACTUAL ANALYSIS

- Counterfactual analysis is one way of demonstrating cause and effect. It is frequently used as the analytical framework for cost-benefit analysis¹ in the energy sector.
- By creating scenarios that differ only along one dimension, counterfactual analysis can allow for causation to be attributed to this dimension.
 - For example, if you wanted to examine the benefits to consumers of developing wind power, you could construct a scenario with no wind generation capacity and an alternative with 10GW of wind generation capacity. Any differences could be attributed to the 10GW of additional wind in the alternative scenario.
- This study relies on counterfactual analysis to explore the economic potential for ORE surplus.

BASELINE SCENARIO FOR COMPARISON: DOMESTIC NET ZERO

- The baseline Domestic Net Zero (DNZ) scenario that has been developed for this study is a world that achieves net zero in Ireland by 2050 without a specific focus on generating an ORE surplus.
- This is a world of high renewables, significant electrification of the entire economy and a significant amount of offshore wind (21GW in total by 2050), albeit an amount that falls short of government targets for 2040 and 2050.

1. For example, ENTSO-E's entire Ten Year Network Development Plan (TYNDP) assessments or alternatively Ofgem's assessments for interconnectors seeking a cap and floor arrangement.

- For the avoidance of doubt, the DNZ scenario is not an expected or intended pathway and certainly should not be construed as DECC's baseline or reference scenario. Instead, it is a plausible point of comparison to explore the economic potential of varying export-led scenarios.

ALTERNATIVE SCENARIOS

- The alternative scenarios explored in this study differ from the DNZ scenario in the amount of ORE and electricity interconnection capacity.
- We have explored two alternative ORE pathways:
 - 37GW. This pathway sees offshore wind capacity reach the Government's targets of 20GW of installed capacity by 2040 and 37GW by 2050.
 - 50GW. This pathway represents a more aggressive target that sees capacity reach 25GW by 2040 and 50GW by 2050.
- We have also investigated two levels of electricity interconnection:
 - Well Connected. This pathway sees electricity interconnection reach 15% of total installed generation capacity in Ireland in the 37GW offshore wind scenario, equivalent to a little over 12GW.
 - Stretch. This pathway sees interconnector capacity reach 20% of total installed generation capacity in Ireland in the 50GW ORE pathway, equivalent to almost 17GW.

2 INTRODUCTION

7 scenarios have been modelled: the underlying DNZ scenario and six combinations of the additional ORE and interconnection pathways

Scenario Name	Domestic demand	Offshore MW	IC MW	Other capacity mix	Connected markets
1. Domestic Net Zero (DNZ)	TES Self-Sustaining (SS)	TES SS	10GW by 2050 (15% of Ireland installed generation capacity)	TES SS with additional H2-fuelled capacity	Aligned with TYNDP 2022 Global Ambition (power sector net zero by 2050)
2. 37GW ORE DNZ IC	DNZ	37GW	DNZ	DNZ	DNZ
3. 37GW ORE Well Connected IC	DNZ	37GW	Well Connected (12.2GW by 2050)	DNZ	DNZ
4. 37GW ORE Stretch IC	DNZ	37GW	Stretch (16.7GW by 2050)	DNZ	DNZ
5. 50GW ORE DNZ IC	DNZ	50GW	DNZ	DNZ	DNZ
6. 50GW ORE Well Connected IC	DNZ	50GW	Well Connected	DNZ	DNZ
7. 50GW ORE Stretch IC	DNZ	50GW	Stretch	DNZ	DNZ

Table of Contents

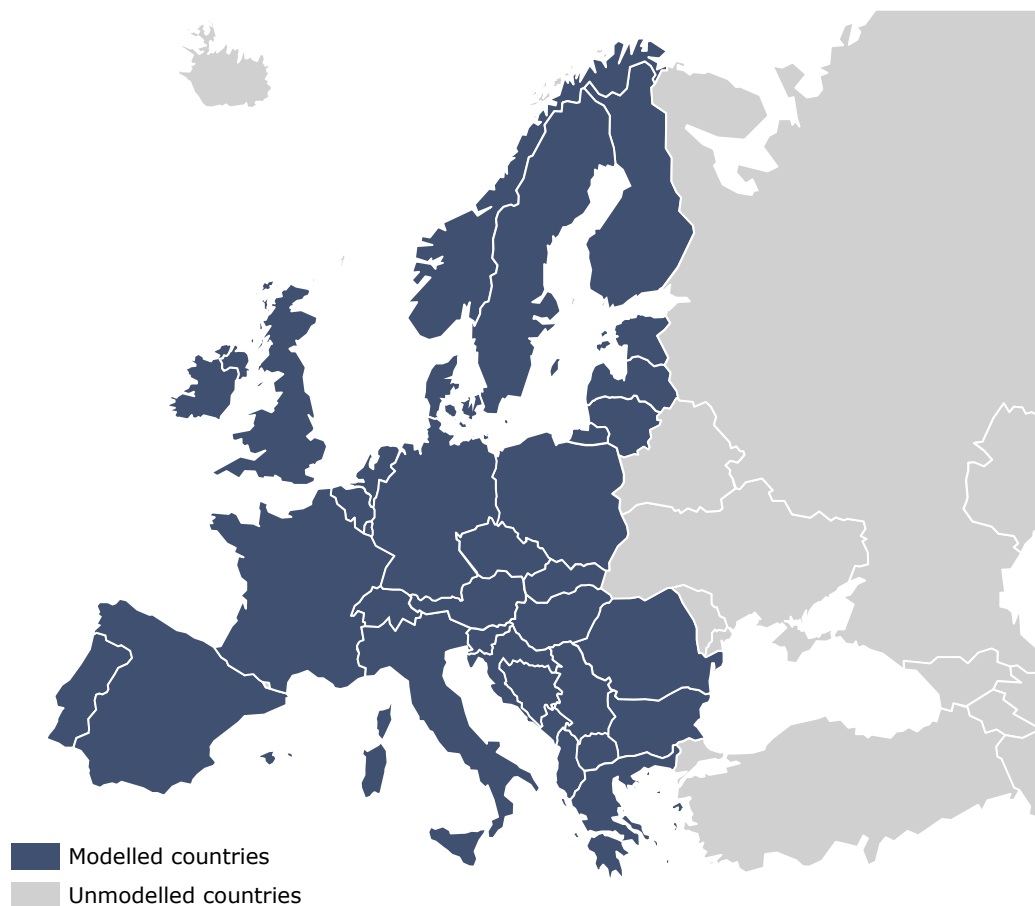
3. Modelling approach

24



The interconnected European power simulation has been simulated using AFRY's in house power market model

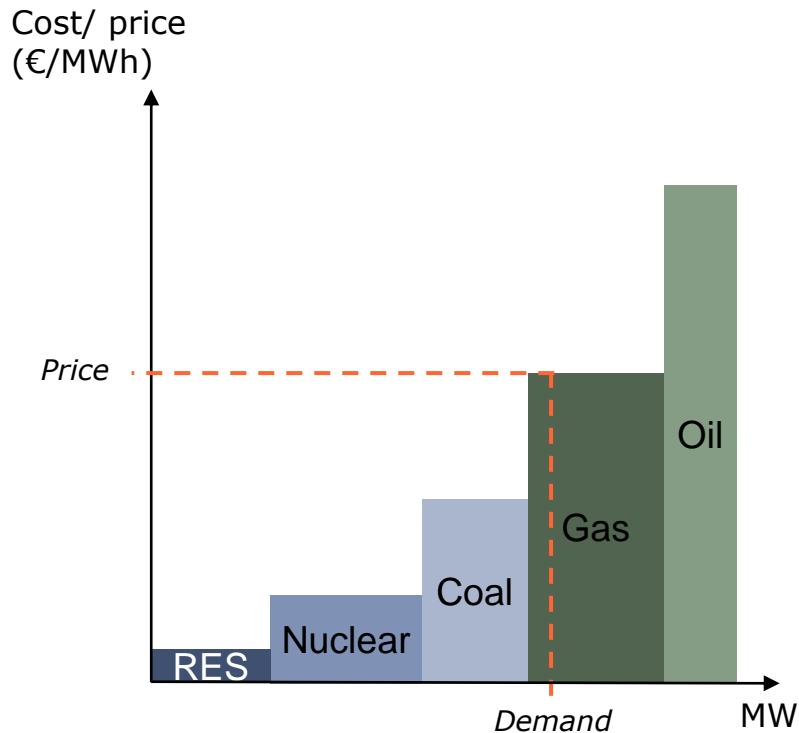
OUR POWER MARKET MODEL COVERS ALL EUROPEAN MARKETS



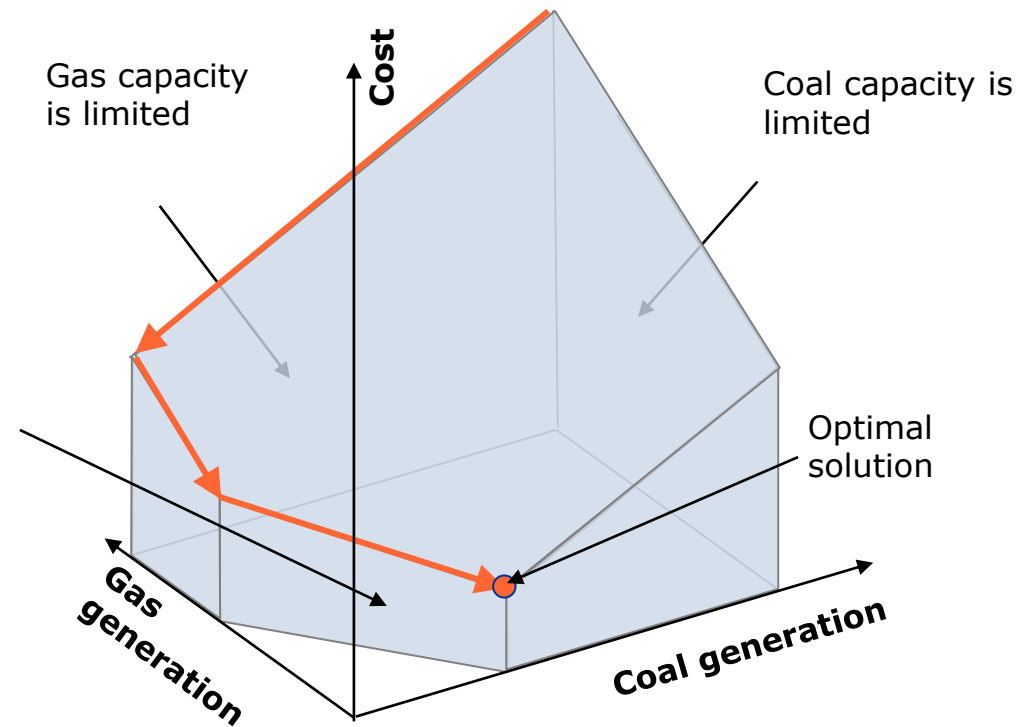
- AFRY's power market model is called BID3.
- BID3 is used both internally by AFRY and by external Clients, including:
 - System operators (e.g. APG, Fingrid, Energinet, National Grid, Statnett, Svenska Kraftnät, Terna, Transnet)
 - Utilities (e.g. Drax, ENBW, Hydro, Statkraft, Tiroler Wasserkraft, Uniper, Vattenfall)
 - Energy players (e.g. Siemens Energy)
- BID3 is typically used to model the hourly dispatch and redispatch of European power markets. This gives insights into:
 - Projected plant operations (e.g. cycling, dispatch seasonality, etc.)
 - Power prices (typically day ahead, but also imbalance prices and redispatch costs)
 - Cross-border interconnector flows
 - Plant revenues and variable operating costs
- We use these projections as the basis for conducting: commercial evaluations of generation assets; interconnector cost-benefit assessments; policy impact assessments; etc.

BID3 generates the hourly 'merit order' curve of each power market in Europe after taking into account a number of intertemporal constraints

SIMPLE MERIT ORDER APPROACH



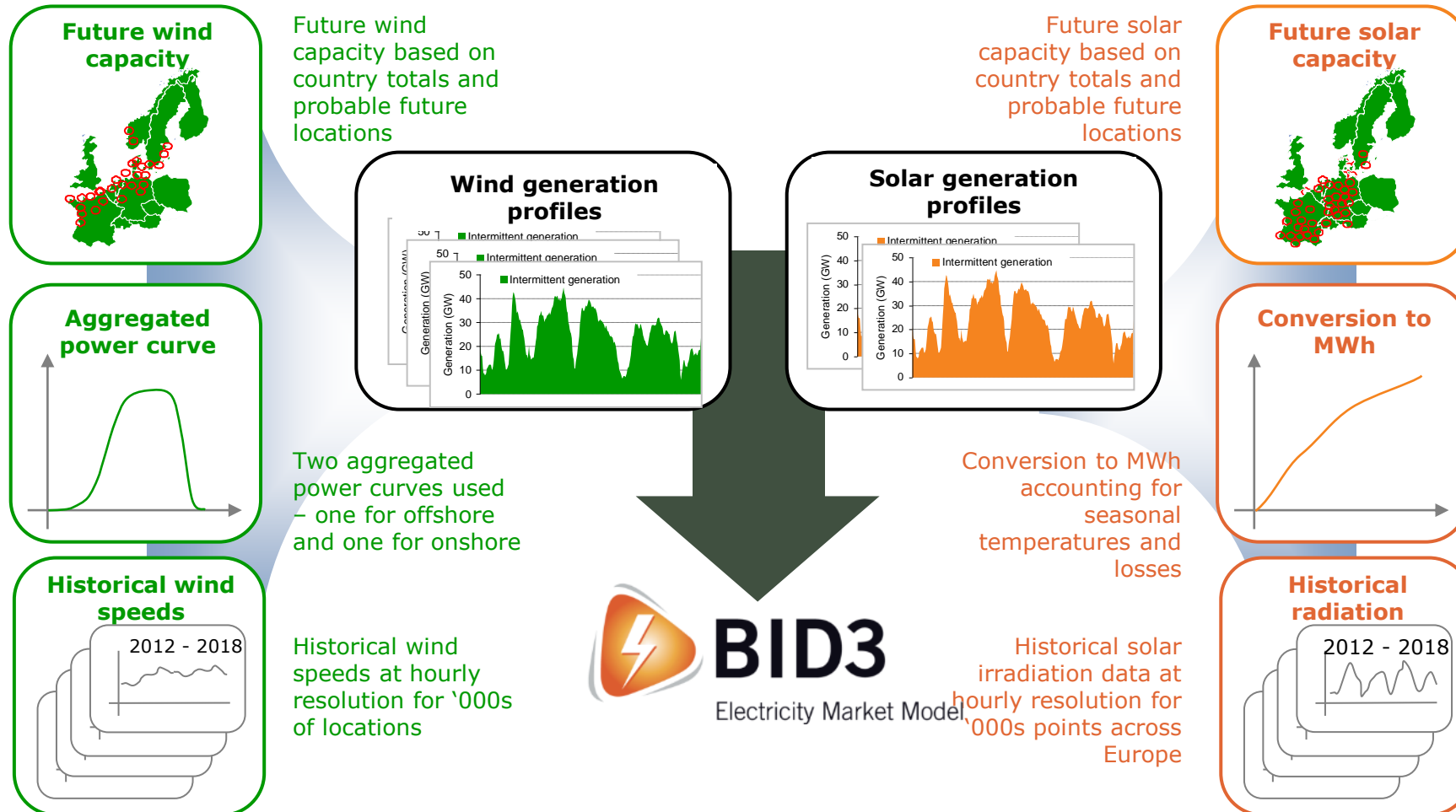
LINEAR OPTIMISATION APPROACH



Unlike a simple merit order stack, linear or MILP optimisation allows the inclusion of inter-temporal constraints (start-up costs, pumped storage, hydro etc.) and multiple zones

3 MODELLING APPROACH

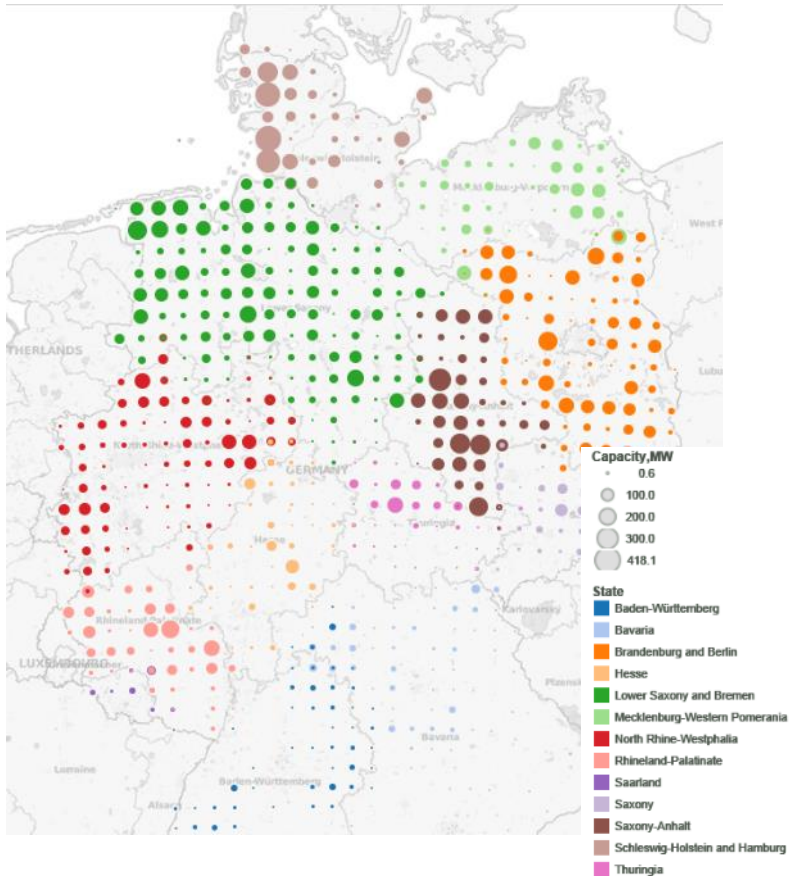
BID3 uses hourly wind and solar data from historical weather years to simulate variability on the future generation mix



3 MODELLING APPROACH

By modelling consistent historical weather patterns, BID3 accurately examines the impact of wind and solar on dispatch and prices

