CORNWALL INSIGHT

CREATING CLARITY

Ireland Electrified – Incentivising Electrification in Ireland modelling results

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About Cornwall Insight

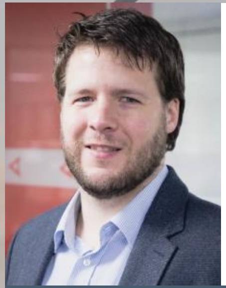
Established in 2005, Cornwall Insight is one of the most respected voices in the energy industry. We provide research, analysis, consulting and training to businesses and stakeholders in the Great British, Irish and Australian energy markets.

Our insight

Our independent experts work across the energy market and provide high quality and actionable insights on which to base your business decisions. We look to facilitate positive market and policy change, whilst also advising customers on how to navigate and comply with energy market dynamics, rules and regulations.

Our expertise

Our experts in-depth working knowledge of energy market design, including policy and regulatory changes, means we are perfectly placed to advise on changes to the future market design and help businesses achieve their net zero goals.



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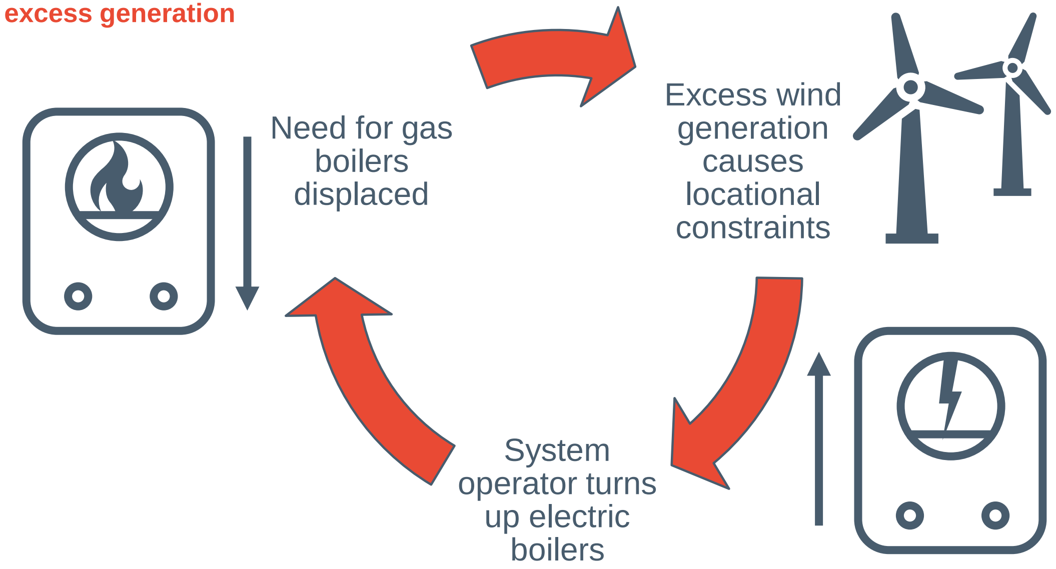
Executive summary

Introduction and purpose of report

- Ireland Electrified ("IE") is a new trade association advocating for increased electrification of heat, domestic and industrial as well as transport. Ireland Electrified, working with Wind Energy Ireland ("WEI"), have commissioned this analysis. They believe that implementing a rebate on Imperfection Charges, network capacity charges and other levies for energy consumers that electrify heat and transport would create benefits for these consumers and the system as a whole
- These benefits are reliant on the ability of electrified heat and electric vehicle (EV) consumption to absorb excess generation during peak periods, in particular flexing some elements of power demand away from times when the system might be short of generation, or creating additional power demand during periods when generation would otherwise have to be turned off
- This in turn reduces the costs of these technologies, on an operational, day-to-day basis, and would support more deployment of these low carbon technologies and hence faster decarbonisation of the economy. The more rapid growth of electrified technologies would also result in demand growth, which would support the connection of additional renewable generation technologies to the system by absorbing any surplus power they generate
- Our analysis is constructed using our Single Electricity Market (SEM) Benchmark Power Curve (BPC), adjusting inputs to test scenarios of asset deployment and outturn wholesale power prices, system costs, and curtailment
- The core of our analysis has focused on the benefits which highly flexible industrial heating plant, dispatched by the system operator, could bring to the system in terms of alleviating dispatch down of renewable generation and reducing carbon emissions by reducing burning of natural gas
- In order to spur investments in this plant and make it economically viable, reductions in charges and levies would be required, along the lines of reductions in cost for other flexible assets like batteries. This reduction could be around 15% which, along with the reduced cost of wholesale power, would cut the cost of power used in these assets by around 65%
- Proposed levy exemptions include Imperfections charges and network capacity charges

Figure 1: Highly flexible electric heat production, displacing gas burn and consuming excess generation



Key takeaways from increased electrification

Highly flexible assets could be incentivised to connect to the system by offering reductions in pass-through costs, by around 15%

The System Operator would then have access to an additional zero-cost resource to manage excess generation

Very low wholesale power prices provided by flexible dispatch to absorb renewable oversupply – close to €0/MWh – offer savings of 65% versus average industrial prices and provide a lower cost than the natural gas alternative

Renewable generation dispatch down due to network constraints could be reduced by 54% in 2030, by consuming power locally. Reducing forecast curtailment could also allow reduced RESS outturn prices

Additional highly flexible electricity consumption reduces wholesale prices, benefiting all consumers, with savings forecast at 3.3% in 2030

Carbon emissions could be cut directly by these assets by over 170,000 tonnes/year in 2030, and industry save €30mn/year on natural gas purchase

Executive summary of findings

- We found that the increase in electricity demand and demand flexibility arising from the changes in the pattern of electrification of heat and transport would have impacts on the outturn wholesale price, level of curtailment of renewable generation, and carbon emissions of the Irish electricity system
- This particularly arises as a result of the highly flexible electricity demand enabled by providing exemptions to SEMO and network charges to industrial heat electrification, which recognise the benefits provided by this flexible demand
- **A decrease in wholesale prices is forecast**, approximately 3.3% in 2030, 0.8% in 2035 and 5.6% in 2040, due to additional low-cost power generation being enabled by flexible consumption, and lower demand at times of high power prices. This provides a benefit to all electricity consumers
- **Wastage of renewable energy due to dispatch down is reduced by over 50% in 2030**, and around a quarter in 2035 and 2040, between the Slow and Fast Transition scenarios, enabled by additional local consumption of renewable power
- **Electricity system carbon emissions are forecast to be slightly lowe**r, with more renewable generation on the system. This is supported, outside of the electricity industry, by **much lower emissions from transport, heating, and industrial gas consumption**
- Flexible industrial e-boilers provide **savings of 170,000 tonnes of carbon and €30mn in 2030, rising to 670,000 tonnes of emissions and €130mn in 2040**, as well as reducing purchase of foreign natural gas by €10mn, rising to €91mn
- While financial savings to the average consumer are small, significant carbon savings and industrial benefits are achieved without increasing costs to average consumers
- There is also the potential for savings to all consumers in terms of the avoided cost of network reinforcement and new asset investment due to additional demand flexibility mitigating the need for new transmission lines, interconnectors and electricity storage assets

Figure 2: Average Annual Wholesale Power Prices, €/MWh

€/MWh	Fast	Slow	Discount	Discount %
2030	€77.16	€79.78	-€2.62	3.3%
2035	€47.66	€48.03	-€0.37	0.8%
2040	€63.95	€67.76	-€3.81	5.6%