DETAILED DATABASE OF WIND FARM LOCATIONS USED



A SNAPSHOT OF THE SYSTEM

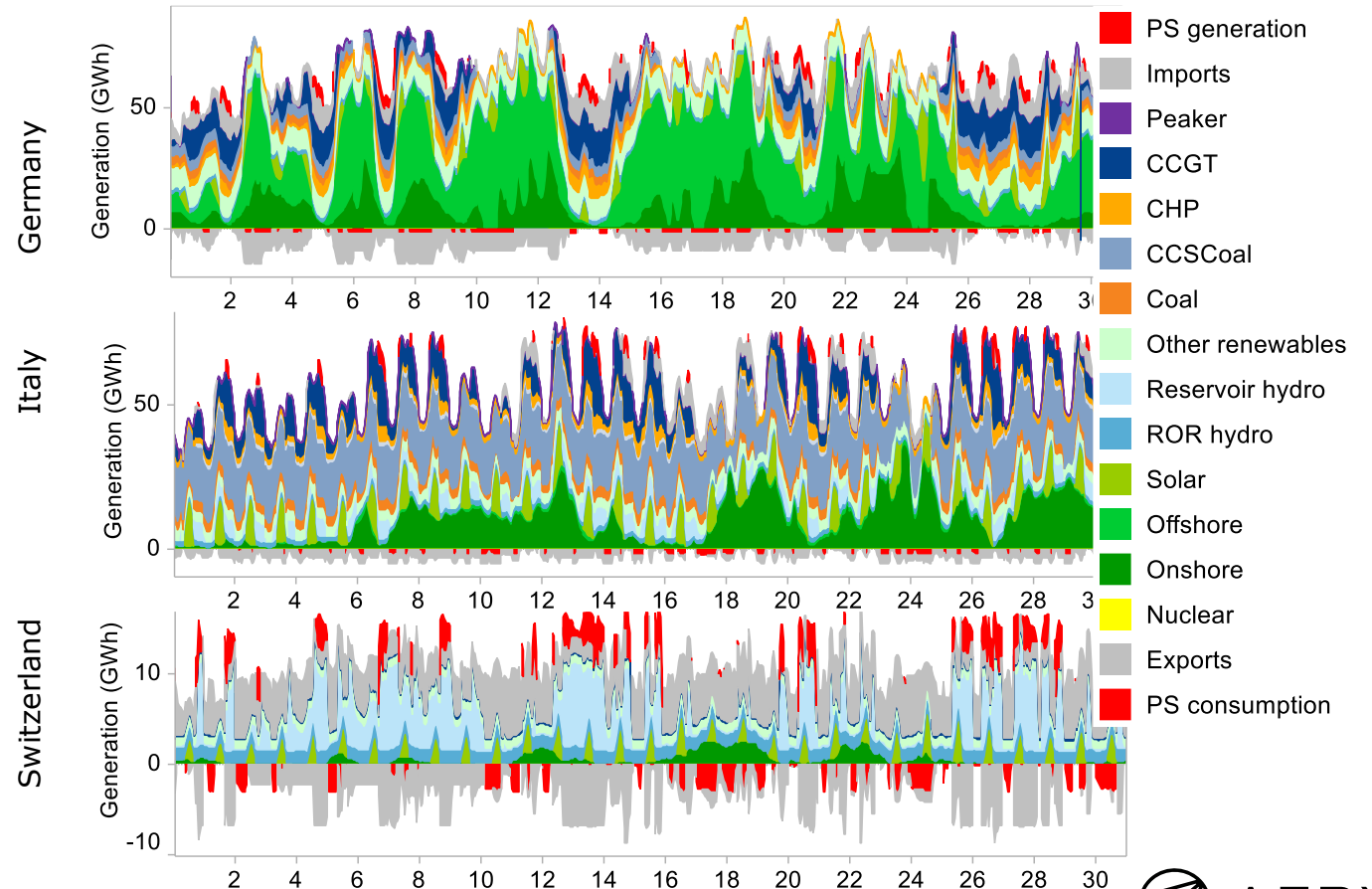


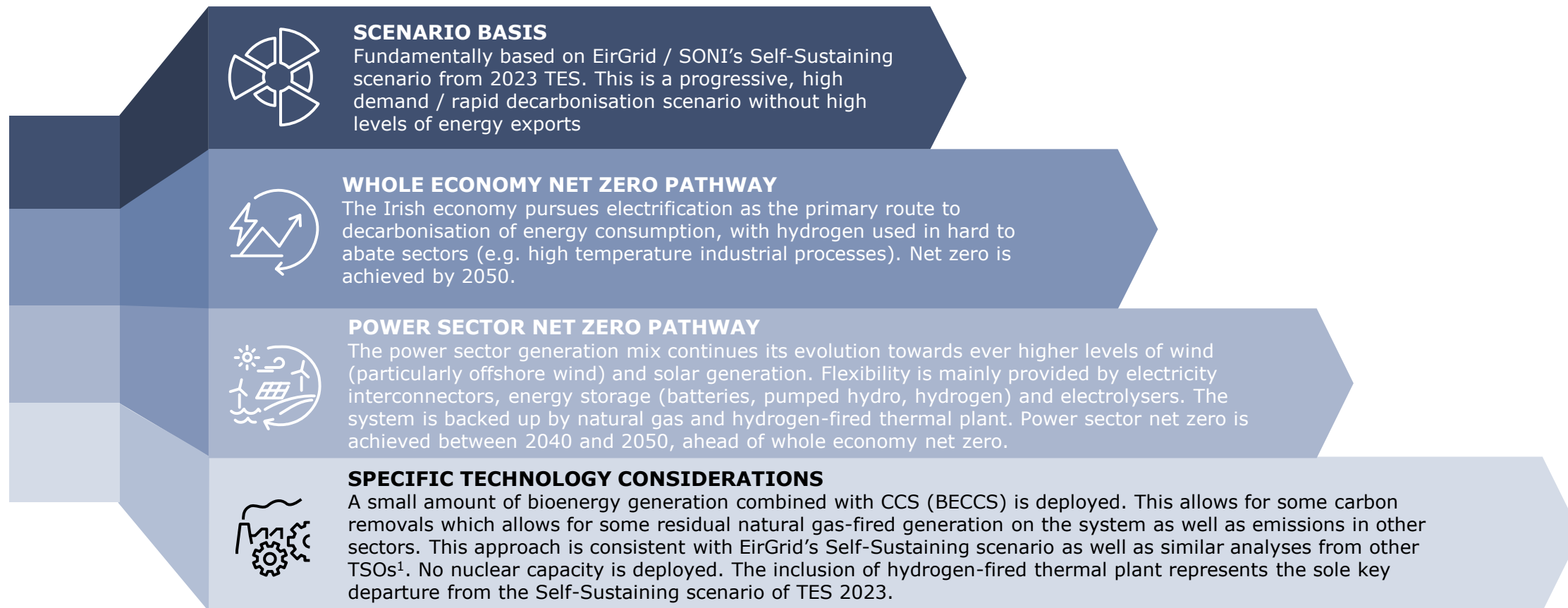
Table of Contents

4. One vision for domestic net zero	29
4.1 Scenario narrative	29
4.2 GB and EU markets	31
4.3 Fuel and carbon prices	33
4.4 SEM demand	35
4.5 SEM capacity mix	39



4.1 SCENARIO NARRATIVE

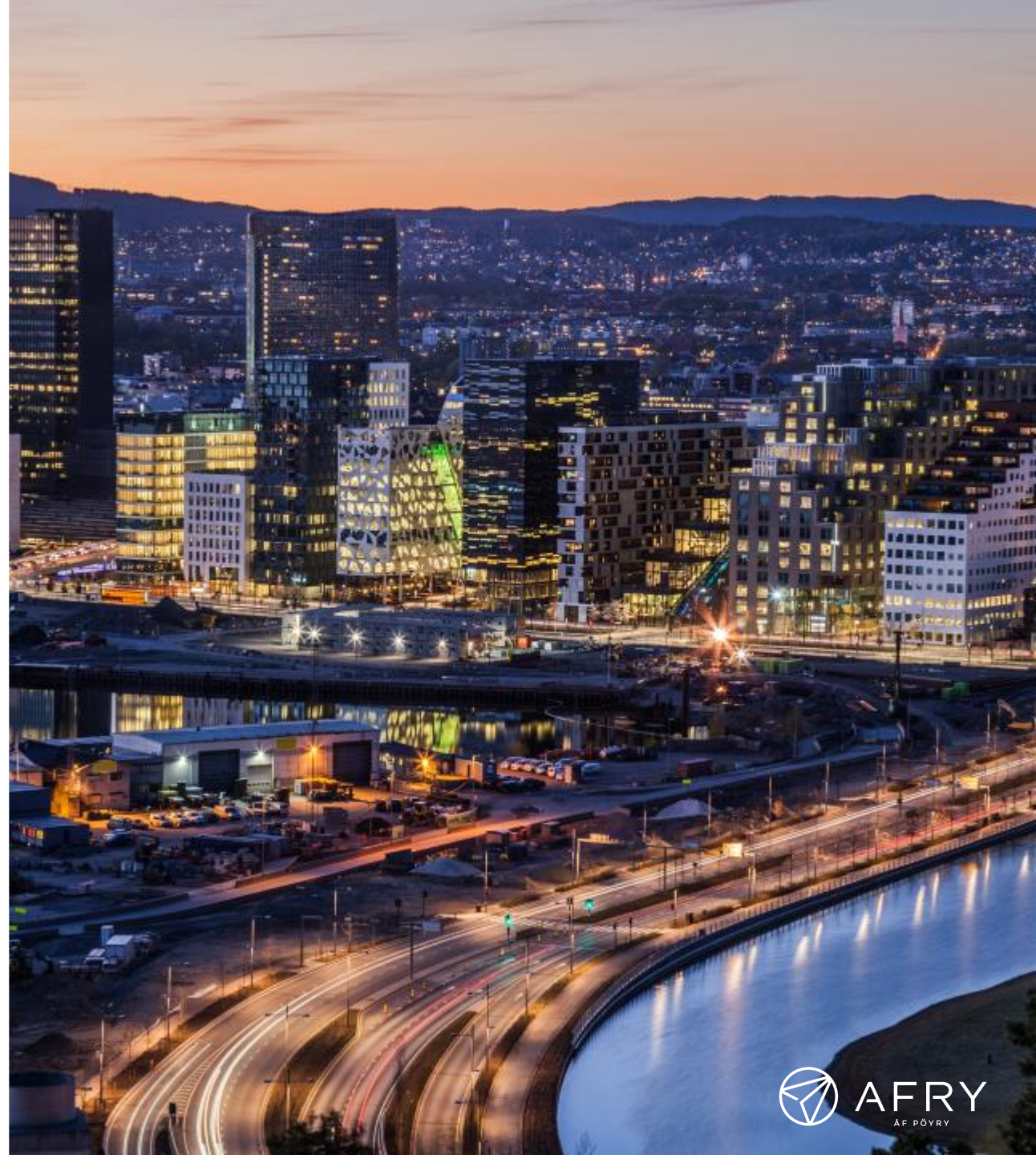
The Domestic Net Zero scenario draws heavily from published EirGrid scenarios and is one view (of many) of the energy sector's route to 2050



1. National Grid ESO, [Future Energy Scenarios 2023](#), July 2023.

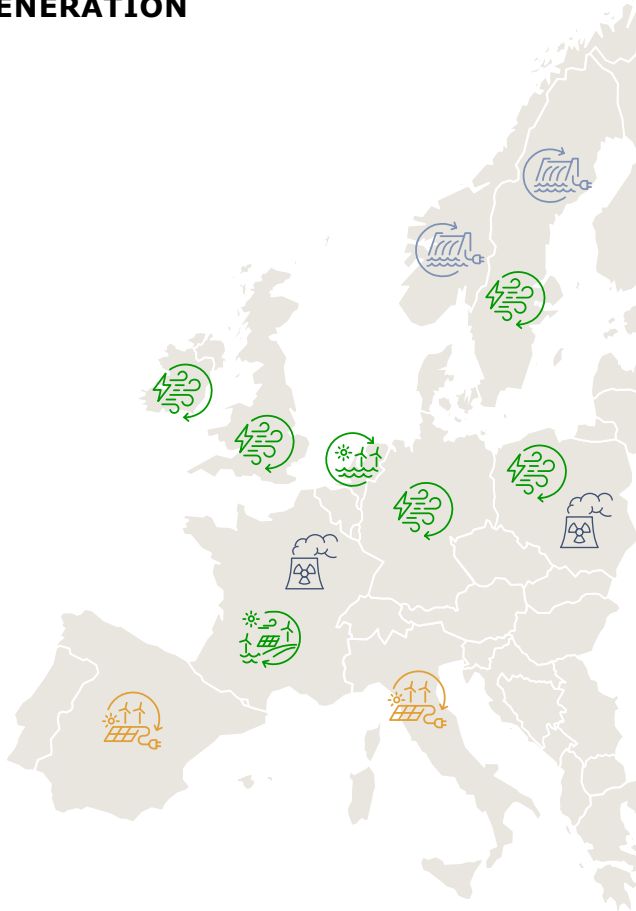
Table of Contents

4. One vision for domestic net zero	29
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4.2 GB and EU markets	31
4.3 Fuel and carbon prices	33
4.4 SEM demand	35
4.5 SEM capacity mix	39



European markets are assumed to reach net zero by 2050, with critical decarbonisation levers aligned to ENTSO-E's Global Ambition scenario

KEY SOURCES OF DECARBONISED GENERATION



RATIONALE

- Given this study's focus on energy export potential, assumptions around the make-up of the GB and wider European energy sectors are critical.
- Our starting point was AFRY's proprietary modelling of the interconnected pan-European energy system which assumes whole economy net zero is reached by 2050 across the system overall.
- This has subsequently been adjusted so that the key power sector decarbonisation levers in the major European markets (i.e. GB, France, Germany, Spain, Italy, Poland, Netherlands) are aligned with ENTSO-E's Global Ambition scenario from the 2022 Ten Year Network Development Plan (TYNDP).
- More specifically, we have sought to align: (1) wind / solar penetration (i.e. generation as a percentage of demand); (2) thermal / storage capacity that is used to 'back up' the system; (3) hydrogen demand and production (and consequently the hydrogen price).
- On electricity interconnection, we have included existing interconnectors as well as projects in relatively advanced development in 2030. By 2050, we assume that the European target for having electricity interconnection equivalent to 15% of installed generation capacity has been met. 2040 is intermediate between 2030 and 2050.

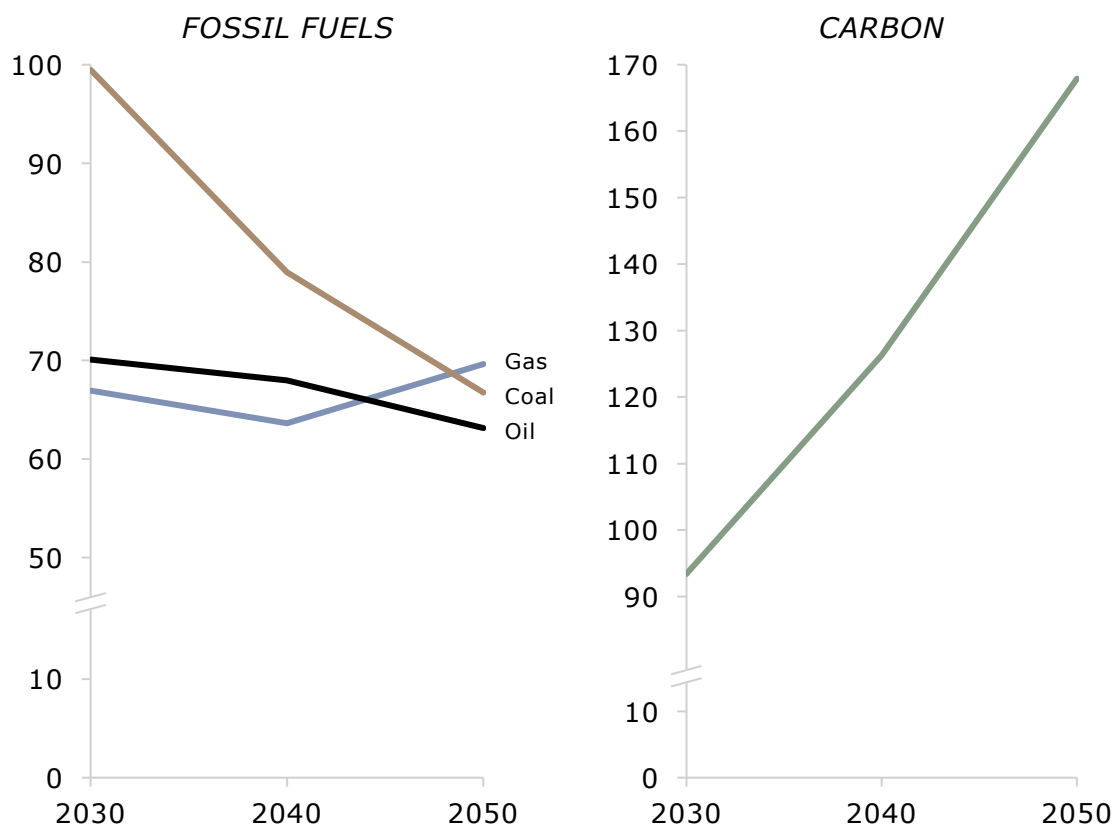
Table of Contents

4. One vision for domestic net zero	29
4.1 Scenario narrative	29
4.2 GB and EU markets	31
4.3 Fuel and carbon prices	33
4.4 SEM demand	35
4.5 SEM capacity mix	39

4.3 FUEL AND CARBON PRICES

Underlying fossil fuel and carbon prices have been taken from National Grid ESO's 2023 Future Energy Scenarios

UNDERLYING FUEL AND CARBON PRICES (P/THERM, \$/BBL, \$/TONNE, €/TCO₂, REAL 2022 PRICES)



Note: natural gas benchmark – NBP; oil benchmark – Brent; coal benchmark – ARA CIF; carbon benchmark – EU ETS EU Allowances.

RATIONALE

- Although EirGrid's Tomorrow's Energy Scenarios are based on fuel and carbon prices from ENTSO-E's TYNDP 2022, this data is based on a world from 2021, prior to the war in Ukraine.
- It is reasonable to argue that there has been a structural withdrawal of Russian gas supply from European markets that will not return in the future. Consequently, the more recent fossil fuel and carbon price curves from National Grid ESO's Future Energy Scenarios (FES) 2023 have been chosen.

GAS

Gas prices are broadly stable over the period 2030 to 2050. The UK's dependency on imports is high across the period and the price of gas is closely linked to the cost of liquified natural gas (LNG) imports.

NB: AFRY has included gas network charges in the gas price faced by gas-fired generation units on account of their low load factor from 2030 onwards. The framework for gas network charging is assumed not to change over the modelled horizon.

CARBON

Carbon prices increase significantly between 2030 and 2050. The cost of technologies required to abate the last few tonnes of CO₂ is high and prices increase over time as a result.