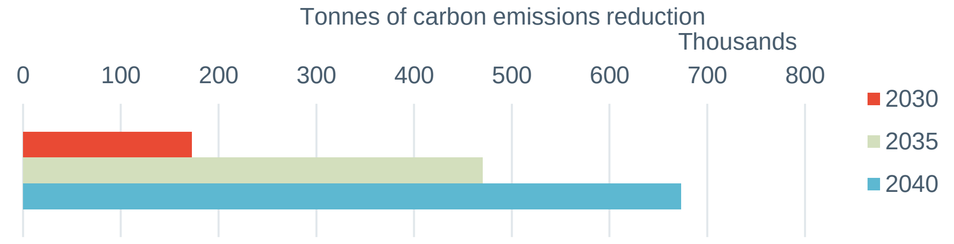
Source: Cornwall Insight

Figure 3: Annual average carbon emissions, Fast Transition and Slow Transition scenarios, gCO2e/kWh

gCO2e/kWh	Fast	Slow	Difference
2030	314.6	326.0	-11.4
2035	284.2	301.7	-17.6
2040	283.2	301.6	-18.3

Source: Cornwall Insight

Figure 4: Carbon savings from industrial e-boilers, thousands of tonnes



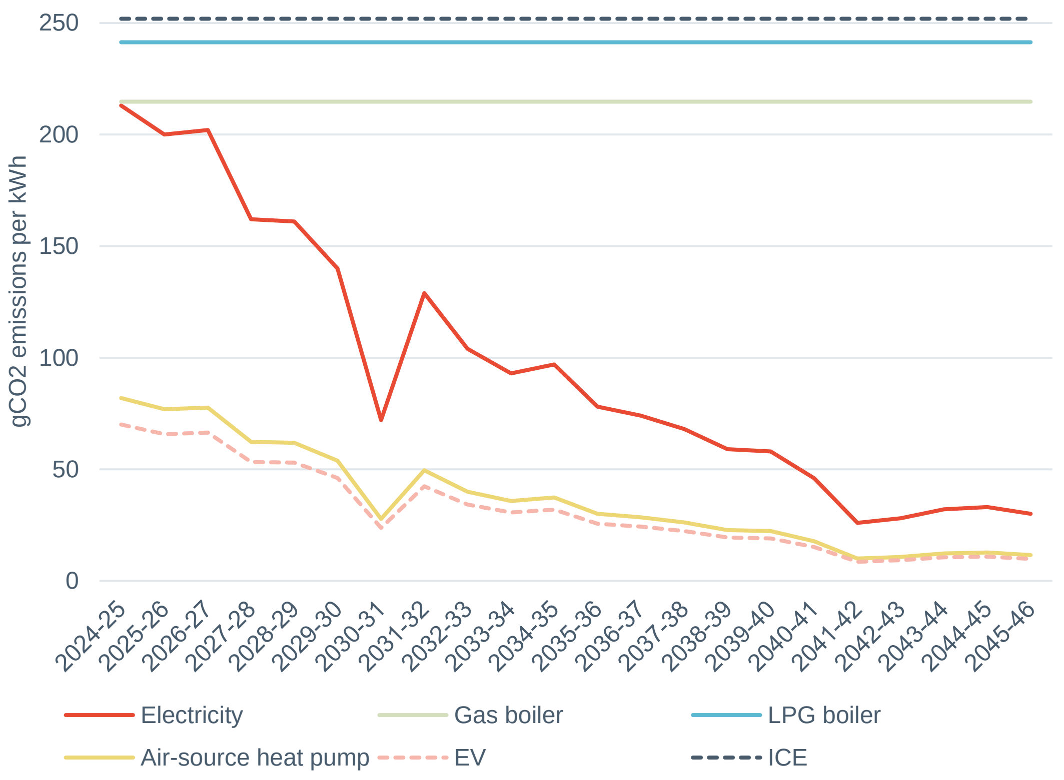
Source: Cornwall Insight

Benefits and challenges of electrification

Electrification of heating and transport is one of the most efficient ways to reduce emissions