Table of Contents

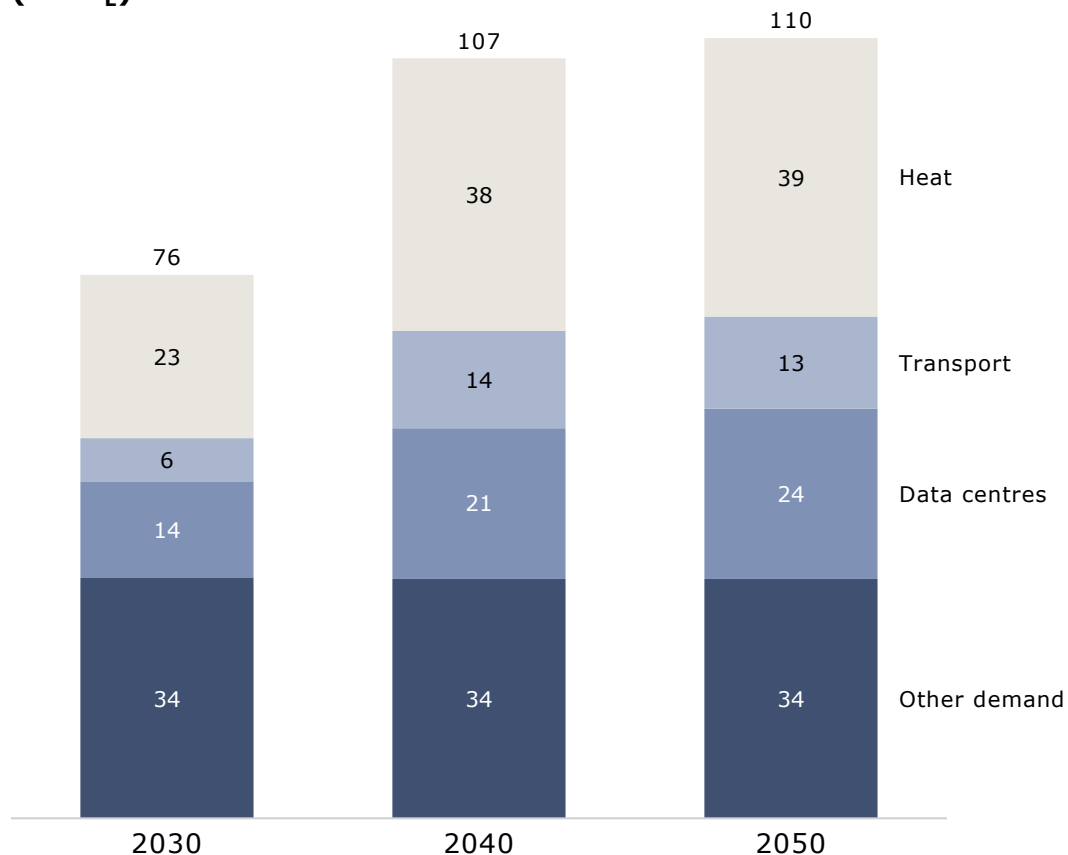
4. One vision for domestic net zero	29
4.1 Scenario narrative	29
4.2 GB and EU markets	31
4.3 Fuel and carbon prices	33
4.4 SEM demand	35
4.5 SEM capacity mix	39



4.4 SEM DEMAND

Underlying power demand has been aligned with EirGrid's Self-Sustaining scenario from the 2023 TES

SEM UNDERLYING ANNUAL POWER DEMAND (TWH_E)



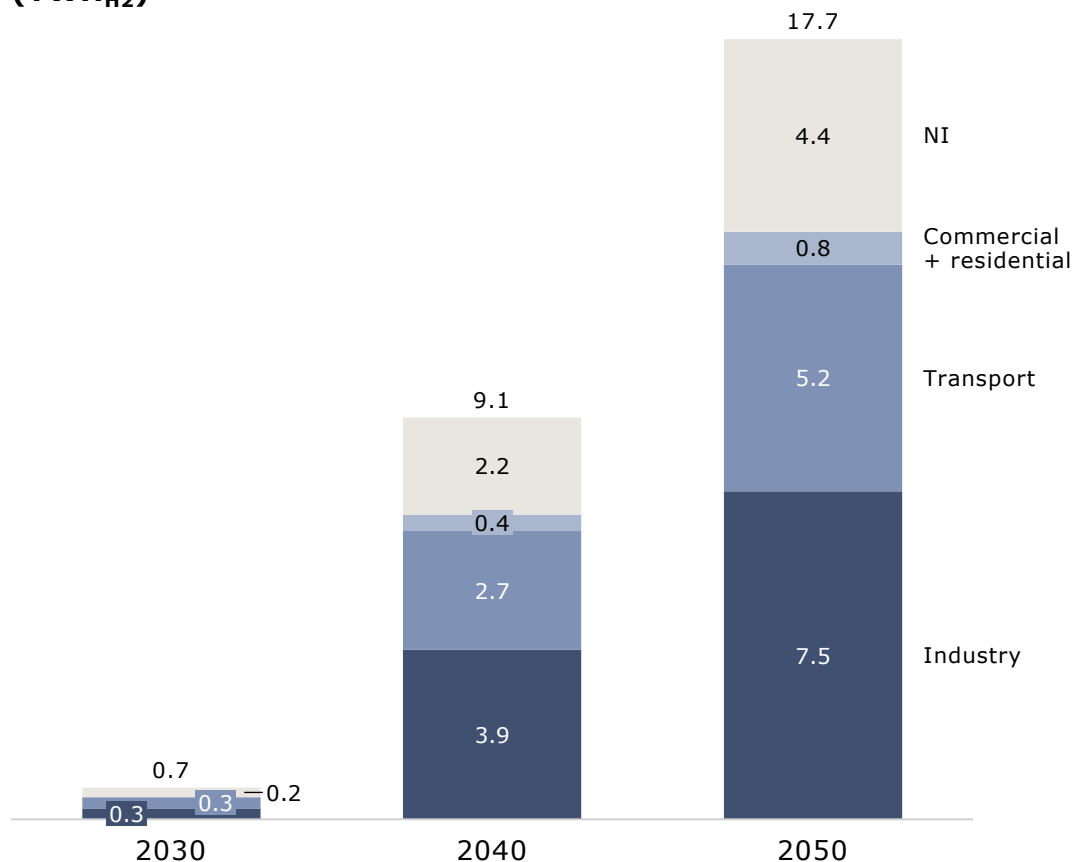
RATIONALE

- EirGrid / SONI's Self-Sustaining scenario from the 2023 TES was chosen as the alignment point for this study as it represents a higher industrial demand / higher pace of transition. We view this as an appropriate target for policy makers rather than some of the more conservative scenarios from the 2023 TES.
- In general, there is very significant growth in power demand, driven by significant electrification of heat as well as continued growth in data centre and transport power demand.
- Note that demand from electrolysers is not considered as a scenario input and is instead determined as part of the optimisation of power system dispatch.

4.4 SEM DEMAND

The mid-point of the demand estimates in the 2023 National Hydrogen Strategy have been assumed for 2050

SEM DOMESTIC NON-POWER HYDROGEN DEMAND (TWH_{H2})



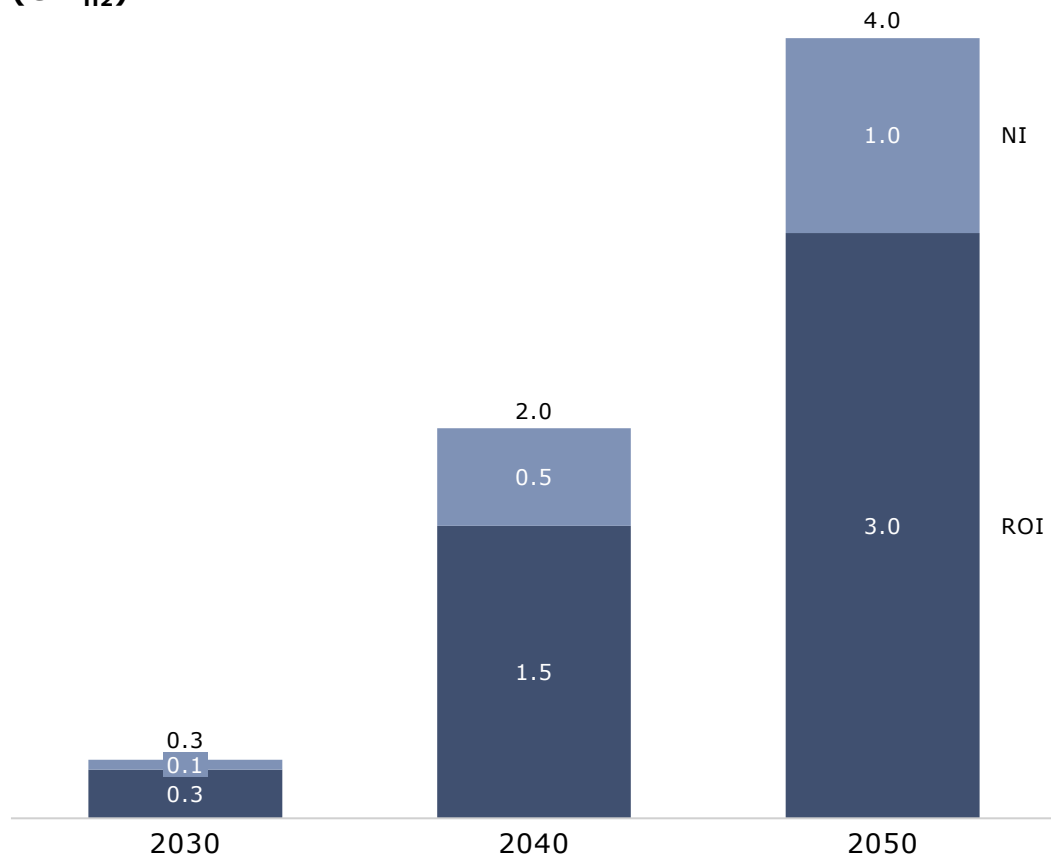
RATIONALE

- The National Hydrogen Strategy published in July 2023 contains a range of estimates for 2050 domestic hydrogen demand. This study has been aligned with the mid-point of those estimates for 2050 for Ireland, and with EirGrid’s Self-Sustaining scenario from TES 2023 for Northern Ireland.
- For 2030, the 2023 Climate Action Plan has suggested that there may be some green hydrogen production from surplus renewable electricity (the 2GW of offshore wind capacity dedicated to green hydrogen production is included as a 2031-35 measure). Considering the current lack of hydrogen demand in Ireland and the relative lack of maturity of the hydrogen sector, we have assumed a relatively low amount of domestic hydrogen demand for 2030, equally split between transport and Industry.
- More generally, the narrative around domestic hydrogen demand focusses on the use of hydrogen in hard to decarbonise sectors, particularly in high temperature industrial processes and in heavy transport. Hydrogen is not expected to feature prominently in space heating and light vehicle transport (either passenger or trucks).

4.4 SEM DEMAND

Electrolyser capacity has been set at levels sufficient to meet domestic hydrogen needs (both power and non-power)

SEM ELECTROLYSER CAPACITY (GW_{H2})



RATIONALE

- The level of electrolyser capacity assumed in this study has been set at a level that is sufficient to meet both power and non-power domestic hydrogen demand. In general, there is less electrolyser capacity in this study than in the TES 2023 Self-Sustaining scenario as a result of lower non-power hydrogen demand (c.24TWh in 2050 in the TES¹ on an all-island basis vs. 18TWh in this study).
- Unlike in EirGrid's TES, all electrolyser capacities in this study is assumed to be on-grid. Because electrolysers can be run flexibly, deploying capacity on-grid can help with system balancing and could potentially result in lower power system costs. Furthermore, we understand EirGrid's exclusion of on-grid capacity is not the result of a technical assessment indicating a lack of feasibility.

1. The 24TWh total is derived by summing non-power electrolyser consumption in Ireland (24.4TWh) and Northern Ireland (5.2TWh) and applying AFRY's assumption of 80% electrolyser efficiency.

Table of Contents

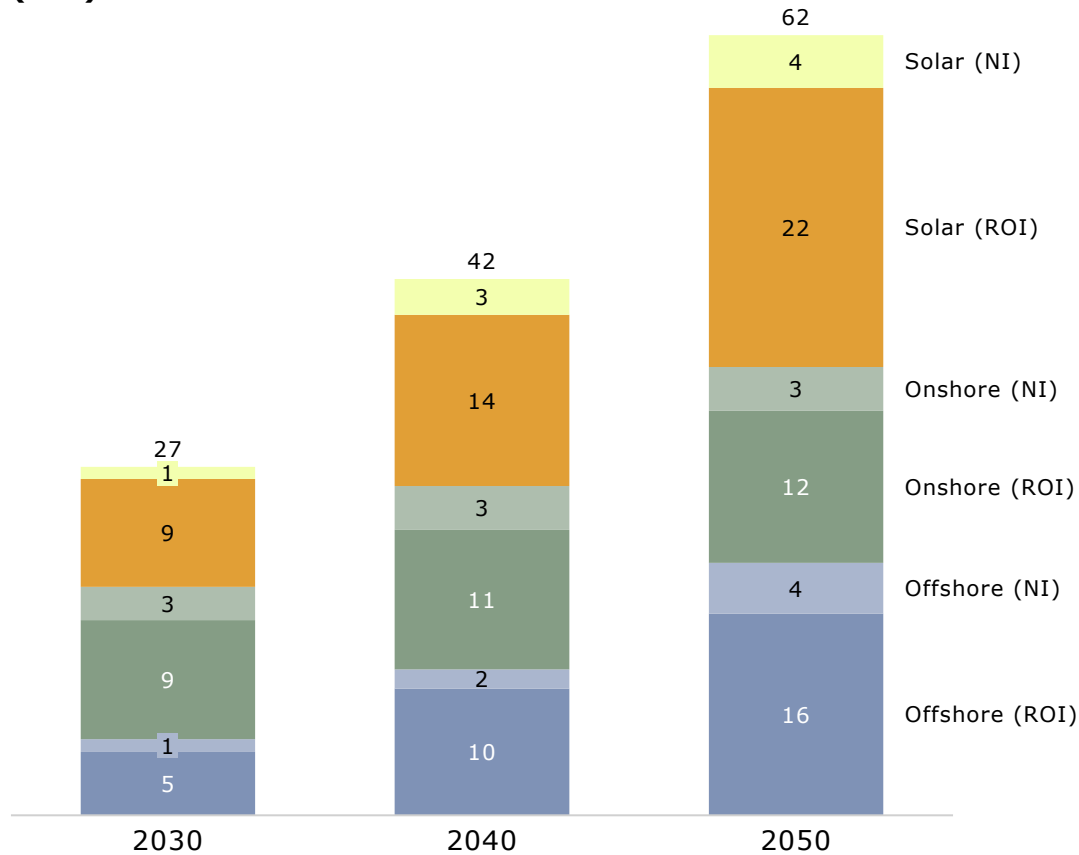
4. One vision for domestic net zero	29
4.1 Scenario narrative	29
4.2 GB and EU markets	31
4.3 Fuel and carbon prices	33
4.4 SEM demand	35
4.5 SEM capacity mix	39



4.5 SEM CAPACITY MIX

Renewables capacity growth is driven by offshore wind and solar (particularly small scale solar)

SEM RENEWABLES CAPACITY (GW)



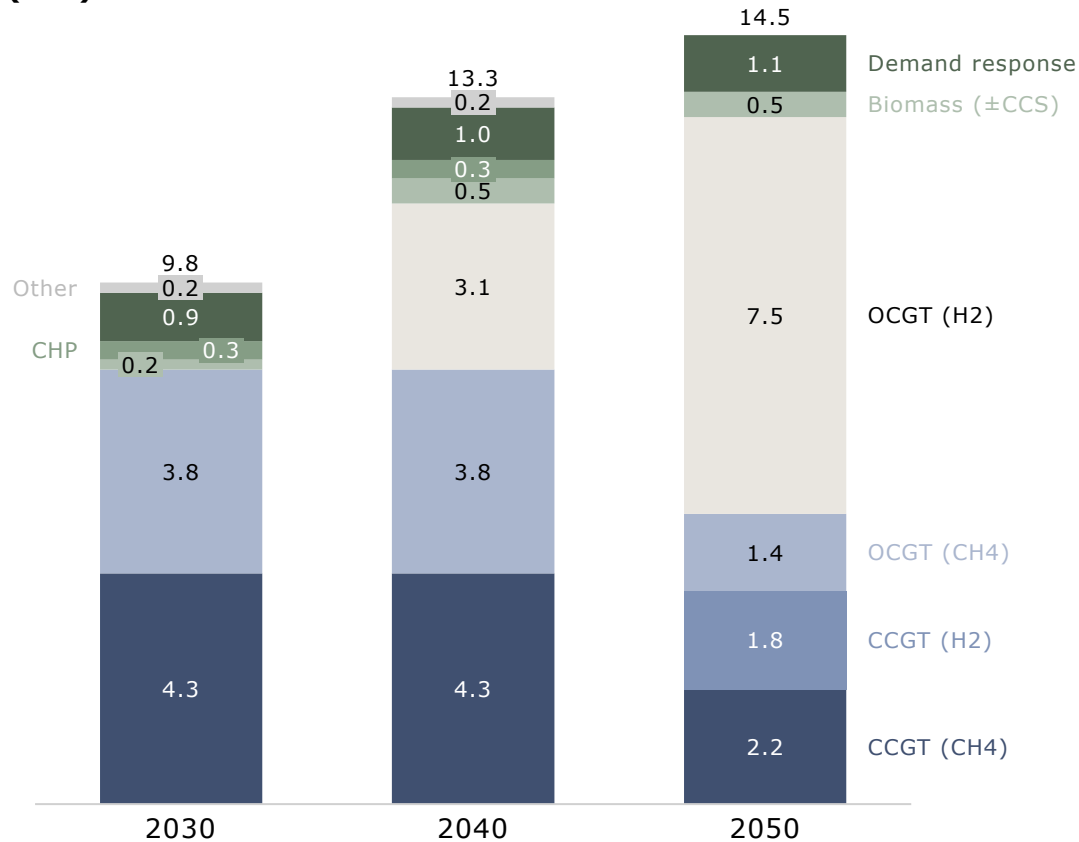
RATIONALE

- Wind and solar capacities have been taken from EirGrid / SONI’s Self-Sustaining scenario from TES 2023. The assumed level of installed capacity is consistent with meeting / exceeding Irelands’ 2030 target of satisfying 80% of electricity demand from renewable generation.
- The figures to the left include only on-grid capacities. We have not included off-grid capacities for either electrolysis or offshore wind. This relates to differences in how AFRY models the hydrogen system (our model fully co-optimises hydrogen and power sectors, whilst we understand the TES 2023 have not done this) and the findings of initial test runs suggesting that off-grid capacity would not be required to satisfy domestic hydrogen production.
- Note also that the solar figures include non-utility small scale solar in the totals.

4.5 SEM CAPACITY MIX

Thermal generation capacity is ultimately required to 'back up' the system, with the fleet being increasingly fuelled by hydrogen over time

SEM THERMAL CAPACITY (GW)



RATIONALE

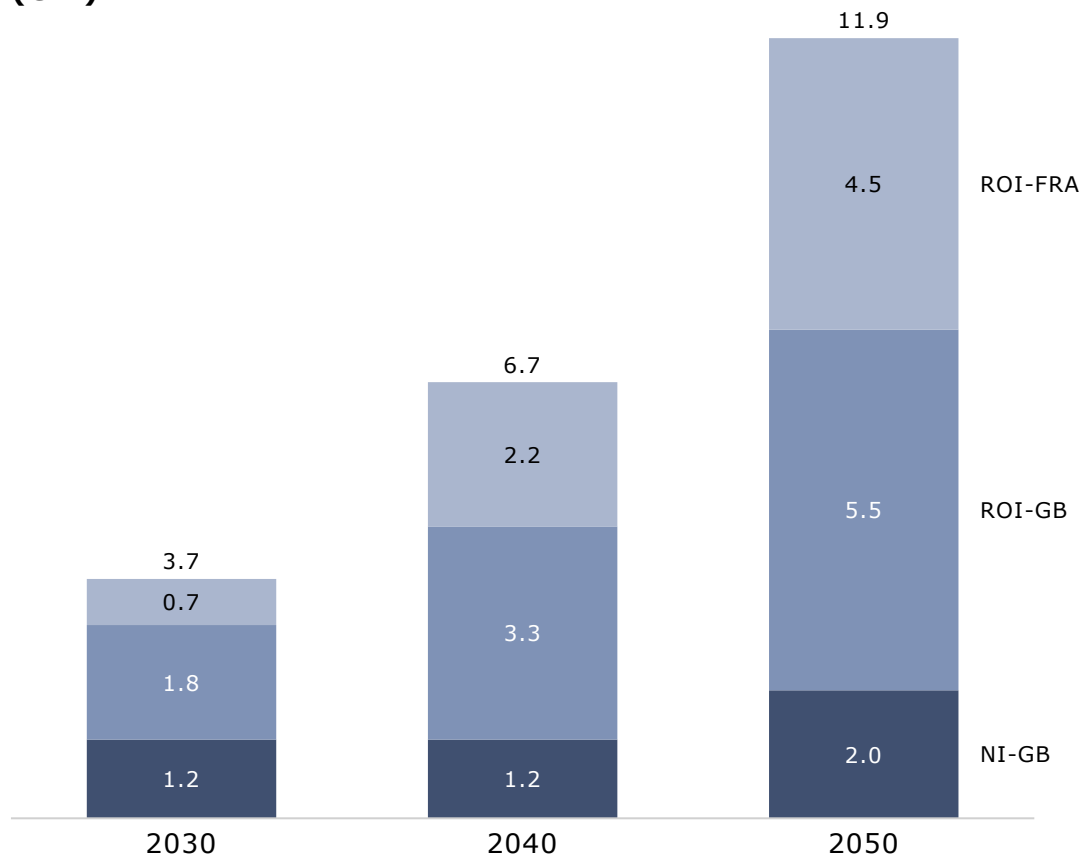
- The technology mix and MW of thermal capacity is largely aligned with EirGrid's Self-Sustaining scenario from TES 2023. With that said, there are a number of specific departures from the Self-Sustaining scenario, including:
 - Gas + CCS capacity in the Self-Sustaining scenario has been switched to hydrogen-fired capacity.
 - In 2050, around half of the existing (and thus old, by 2050) natural gas-fired capacity on the system is replaced by hydrogen-fired capacity.
- More generally, the capacity of the thermal fleet increases on the back of rising demand. Although ever higher levels of renewables may mean this fleet runs increasingly infrequently, it remains required to ensure security of supply.
- Over time, there is a marked shift to low carbon sources of generation and particularly hydrogen-fired capacity.

Note: CHP includes biomass and CCGT CHP units; Other includes engines and waste plants.

4.5 SEM CAPACITY MIX

Electricity interconnection achieves European targets (15% of installed generation capacity) by 2050, with Ireland linked to GB and France

SEM INTERCONNECTOR CAPACITY (GW)



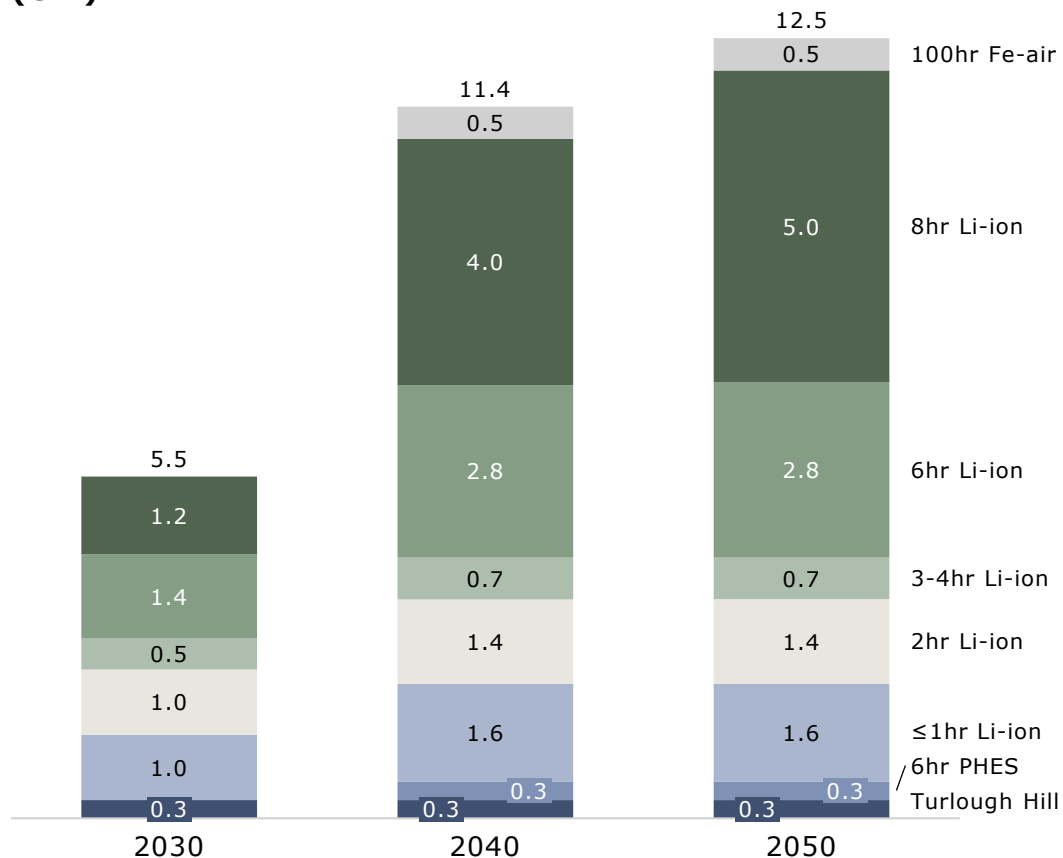
RATIONALE

- In 2030, existing and planned interconnectors between the SEM and GB / France are included. These include:
 - Moyle from Northern Ireland to Scotland (500MW)
 - EWIC from Ireland to Wales (500MW)
 - Greenlink from Ireland to Wales (500MW)
 - Celtic from Ireland to France (700MW)
 - LirIC from Northern Ireland to Scotland (700MW)
 - MaresConnect from Ireland to Wales (750MW)
- In 2040, interconnector capacity reflects an intermediate point between 2030 and 2050.
- In 2050, we have assumed that interconnection capacity amounts to c.15% of installed generating capacity in Ireland. This is loosely equivalent to five additional c.750MW cables being built to GB and another five to France.
- Interconnection from Northern Ireland to GB reflects capacities assumed in EirGrid's Self-Sustaining TES 2023 scenario.

4.5 SEM CAPACITY MIX

Electricity storage capacity increases significantly, with the battery fleet growing to around 12GW by 2050

SEM ELECTRICITY STORAGE CAPACITY (GW)



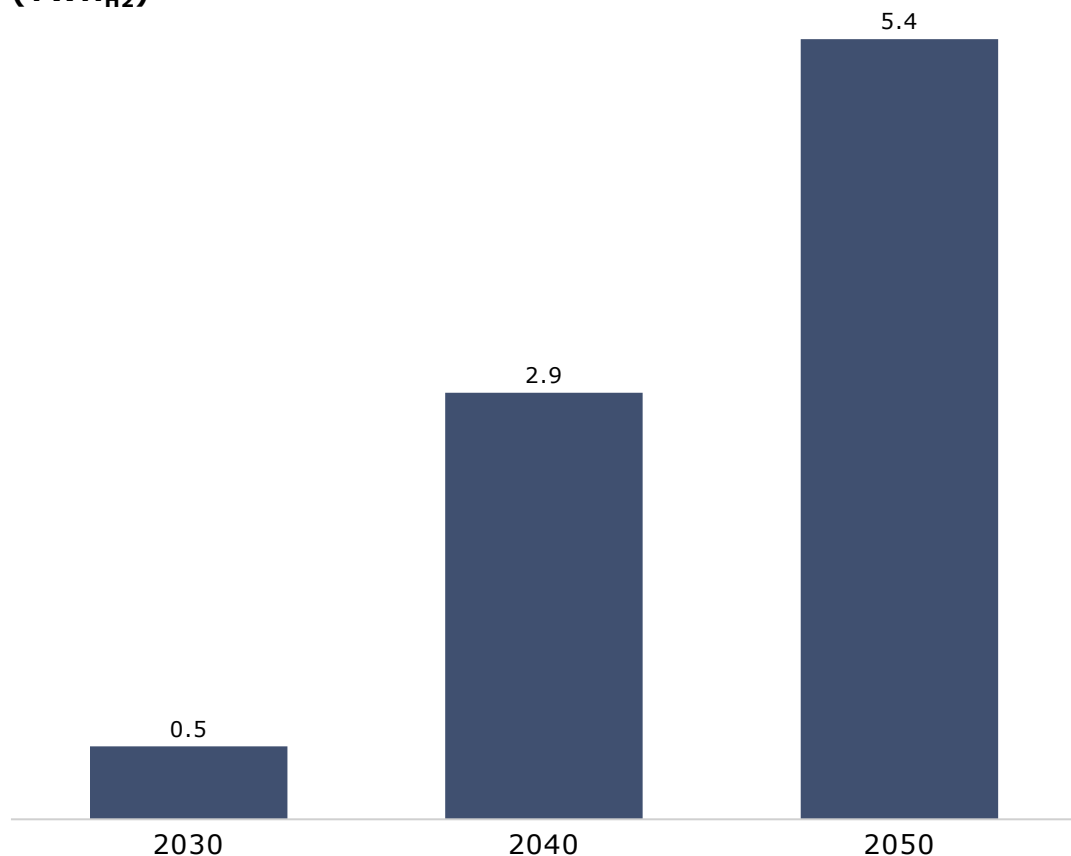
RATIONALE

- Electricity storage capacity is aligned with EirGrid’s Self-Sustaining scenario from TES 2023.
- This scenario sees a significant increase in short / medium duration (i.e. sub 8hr) battery capacity, which is able to take advantage of the significant increase in renewables capacity assumed over 2030-50.
- In addition, there is also 500MW of 100hr battery capacity. The technical characteristics of this storage have been assumed to be comparable to those of Form Energy’s iron-air battery, i.e. with efficiency of c.40%.
- The key departure from the Self-Sustaining TES scenario relates to how electric vehicles (EVs) have been modelled. In this study, EVs are modelled as demand with consumption profiles of varying flexibility (including some highly optimised consumption profiles, that can be considered as equivalent to EVs with vehicle to grid (V2G) capability).
- This contrasts with the approach in the TES which includes some EV demand with consumption profiles of varying flexibility and some EV demand modelled as a battery corresponding to EVs with V2G capability.

4.5 SEM CAPACITY MIX

Hydrogen storage volumes are taken from the National Hydrogen Strategy for Ireland and from EirGrid's TES for Northern Ireland

SEM HYDROGEN STORAGE CAPACITY (TWH_{H2})



RATIONALE

- The National Hydrogen Strategy published in July 2023 contains a range of estimates for 2050 hydrogen storage. More specifically, it estimated a range of 1.1-9.6TWh_{H2} for 90 day domestic gaseous energy needs (i.e. hydrogen gas).
- This study has been aligned with the mid-point of these estimates in 2050.
- For 2030, the 2023 Climate Action Plan has suggested that there may be some green hydrogen production from surplus renewable electricity (the 2GW of offshore wind capacity dedicated to green hydrogen is included as a 2031-35 measure). Considering the current lack of hydrogen demand in Ireland and the relative lack of maturity of the hydrogen sector, we have assumed a relatively low amount of hydrogen storage for 2030. 2040 represents the midpoint between 2030 and 2050.

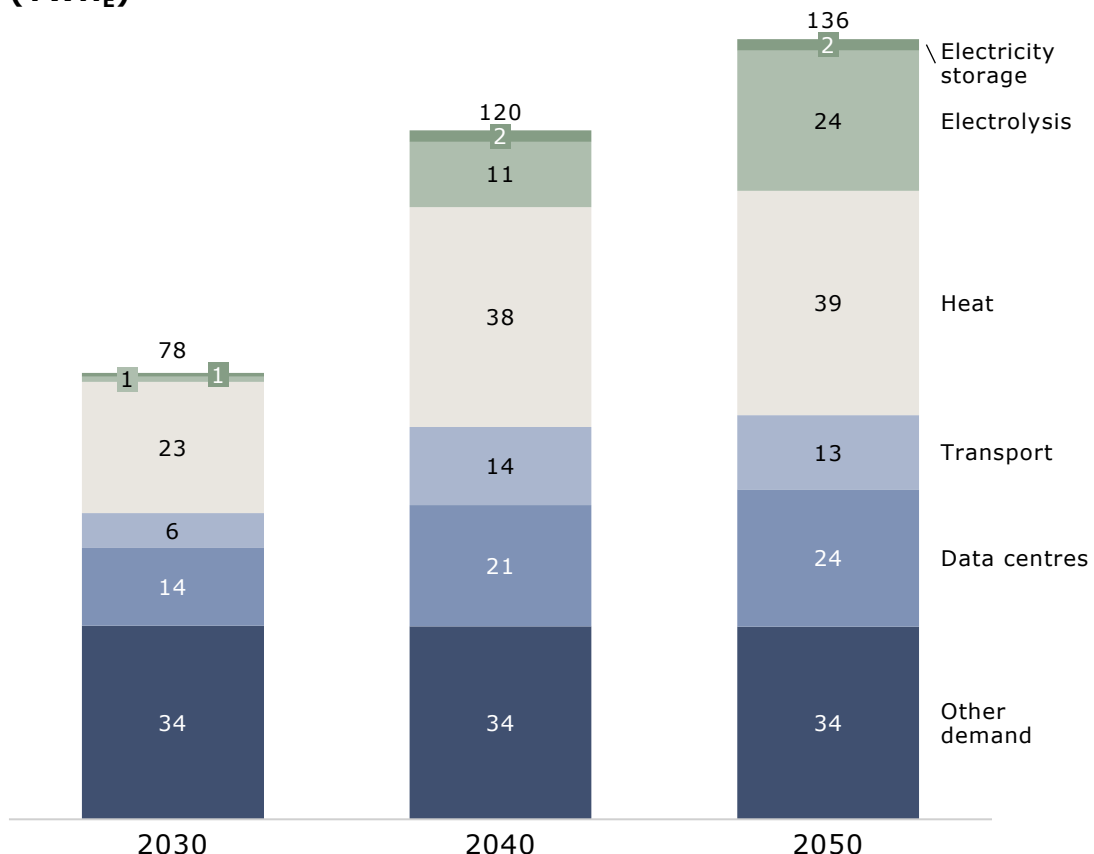
Table of Contents

5. Domestic net zero summary findings 45



Electricity demand triples by 2050 compared to 2022 as a result of significant electrification of the All-Island economy

SEM POWER DEMAND (TWH_E)



Note: Electricity storage consumption reflects the impact of round-trip efficiency losses. Other demand, Data centres, Transport and Heat are input assumptions of the study.

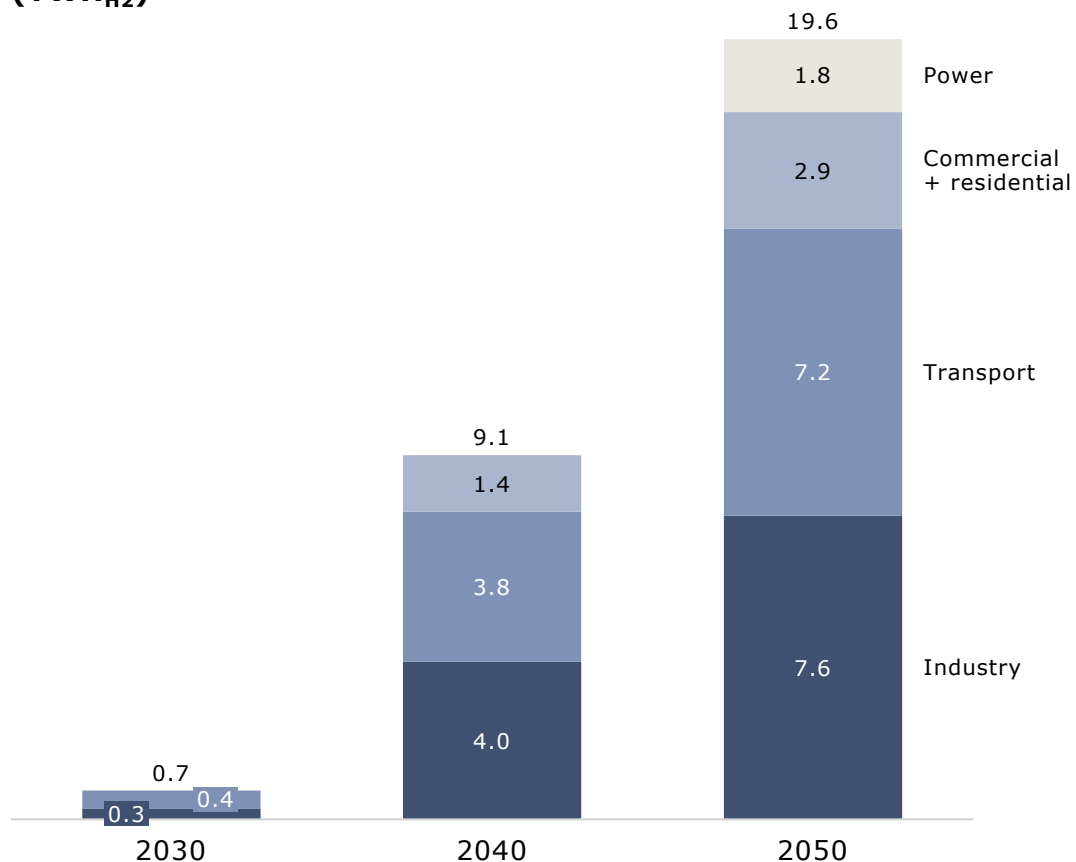
DISCUSSION

- Power demand in 2030 is significantly higher than projections included in the last All-Island Generation Capacity Statement¹ (GCS), published in 2022 and even the Shaping Our Electricity Future (SOEF) Roadmap, published in 2023. This follows from the SS scenario in TES2023 aligning more closely with aspirational decarbonisation targets and apparently including significantly higher levels of electrification by 2030 than either the GCS or SOEF.
- The 2030s are assumed to be the decade when significant strides towards net zero are made and low hanging fruit are plucked. Electricity demand increases 54% between 2030 and 2040, driven by significant growth in data centres and continued electrification of heat and transport. Electrolyser consumption also becomes a material source of demand by 2040, accounting for almost 10% of demand.
- Demand growth slows in the 2040s as there are fewer easy wins in the electrification and we start to reach harder-to-decarbonise elements of energy demand that require hydrogen in order to decarbonise. This is evident in the vast majority of growth in the 2040s stemming from increasing electrolyser demand.

1. EirGrid / SONI, All-Island Generation Capacity Statement 2022-31, October 2022.
 2. EirGrid / SONI, Shaping Our Electricity Future Roadmap Version 1.1, July 2023.

Hydrogen demand in the power sector reaches 1.8TWh, with H2-fuelled generation capacity dispatched infrequently to back up the system

SEM HYDROGEN DEMAND (TWH_{H2})

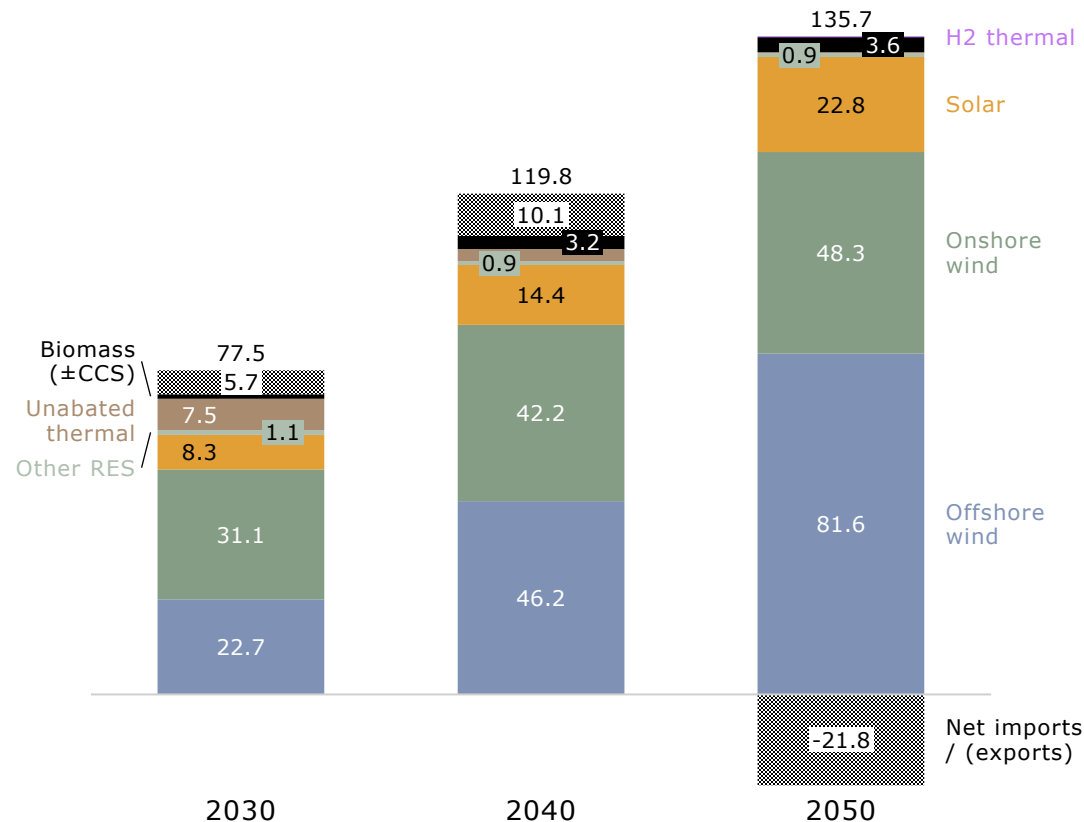


DISCUSSION

- SEM-wide hydrogen demand increases significantly in the two decades after 2030, albeit primarily as a result of demand outside of the power sector (i.e. the demand this study has assumed as an input).
- Power sector demand is relatively low. This is because in 'normal' weather conditions (note that the modelling in this study has investigated the system under 5 representative weather patterns), there is sufficient renewables generation / energy storage / interconnection to address the vast bulk of demand.
- Thermal generation is only required when the system is very tight (e.g. when demand is high and renewables output is low in the SEM, GB and France leading to relatively low imports).
- System stability is provided by a range of low carbon technologies, with synchronous condensers providing inertia, system strength and reactive power, STATCOMs and shunt reactors providing reactive power capability and 6.5GW of sub 6hr Li-ion batteries providing reserves and short-duration ramping capacity.

The generation mix is eventually dominated by renewables, with only small contributions from the thermal fleet

SEM GENERATION MIX (TWH)



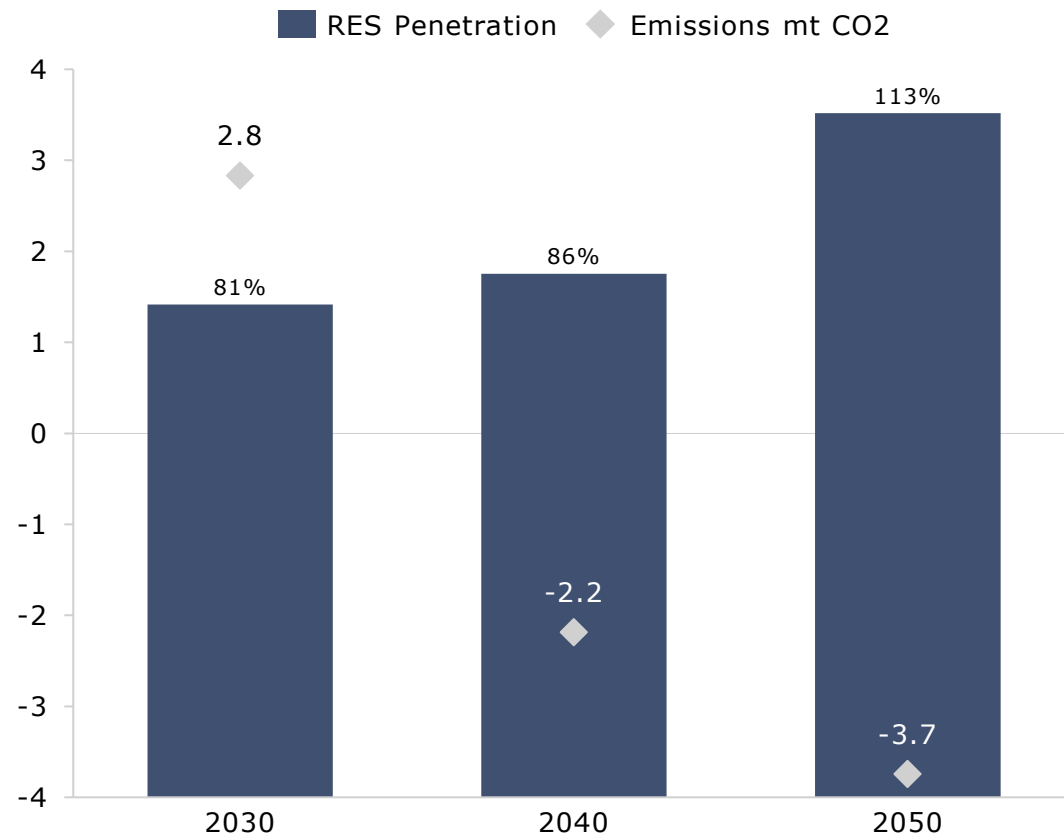
Note: Other RES includes hydro and biomass. Demand response is not shown on the chart but amounts to c.0.2-0.3TWh/yr

DISCUSSION

- The SEM remains a 'windy' system in the DNZ scenario, with half of all generation coming from offshore wind and a further 31% coming from onshore wind. Once solar is included in the picture, 97% of all generation is derived from intermittent renewables.
- A key driver of the growth of wind generation relates to the deployment of higher load factor capacity over time. For onshore wind, this is related to larger turbines and higher hub heights for new capacity, whilst for offshore wind, deployment of capacity on the windier west coast improves aggregate load factors by 5 percentage points between 2030 and 2050.
- Thermal generation accounts for only 3% of generation and the vast majority of this stems from the c.500MW of BECCS in Ireland and Northern Ireland. Hydrogen and natural gas fired generation is used on occasion when the system is particularly tight.
- In the DNZ scenario, the SEM evolves from a net importer to a net exporter of power. The shift occurs in the 2040s as demand growth slows and the assumed renewables build out continues. This results in a degree of cheap excess renewable generation¹ that is economic to export to GB and France.

Renewables penetration increases significantly between 2040 and 2050, with SEM net zero achieved by 2040 due to presence of BECCS on the system

SEM EMISSIONS AND RENEWABLES PENETRATION (MTCO₂, % OF ANNUAL DEMAND)



Note: Renewables include, wind, solar and hydro. Biomass is not included.

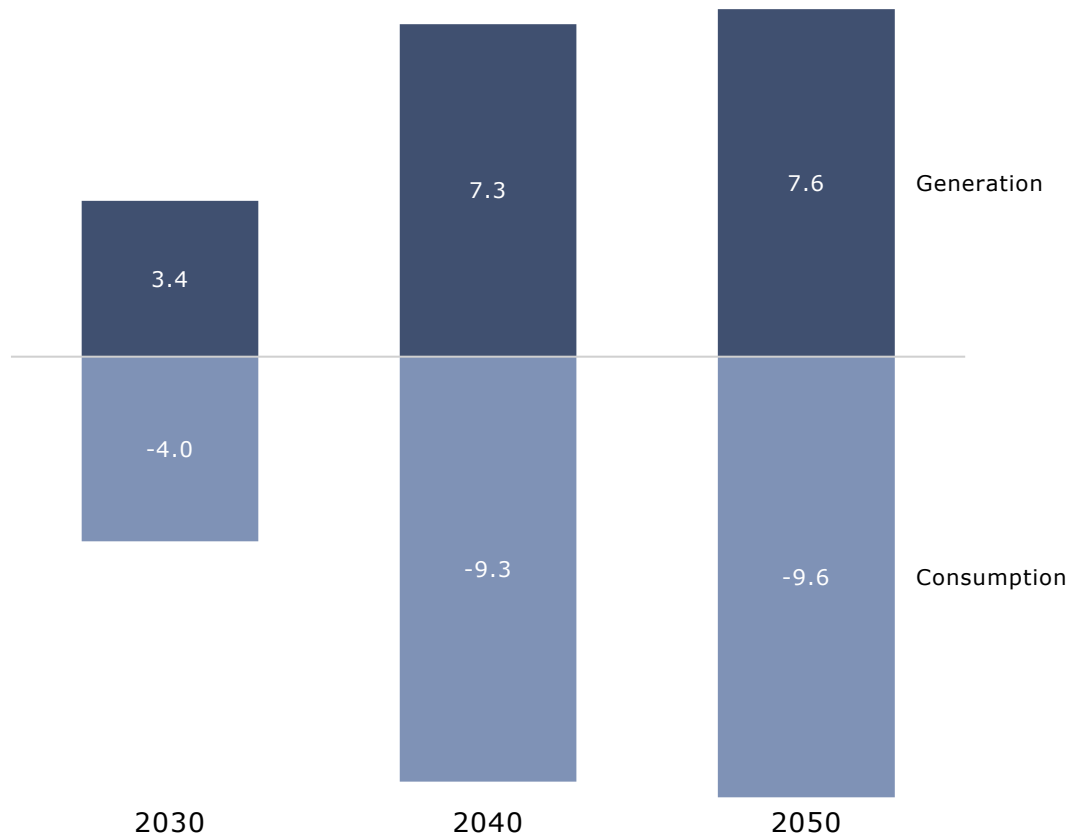
DISCUSSION

- Renewables penetration achieves targets in both Ireland and Northern Ireland in 2030, before rising above 80% in the years beyond 2030.
- By 2050, our simulations suggest renewables penetration in the DNZ scenario would reach 113%, indicating there is excess renewables generation. Note that this represents the excess **generation** over power demand and does not include the renewables surplus that has not been used in the DNZ scenario. To put it another way, the 13% of additional renewables penetration in 2050 in the graph on the left corresponds to the clean power that is exported via interconnectors.
- Net zero is reached in 2040, and is certainly facilitated by the presence of BECCS on the system. In both 2040 and 2050, this allows for limited use of unabated natural gas capacity when the system is very tight.
- Considering the known difficulties of decarbonising the agricultural sector and this sector’s contribution to Ireland’s economy, it would certainly be helpful if the power sector’s 3.7MtCO₂ of carbon removals in 2050 could be used to offset agricultural emissions. For context, the agriculture sector had emissions of 23.3MtCO₂¹ in 2022 with 2050 power sector removals amounting to c.15% of 2022 agriculture emissions.

1. EPA, [Ireland’s 2022 Greenhouse Gas Emissions show a welcome decrease, but much work remains to be done](#), 13 July 2023.

Electricity storage allows for 7-8% of annual power consumption to be time-shifted in 2040 and 2050

SEM ELECTRICITY STORAGE UTILISATION (TWH)



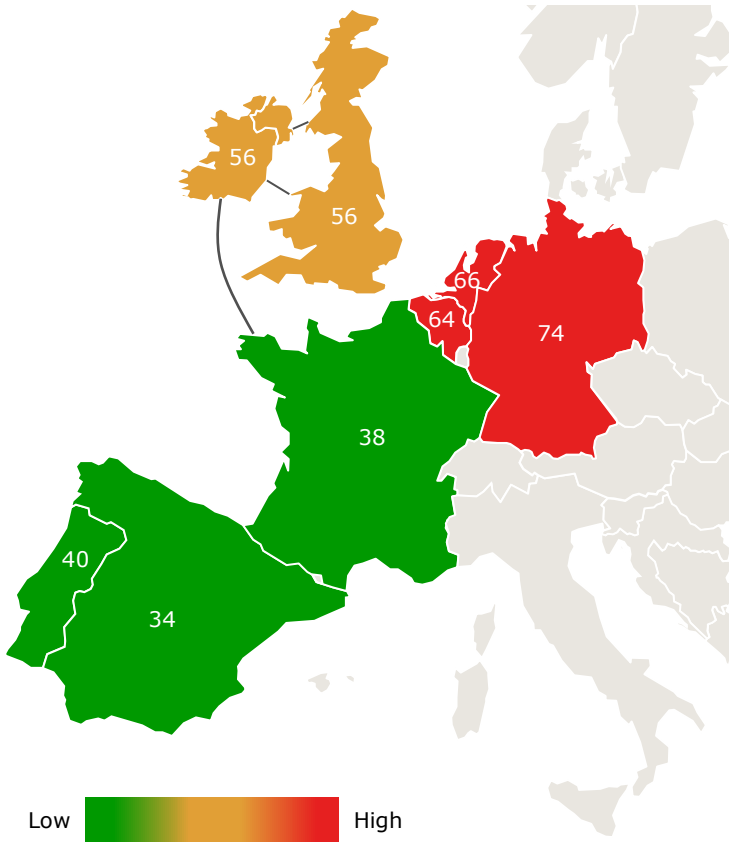
DISCUSSION

- Electricity storage gross utilisation¹ ranges between 15-17% in the DNZ scenario. This is sufficient to shift 5% of annual power demand in 2030, 7.7% in 2040 and 7.1% in 2050.
- Note that utilisation would typically be enhanced by operation of storage assets in the balancing market to address forecast errors so what appears to be a relatively low figure is not an especially surprising finding.
- Furthermore, utilisation is likely to be significantly dampened by the presence of hydrogen storage in the system. In a windy system with prolonged periods of high / low wind generation (and correspondingly low / high prices), storage with durations of 8hr or less will frequently be unavailable due to reaching storage limits. Because hydrogen storage is not typically as affected by this, as long as there is sufficient demand for hydrogen (which we have implicitly assumed in the DNZ scenario), power to hydrogen to storage will be a very high merit source of flexibility.
- Had hydrogen storage **not been included** in the model, utilisation of electricity storage would be materially higher, especially if additional long duration energy storage (LDES) were included in the system.

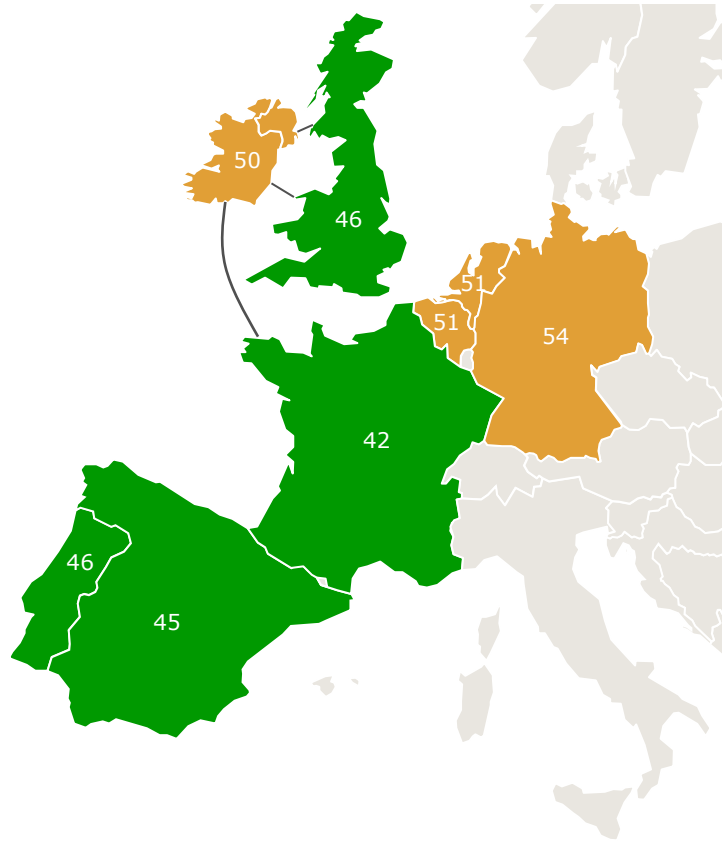
1. Gross utilisation reflects aggregate imports and exports of storage capacity.

Spreads in baseload power prices erode over time as the European power system becomes more interconnected

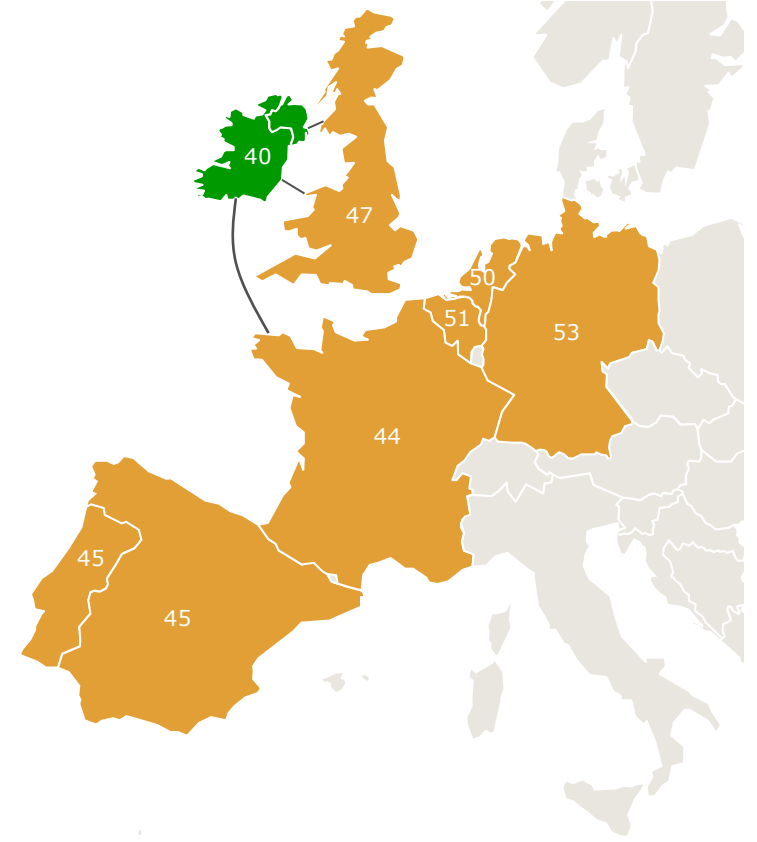
**2030 BASELOAD POWER PRICE
(€/MWH, REAL 2022 PRICES)**



**2040 BASELOAD POWER PRICE
(€/MWH, REAL 2022 PRICES)**

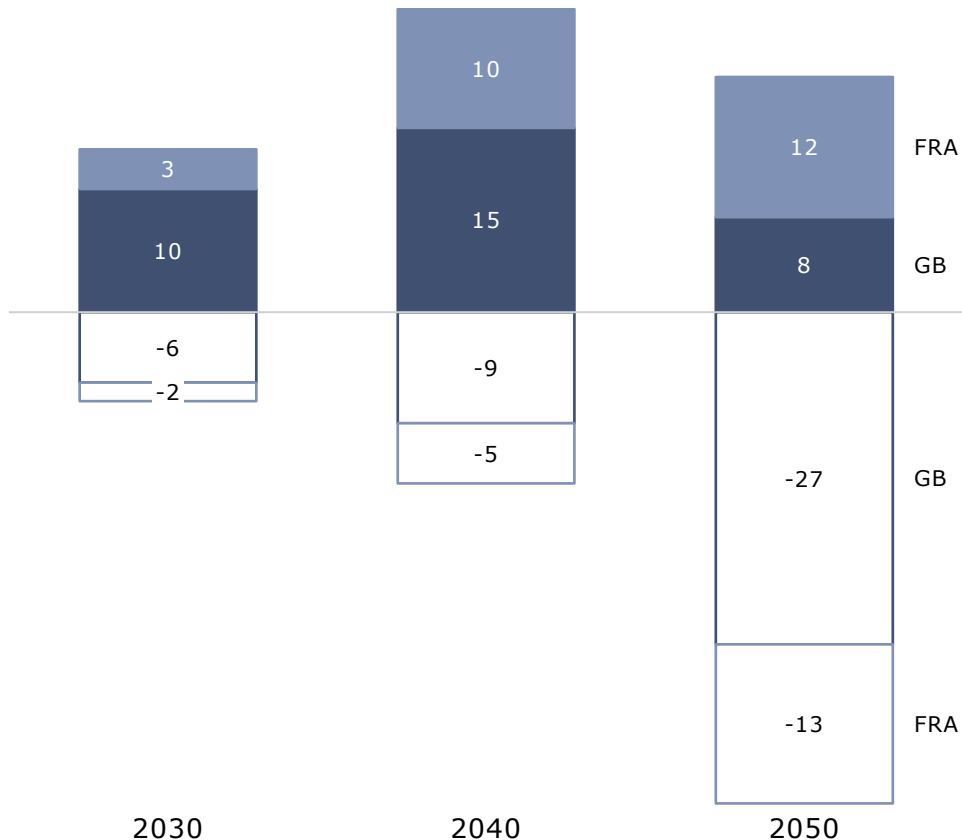


**2050 BASELOAD POWER PRICE
(€/MWH, REAL 2022 PRICES)**



The SEM transitions from being a net importer of power to a significant net exporter by 2050

SEM INTERCONNECTOR IMPORTS / (EXPORTS) (TWH)

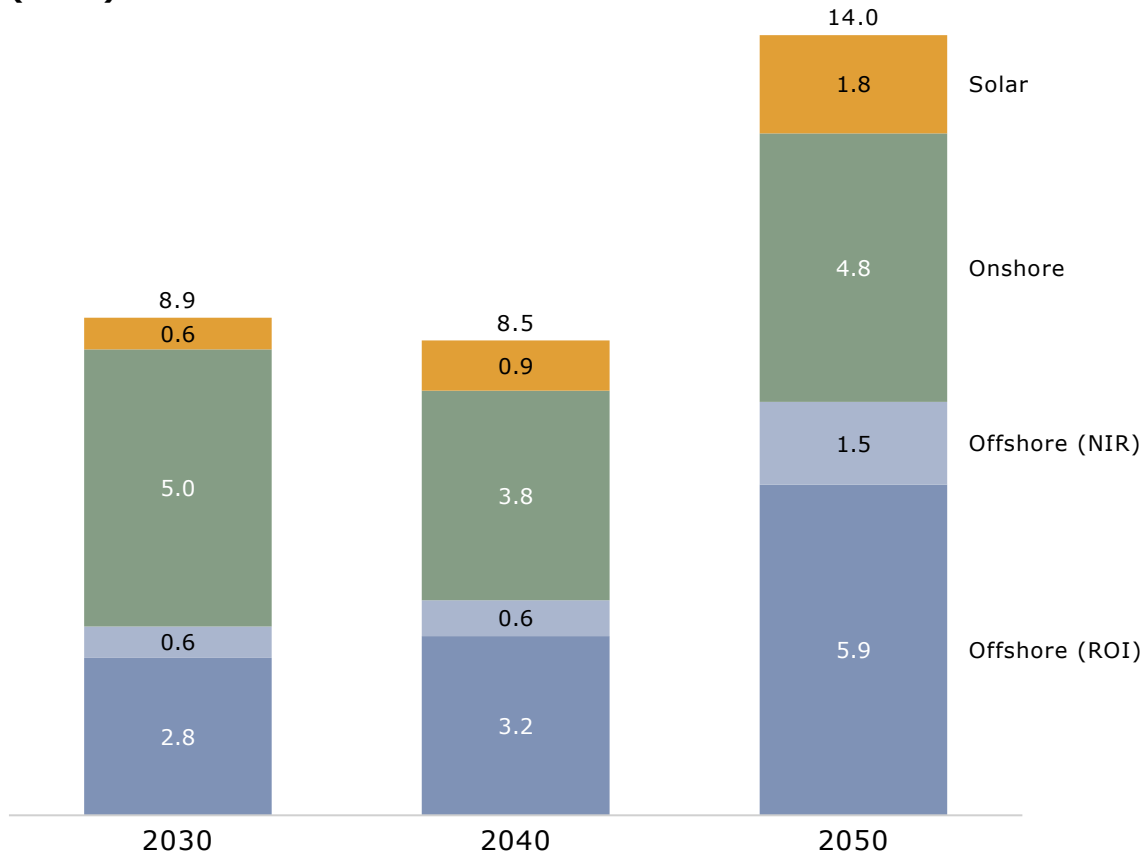


DISCUSSION

- In 2030 and 2040, the SEM is a net importer of power from GB and France. Thus, even in a 2040 world where there is 42GW of wind / solar capacity across the island of Ireland and 10GW of offshore wind, the SEM imports c.10TWh of electricity in hours when power prices in GB and France are cheaper than they are in Ireland.
- In 2050, because of assumed renewables capacity growth exceeding demand growth, there are many more hours where power prices in the SEM are very low and there is more opportunity to export power to GB and France. This results in the SEM becoming a net exporter in 2050.
- Imports / exports are typically skewed towards GB. This can be attributed to both higher IC capacity with GB (c.1GW in all years) as well as lower assumed losses on interconnectors with GB (<3%) than those with France (c.5%). The latter means spreads between the SEM and France need to be larger than spreads between the SEM and GB in order for the interconnectors to be utilised.
- Consequently, despite there generally being larger spreads with between the SEM and France in 2050 than between the SEM and GB, there are more flows with GB.

RES surplus increases significantly, reaching 14TWh by 2050, with Irish ORE surplus reaching 6TWh

SEM RENEWABLES SURPLUS (TWH)



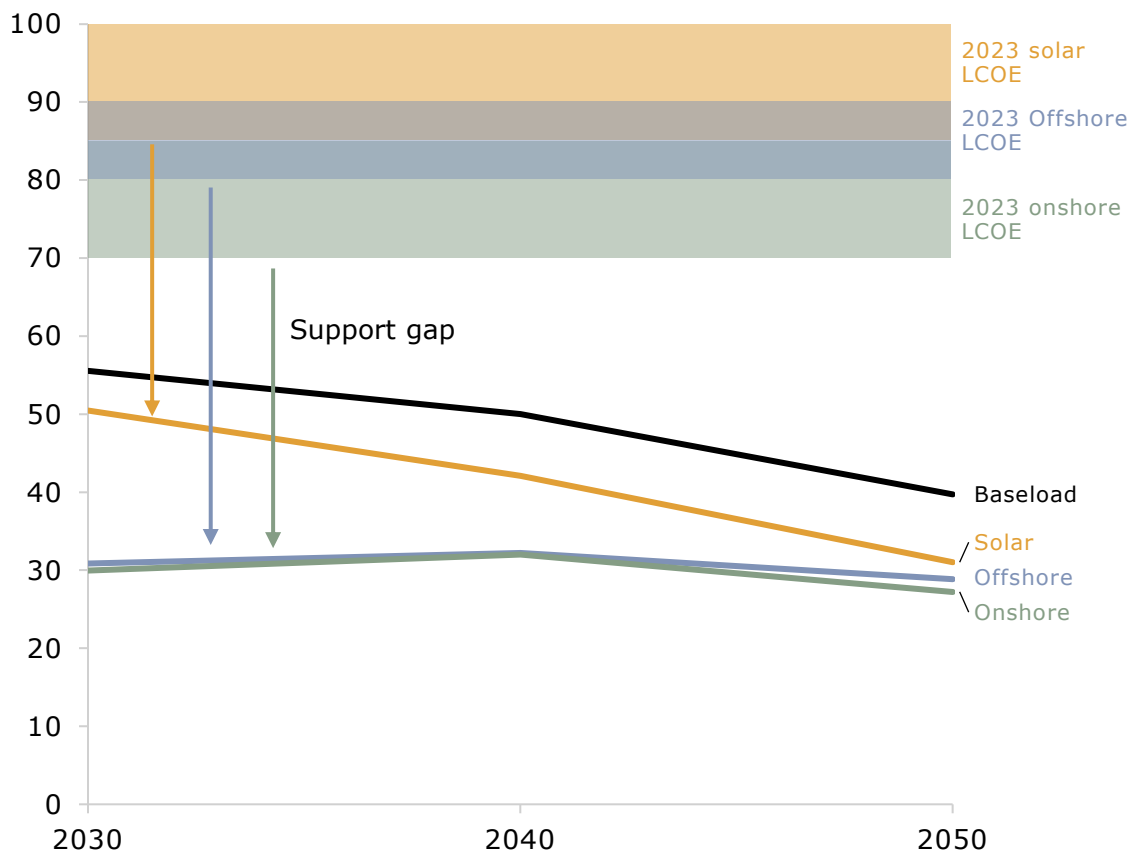
DISCUSSION

- The volume of surplus renewables is in the range of 8-9TWh in 2030 and 2040, before increasing to 14TWh in 2050.
 - To put this figure in context, this represents around one third of 2022 All-Island power demand of 41.5TWh and 41% of 2022 demand in Ireland.
- Considering renewables penetration in both 2030 and 2040 is in the range of 80-90% (i.e. not 100%), it is apparent that some degree of renewables surplus is 'unavoidable'. This follows from the system (i.e. demand plus energy storage plus electricity interconnection) not being sufficiently flexible to make use of all renewables output.
- If one assumes that the 2040 level of surplus is 'inevitable', we could consider the 2050 excess built into our scenarios as c.5.5TWh. This can loosely be considered as the amount of renewables overbuild in 2050.
- Assuming aggregate load factors of 50% for offshore wind, 35% for onshore wind and 11% for solar, this suggests excess capacity of perhaps 800MW of offshore wind (600MW in Ireland), 300MW of onshore wind and 900MW of solar PV.

Note: Renewables surplus is equivalent to renewables oversupply in the Day Ahead Market.

SEM Power prices are expected to decline over time, although wind capture prices are stable, albeit at a level significantly below their levelised cost

SEM DAY AHEAD MARKET POWER PRICES (€/MWH, REAL 2022 PRICES)



Note: LCOE ranges are illustrative and inferred from recent RESS / ORESS auctions.

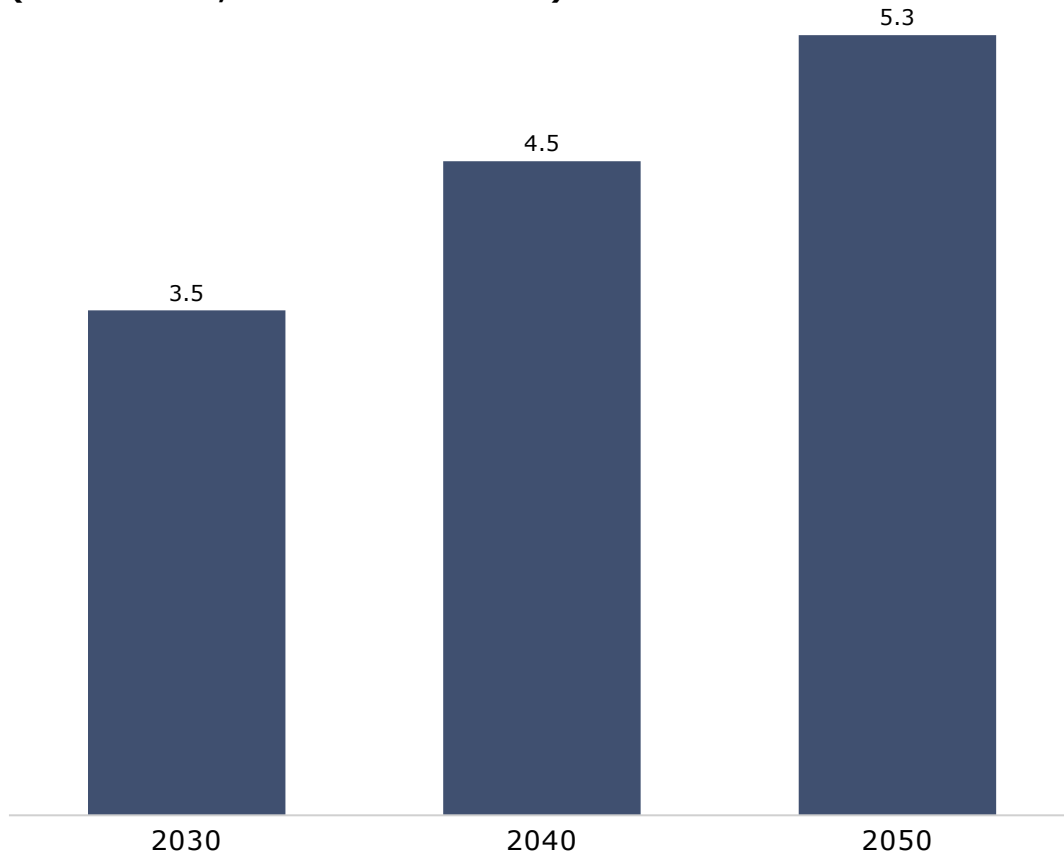
DISCUSSION

- Power prices are projected to decline from c.€55/MWh to €40/MWh as the proportion of renewables on the system increases and there are more hours of low-cost power in a year.
- It is important to stress that the power prices shown to the left are very sensitive to modelled hydrogen prices. In this study, preliminary model runs that result in 2050 hydrogen prices ranging between the plausible extremes resulted in baseload power prices ranging between €30/MWh and €120/MWh. Consequently, continental hydrogen demand has been adjusted such that 2050 hydrogen prices are somewhat optimistic, but plausible. We have then assumed hydrogen prices in Ireland are reflective of European prices.
- Renewables capture prices are low and materially below the recent RESS3 strike price of c.€85/MWh¹ and the ORESS1 strike price of c.€80/MWh².
- We are not aware of any **credible projections** that see renewables LCOE in Ireland falling to the levels of the capture prices modelled in this study.

1. €100.47/MWh weighted average strike price in 2023 but assumed to be earned from 2027 onwards, and therefore reduced by an inflation index of 1.17 between 2022 and 2027.
 2. €86.05/MWh weighted average strike price in 2023 assumed to be fully adjusted for inflation and therefore reduced by an inflation index of 1.06 between 2023 and 2022.

The cost of power demand increases by 55% between 2030 and 2050, with higher demand offset to a degree by lower prices

COST OF SEM DEMAND AT WHOLESALE POWER PRICES (€ BILLIONS, REAL 2022 PRICES)



DISCUSSION

- Considering the scale of electrification taking place across the SEM between 2030 and 2050 (and indeed, vs. 2022), it is unsurprising that the wholesale cost of satisfying power demand increases materially between 2030 and 2050.
- Total costs do not increase by as much as total demand as a result of the decline in wholesale power prices brought about by increasing amounts of renewables on the system and the accompanying rise in the number of low (i.e. close to zero) priced hours.

Table of Contents

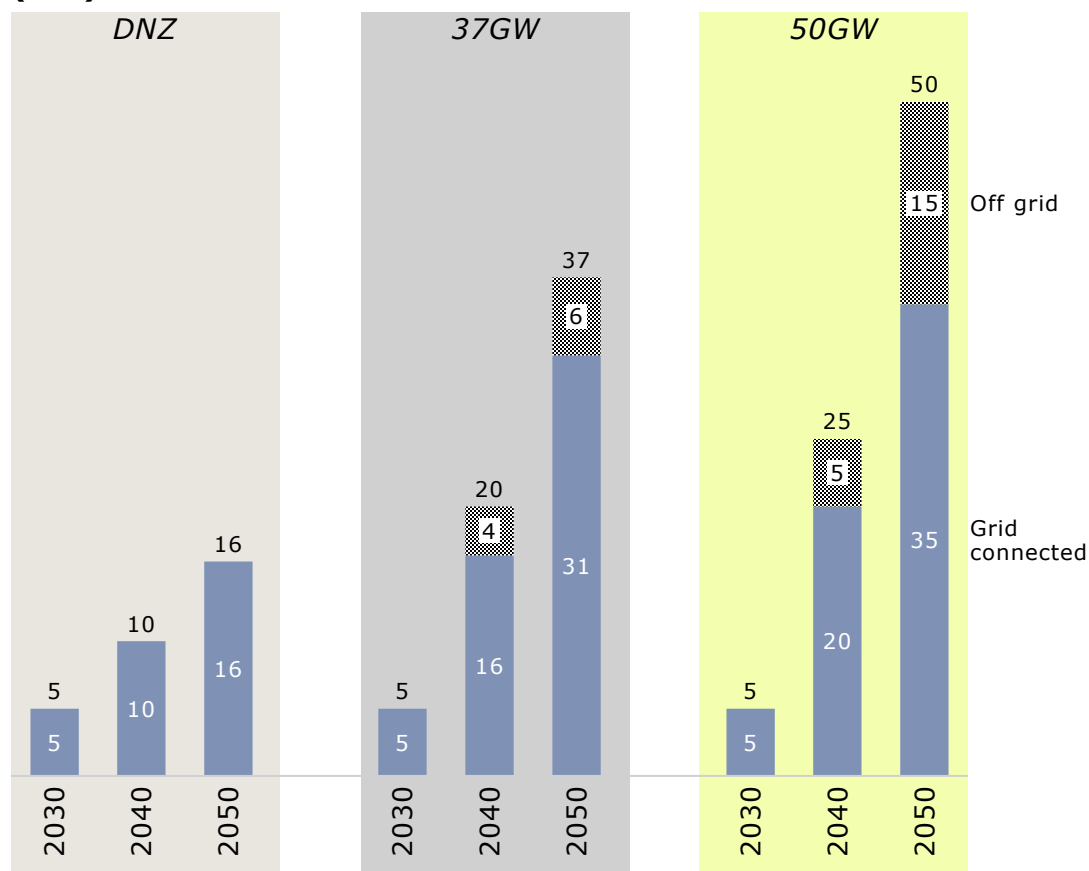
6. Impact of pursuing ORE surplus	56
6.1 Scenarios	56
6.2 Impact	59



6.1 SCENARIOS

This study tests ORE deployment of up to 50GW, with a focus on examining the Government's targeted pathway of 20GW by 2040 and 37GW by 2050

IRELAND ORE PATHWAYS (GW)



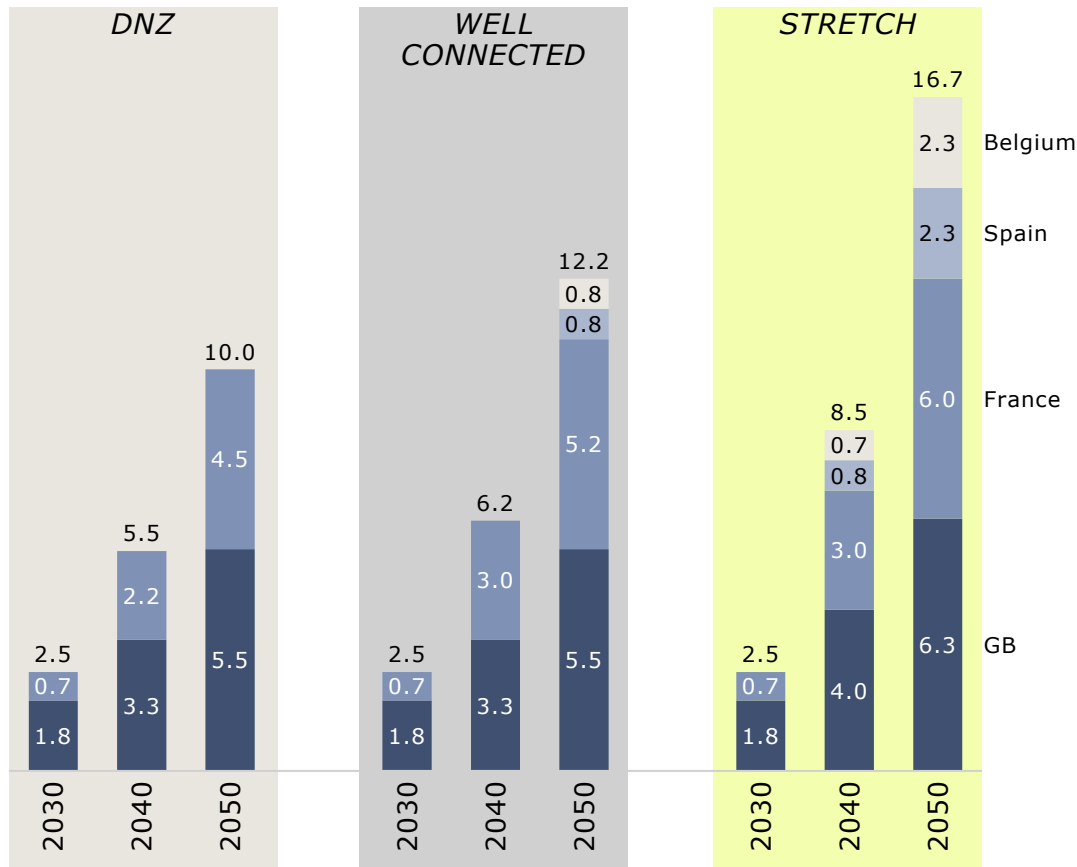
RATIONALE

- The primary cluster of scenarios tested in this study centers on the 37GW ORE pathway. This sees 20GW of offshore wind capacity commissioned by 2040 and 37GW by 2050 in line with current Government targets. Off-grid capacity is aligned with the quantities from EirGrid's Offshore Opportunity scenario from TES 2023 and is assumed to contribute to the Government's targets.
- In order to examine the impact of what might currently be viewed as 'very high' levels of ORE deployment, this study has also considered a 50GW by 2050 pathway. To our knowledge this would exceed the ambitions of most countries in Europe.
 - For example, the Dutch Government has set a 2050 target of 70GW of offshore wind in a market that currently has 2-3x the power demand of the SEM.
 - If GB were to set an equivalent target, then purely on the basis of the relative sizes of the power markets today, GB offshore wind capacity would need to reach more than 300GW by 2050.
- In this pathway, off-grid capacity is increased significantly, with the majority of incremental capacity vs. the 37GW pathway being off-grid.

6.1 SCENARIOS

Cross border electricity interconnection capacity of up to 17GW has also been investigated

IRELAND ELECTRICITY INTERCONNECTOR PATHWAYS (GW)



RATIONALE

- The underlying assumption of both the DNZ and Well Connected electricity interconnector pathways is that Ireland meets the European interconnector target of 15% of installed generation capacity. We have assumed that this applies to grid-connected generation capacity for the purposes of this study.
- For the Well Connected pathway, we assume the installed generation capacity base is the capacity from the 37GW ORE pathway. The additional on-grid capacity of this pathway results in c.2W of additional interconnection in the Well Connected interconnector pathway by 2050. This capacity is built to continental Europe, notably with capacity to Spain and Belgium.
- For the Stretch pathway, we have increased the interconnection percentage (of installed generation capacity) to 20% from 15% in 2050. This is then combined with the additional offshore wind capacity from the 50GW ORE pathway to derive a pathway with 66% more electricity interconnection by 2050 than in the underlying DNZ scenario. Additional capacity is built to GB, France, Belgium and Spain, with the latter two markets seeing a notable increase in IC capacity.

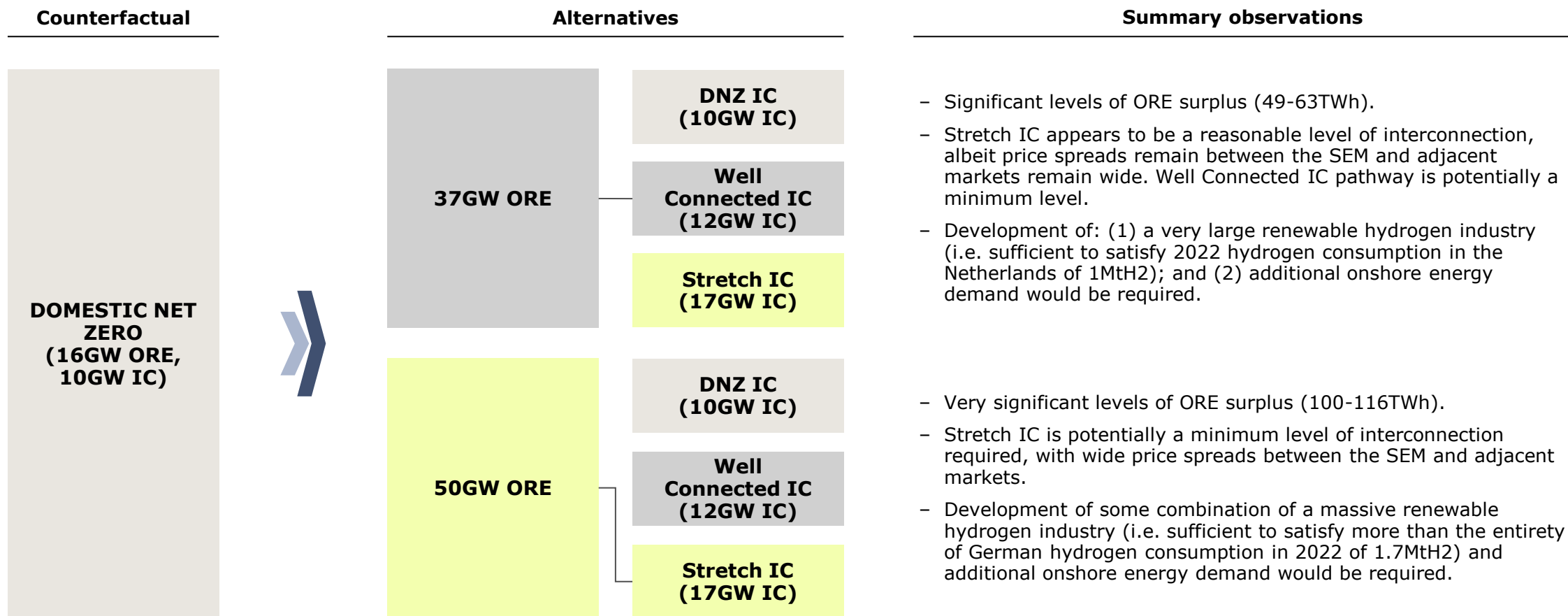
Table of Contents

6. Impact of pursuing ORE surplus	56
6.1 Scenarios	56
6.2 Impact	59



6.2 IMPACT

7 scenarios have been modelled: the underlying DNZ scenario and six combinations of ORE and interconnection pathways



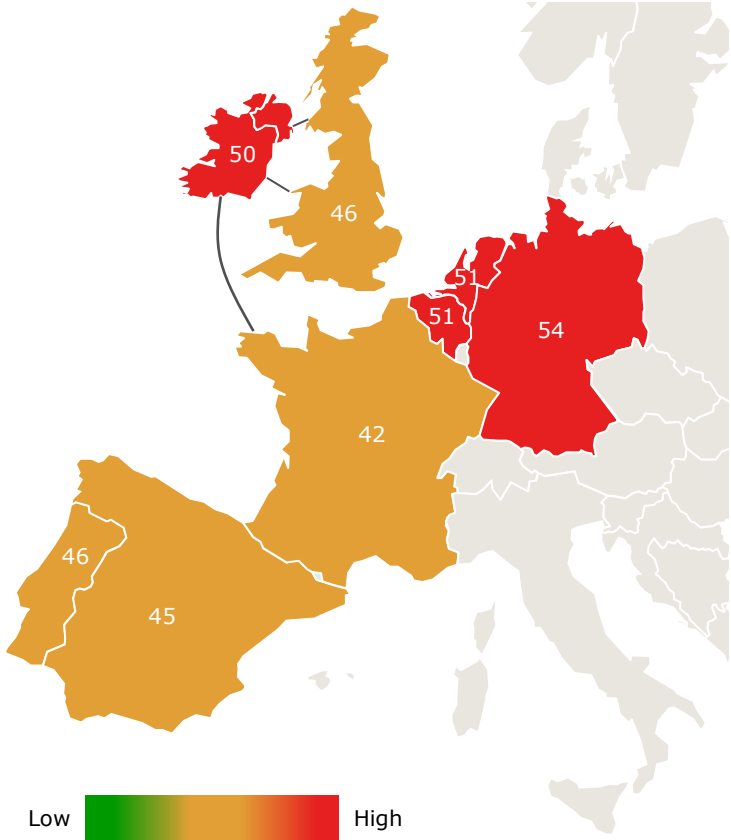
Note: Capacities in parentheses indicate 2050 values. Links between ORE and IC pathways indicate the ORE pathway the IC scenario has been sized against.

1. When comparing the difference in annual average baseload wholesale price across markets.

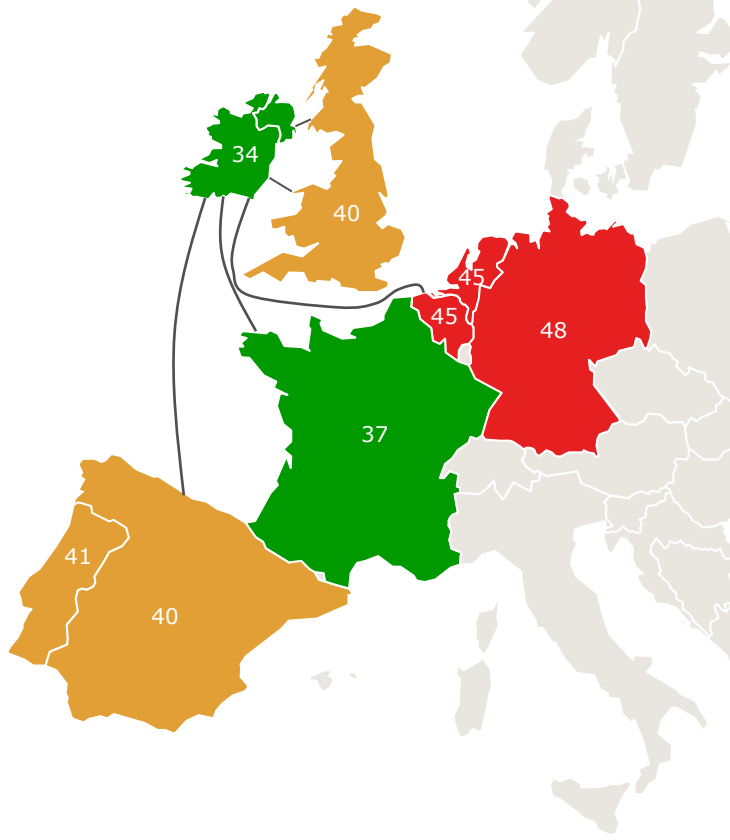
6.2 IMPACT

2040 price spreads are wide, particularly with Belgium / Netherlands even in the 37GW ORE | Stretch IC scenario

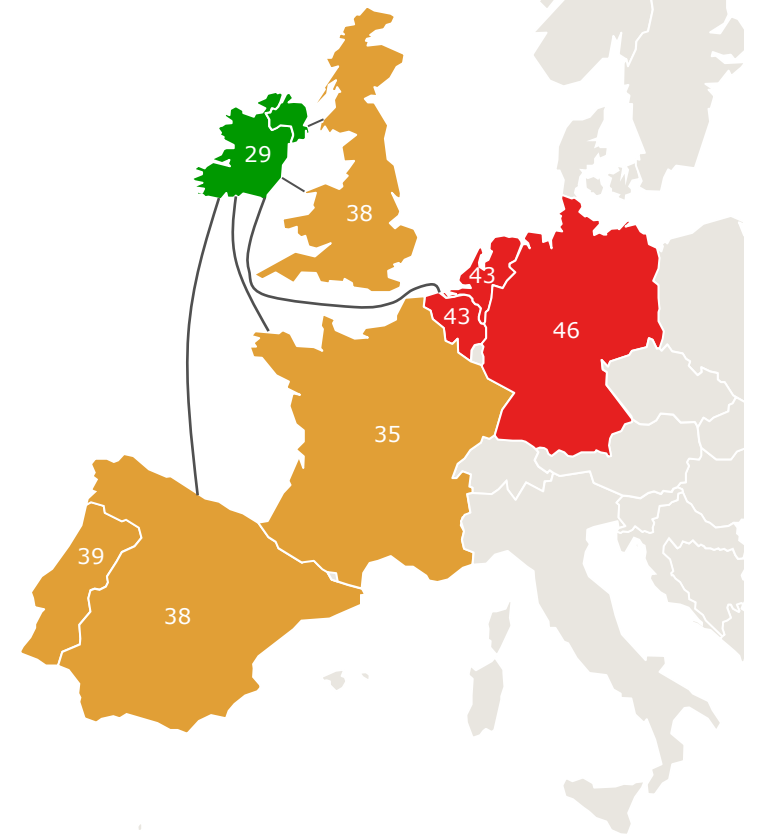
DNZ SCENARIO
2040 BASELOAD POWER PRICE
(€/MWH, REAL 2022 PRICES)



37GW ORE | STRETCH IC SCENARIO
2040 BASELOAD POWER PRICE
(€/MWH, REAL 2022 PRICES)



50GW ORE | STRETCH IC SCENARIO
2040 BASELOAD POWER PRICE
(€/MWH, REAL 2022 PRICES)

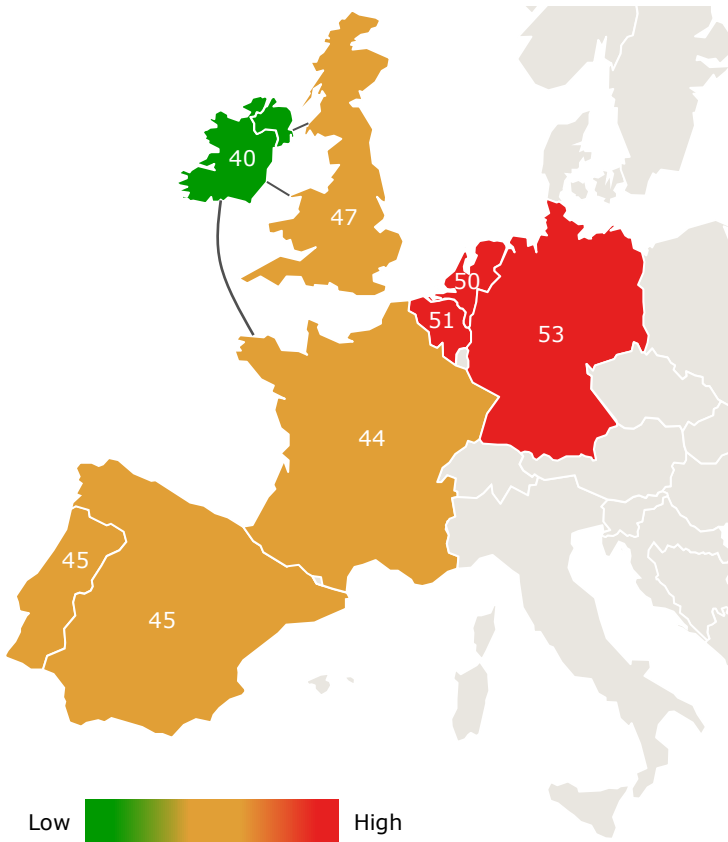


Low  High

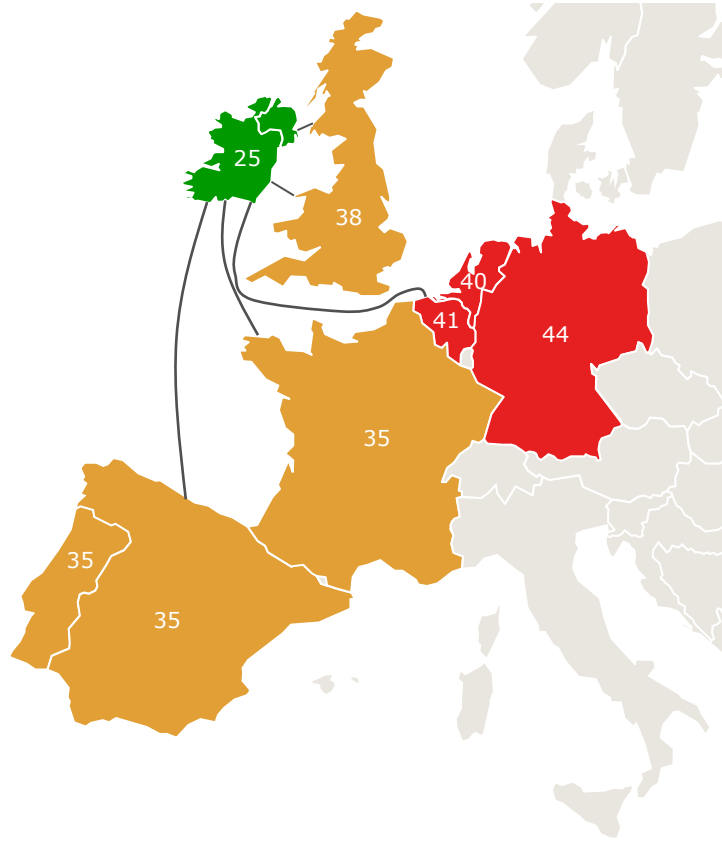
6.2 IMPACT

Unsurprisingly the picture does not change in 2050, with wide spreads persisting even in the Stretch IC pathways

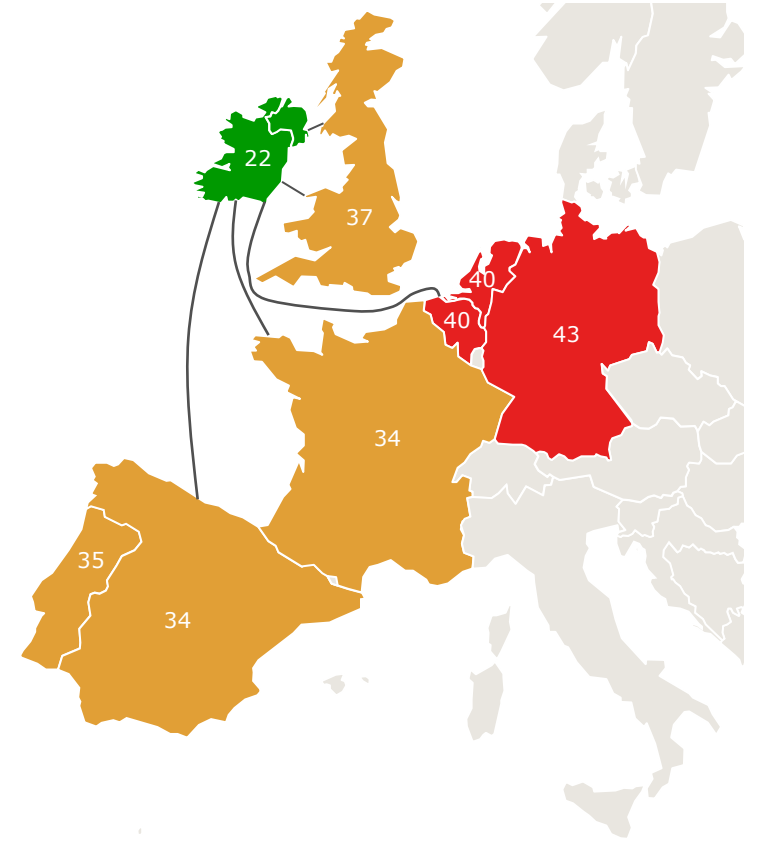
DNZ SCENARIO
2050 BASELOAD POWER PRICE
(€/MWH, REAL 2022 PRICES)



37GW ORE | STRETCH IC SCENARIO
2050 BASELOAD POWER PRICE
(€/MWH, REAL 2022 PRICES)



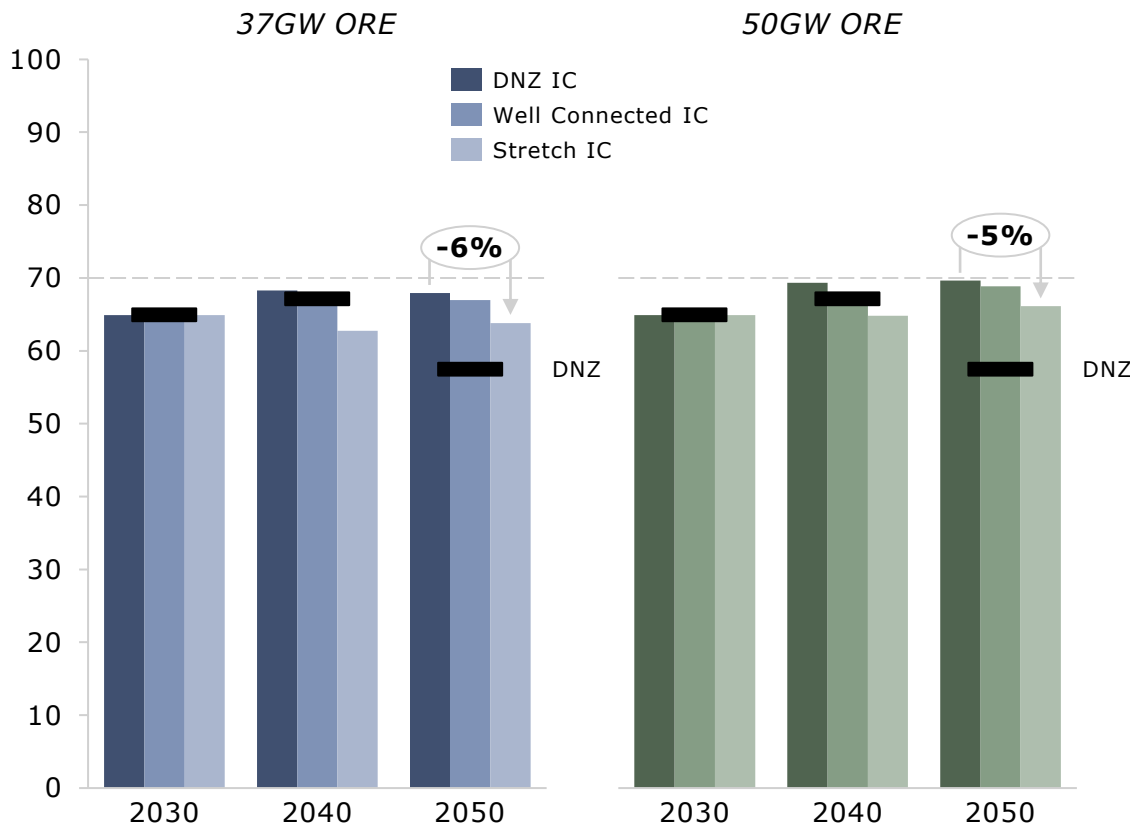
50GW ORE | STRETCH IC SCENARIO
2050 BASELOAD POWER PRICE
(€/MWH, REAL 2022 PRICES)



6.2 IMPACT

There are likely practical limits that mean electricity interconnection can be only one part of the solution to ORE surplus

SEM INTERCONNECTOR GROSS UTILISATION (%)



Note: Gross utilisation is defined as the sum of absolute Imports and Exports divided by the product of capacity and 8760 hours in a year.

DISCUSSION

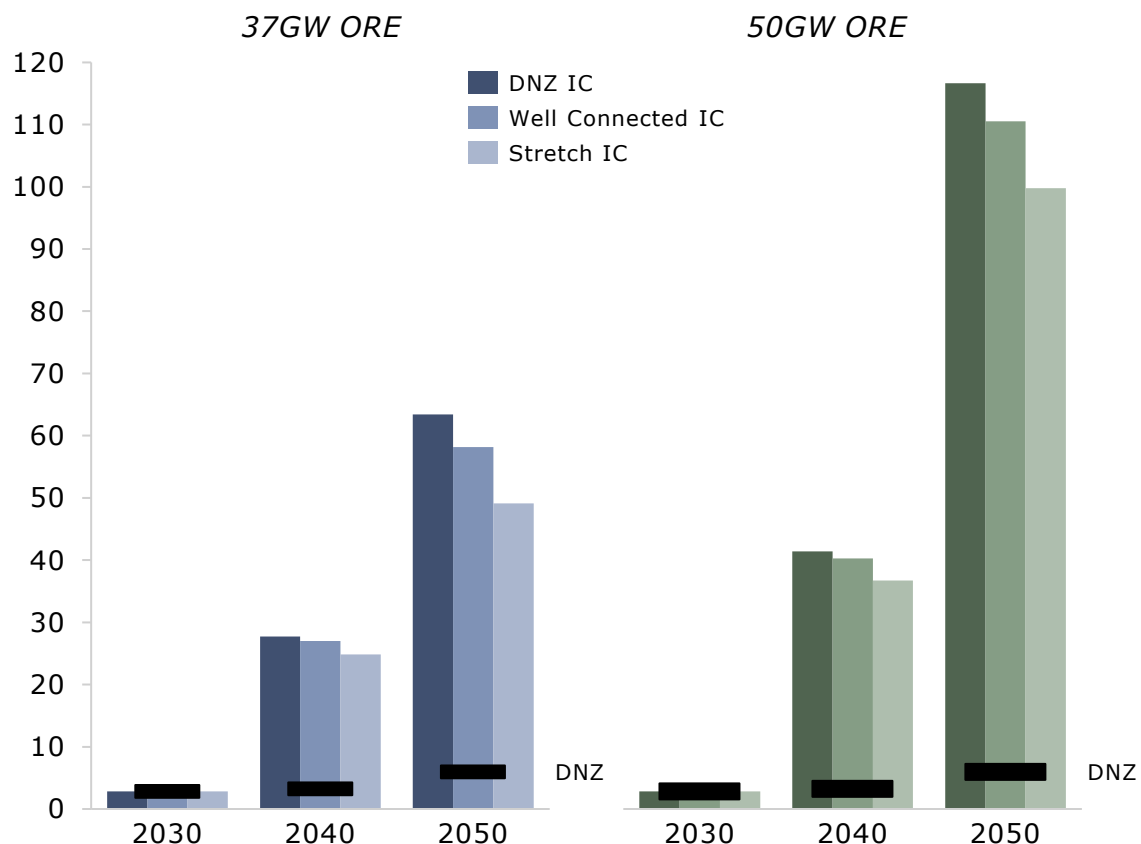
Reading the graph: The left panel shows the 37GW ORE pathway in shade of blue, whilst the right panel shows the 50GW pathway in shades of green. Each of the different shades of blue/green correspond to an IC pathway. The black lines indicate the equivalent result from the DNZ scenario.

- Maximum interconnector utilisation in this study is around 70%, as evidenced by the dark green bar in 2050 in the right hand side graph (i.e. 50GW ORE with DNZ levels of interconnection).
- Going from 12GW of electricity IC connecting the SEM to other markets in 2050 in the DNZ scenario to almost 19GW in the Stretch IC pathway only reduces IC gross utilisation by 5-6 points.
- The reason interconnector utilisation remains so high is because the majority of the additional ORE in the 37GW and 50GW ORE pathways is unable to be used domestically which in turn means most of this output is available to export.
- Considering peak demand excluding electrolysis is around 17GW across the SEM in 2050 and electricity IC capacity exceeds this, it is clear that achieving even this level of IC capacity will be challenging.

6.2 IMPACT

Surplus energy production after electricity IC exports reaches >50TWh and >100TWh in the 37GW ORE and 50GW ORE pathways respectively

IRELAND ORE SURPLUS (TWH)



Note: Contribution of off-grid ORE is included above.

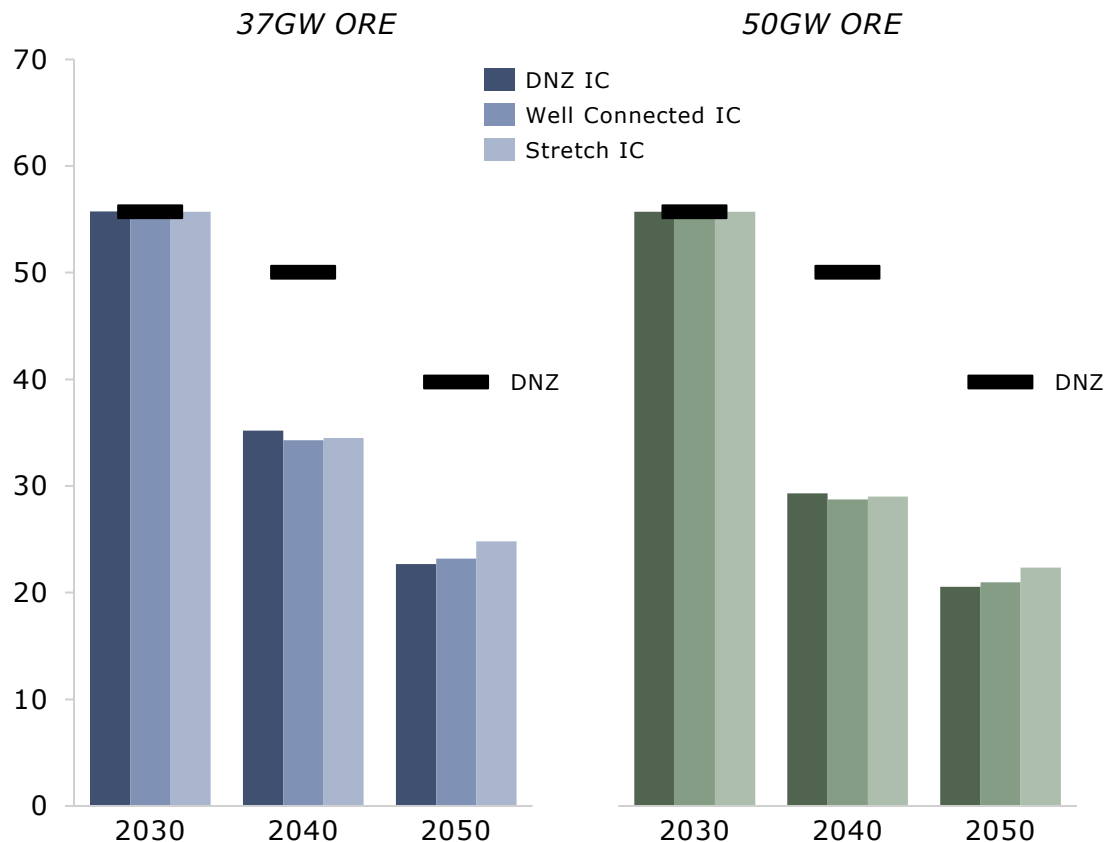
DISCUSSION

- After exporting as much energy as possible via electricity interconnectors, this study suggests the residual ORE surplus in the 37GW and 50GW ORE pathways is extraordinary.
- In the 37GW ORE pathway, regardless of the amount of interconnection built, ORE surplus amounts to around double today's power demand in Ireland by 2050. Compared to expected 2050 domestic power demand of c.135TWh, ORE surplus is a little under half of annual demand.
- Turning to the 50GW ORE pathway, ORE surplus is 100TWh in the Stretch IC pathway, not far from projected 2050 domestic demand. To put it another way, the amount of ORE surplus would be sufficient to power Ireland on its own.
- Irish ORE surplus falls as electricity IC is added as some of the surplus can be sold in adjacent power markets.

6.2 IMPACT

Adding 15GW / 19GW of on-grid offshore wind reduces baseload power prices significantly in 2040 and 2050

SEM BASELOAD WHOLESALE POWER PRICE (€/MWH, REAL 2022 PRICES)



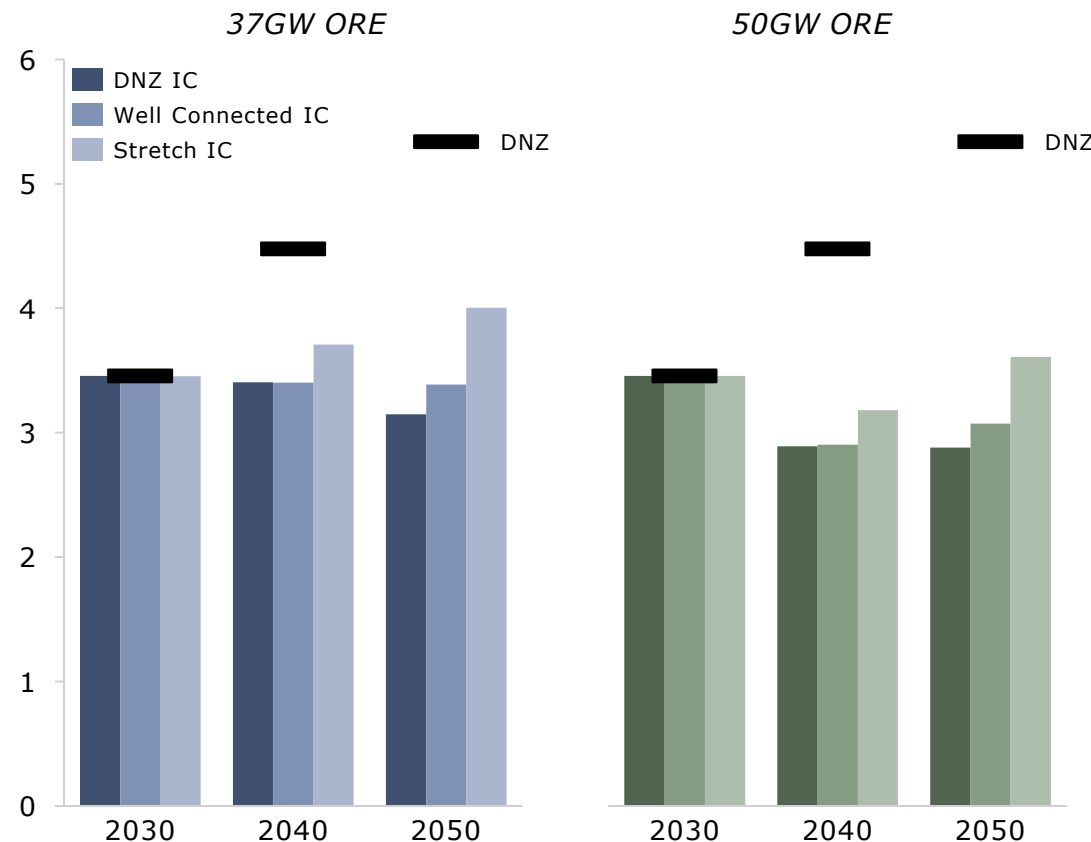
DISCUSSION

- Going from 16GW of offshore wind capacity to 37GW results in significant drops in the cost of baseload power, driven by an increasing number of low (or even zero) priced hours. By 2050, this study suggests the reduction in power prices could be c.€15/MWh.
- Adding an additional 4GW of grid-connected offshore wind capacity in the 50GW ORE pathway, results in wholesale power prices declining a little more, but differences vs. the 37GW ORE pathway are small. This is a result of most of the additional capacity in the 50GW ORE pathway being off-grid.
- In 2050, increasing electricity IC capacity (i.e. the difference between the sets of blue bars or between the sets of green bars) tends to increase power prices a little as it equalises prices to some extent between a very low priced SEM and more expensive adjacent markets. This impact is very muted in 2040, when price differentials between adjacent markets are limited.

6.2 IMPACT

Wholesale price reductions translate into billions of euro of savings on the wholesale cost of power in the SEM from the 2040s onwards

SEM COST OF DEMAND (€ BILLIONS, REAL 2022 PRICES)



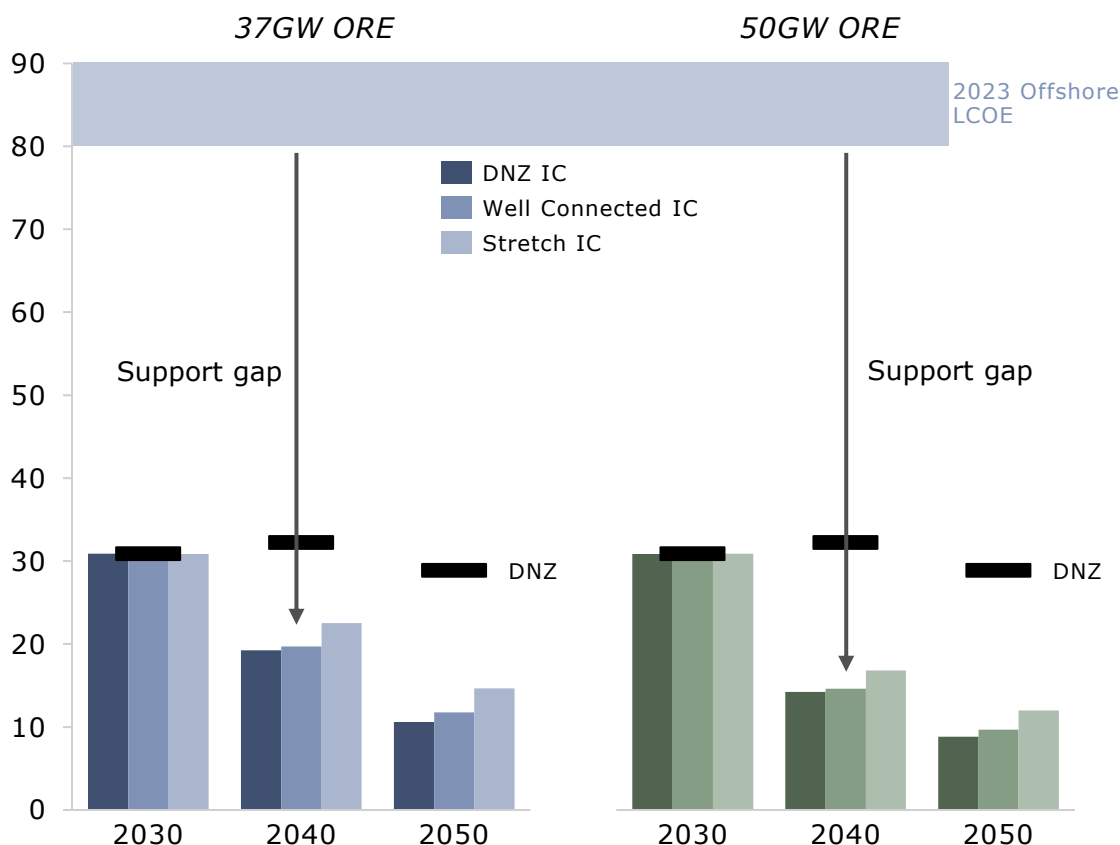
DISCUSSION

- Regardless of the level of interconnection, there are very significant savings in the wholesale cost of demand in the 37GW ORE and 50GW ORE pathways.
- In the 37GW ORE pathway, savings are in the range of €0.75-1B per year in 2040 and €1.3-2.2B per year in 2050. These increase to €1.3-1.6B in 2040 in the 50GW ORE pathway and €1.7-2.5B in 2050 in the 50GW ORE pathway.

6.2 IMPACT

One of the casualties of demand cost savings is the economics of offshore wind, which deteriorate dramatically in the 37GW / 50GW ORE pathways

SEM OFFSHORE WIND CAPTURE PRICE (€/MWH, REAL 2022 PRICES)



Note: LCOE range is illustrative and inferred from the ORESS1 auction.

DISCUSSION

- In the DNZ scenario, we have previously identified a significant gap between the current LCOE (as proxied by ORESS strike prices) and the capture price that offshore wind might earn in the future.
- The additional build out of offshore wind capacity in the 37GW and 50GW ORE pathways results in very significant cannibalisation of offshore wind capture prices, with capture prices getting down to c.€10/MWh by 2050 in both pathways. It is clearly impossible for the LCOE of offshore wind to reach these levels, and some amount of support for this capacity will be required.
- To put this in context, a simplistic analysis suggests the additional costs to households in 2040 of the incremental offshore wind capacity in the 37GW / 50GW ORE pathways vs. the DNZ pathway could be c.€100/€300/household/yr¹. By 2050, this cost could reach €750/€1,100/household/yr² after including savings in the wholesale cost of power. This would come on top of any costs of supporting capacity in the DNZ scenario.
- These costs to households represent the amount that should be targeted to be funded by renewable hydrogen exports or by new sources of demand in Ireland. Alternatively, this could be viewed as the burden on households of overbuilding renewables if the renewable hydrogen sector does not take off or if new sources of demand willing to pay for green energy cannot be attracted to Ireland.

1. ORESS strike price assumed to be €60/MWh, capture price assumed to be €20/MWh in 37GW ORE pathway and €12/MWh in 50GW ORE pathway leading to CfD support payments of €40/MWh and €48/MWh in the two pathways. This is multiplied by annual volumes corresponding to an incremental 6/10GW in the 37/50GW pathways respectively running at a 50% load factor and 95% availability. 2 million households have been assumed.
2. ORESS strike price is assumed to remain at €60/MWh, with capture prices at €15/MWh and €10/MWh in the 37GW and 50GW ORE pathways respectively. Incremental capacities vs. DNZ in 2050 are 15GW/19GW.