- Heat pumps will primarily replace gas consumption on the system, but – particularly in regions where mains gas is not available – they may also displace use of heating oil, LPG or conventional electrical heating
- A modern gas boiler emits 204gCO2e/kWh of fuel consumed. Dividing this by an assumed efficiency of around 95%, this results in emissions of around 215gCO2/kWh of useful heat
- An air-source heat pump, meanwhile, with emissions of 254.8gCO2/kWh (2023 provisional value), and a co-efficient of performance of 2.6, has effective emissions of 98gCO2/kWh. As the grid decarbonises, this figure will reduce further, which we show in Figure 5 alongside other key heating technologies
- Cornwall Insight research indicates that electric vehicles (EVs) are around three times more energy efficient than an equivalent standard petrol or diesel fuelled vehicle. This is due to the greater efficiency of electric motors, compared to combustion engines, as well as measures like regenerative braking which recover further energy from slowing vehicles
- A petrol-fuelled internal combustion engine (ICE) vehicle emits around 251.9gCO2 per kWh of fuel consumed
- The equivalent EV emission, using grid carbon intensity and factoring in the efficiency of the vehicle, which consumes one-third of the energy to deliver the same useful work, shows that EVs are one of the most carbon-beneficial energy use changes which can be implemented
- As grid electricity emissions fall towards net zero, electrified heating and transport become more beneficial in reducing emissions

Figure 5: Carbon intensity of electrified vs conventional heating and transport



Source: SEAI emissions factors and CI emissions forecasts

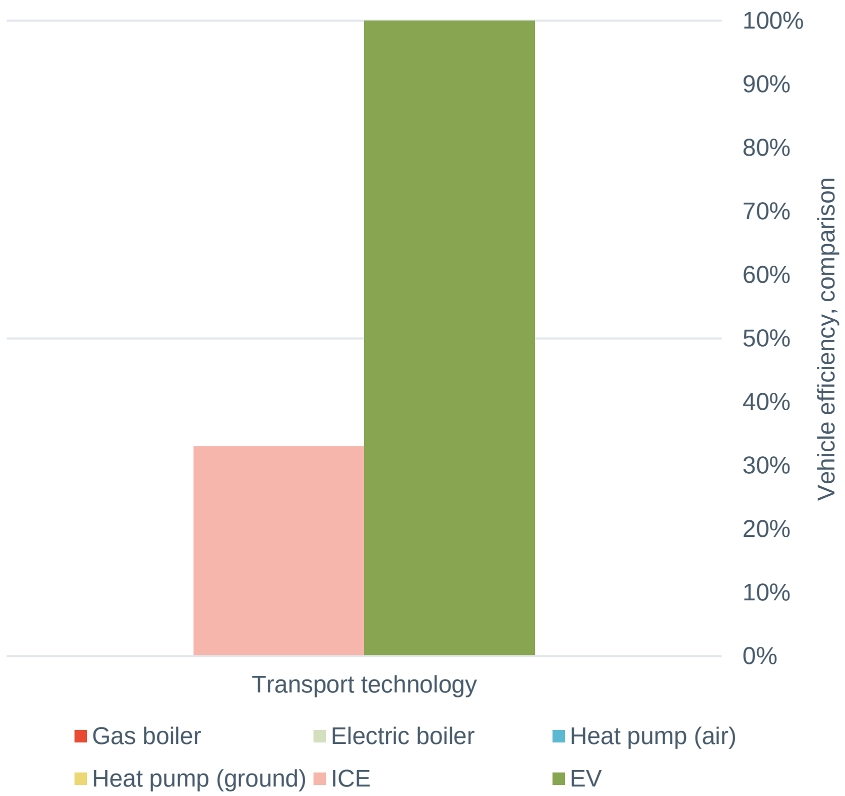
Financial benefits can be seen from electrifying transport, with lower operational costs

- CI's research indicates EVs are around 3x more efficient than conventional petrol or diesel vehicles, due to the higher efficiency of electric motors compared to combustion engines and energy recovery technology
- This uplift in useful work produced per unit of energy input mitigates the impact of the higher cost of electricity than alternative fuels for transport. SEAI's *July 2024 update* and *AA's July national average price index* shows that costs for small users are:

	Energy cost (kWh)	Energy cost (litre)
Electricity	€0.3767	
Petrol	€0.1800	€1.80/litre
Diesel	€0.1735	€1.74/litre

- Electricity is also more expensive per unit than petrol or diesel, but **with the increased efficiency the energy cost is considerably cheaper for EVs**, at €0.3767/kWh versus €0.6121/kWh for petrol or €0.5258/kWh for diesel – around a 40% cost reduction for electricity versus petrol, or 30% versus diesel
- The capital cost of technologies remains higher for EVs than for conventional vehicles, and availability is relatively lower, particularly on the second-hand vehicle market. There are also public concerns surrounding charging availability and range, for longer trips, and about availability of maintenance and service personnel. This acts as disincentive to engage in electrification
- However, for most users, particularly those driving more miles per year, an EV will be financially superior to a conventional vehicle in terms of operational costs

Figure 6: Comparison of energy efficiency of heating and transport, various fuels



Source: SEAI

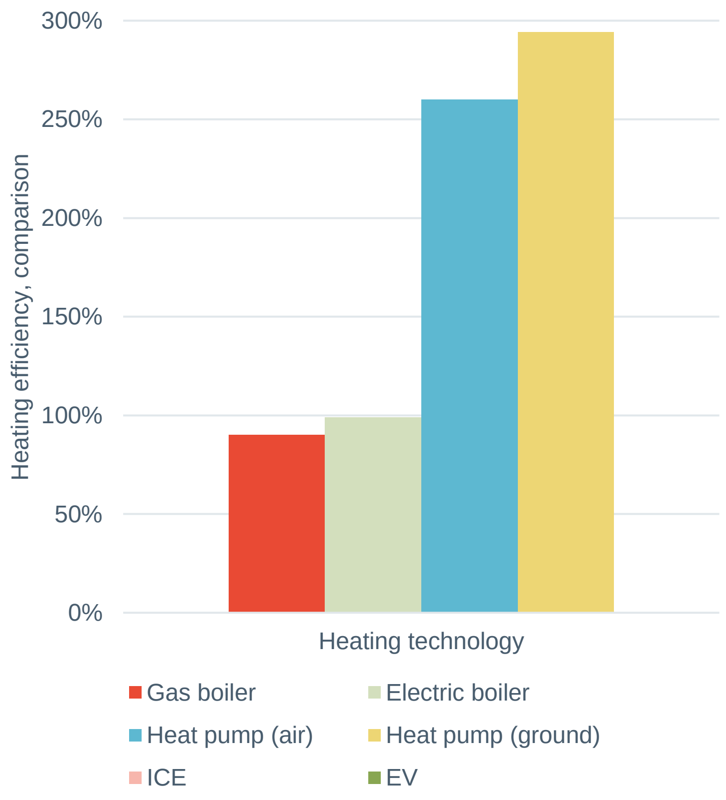
The financial case for electrification of heat is marginal in the current policy environment

- The relative efficiencies of heating via gas and electricity are very different. Modern condensing gas boilers can achieve an efficiency around 90%, and electric boilers around 99%. However, heat pumps don't produce heat from electricity, but instead move heat between locations. They can achieve coefficients of performance (CoP) of 450% or greater, in the right conditions
  - EirGrid assumes a central case of a 260% CoP for air source and 294% for ground source heat pumps
- Looking at the useful work produced per unit of energy input, this again mitigates the impact of the higher cost of electricity than alternative fuels for heat. SEAI's *July 2024 update* shows that costs for users are:

	Small users (domestic)	Large users (industrial)
Natural gas	€0.1414/kWh	€0.0437
Electricity	€0.3767/kWh	€0.2163

  The increase in fuel cost from gas to electricity is around 2.66x
- A 90% efficient gas boiler compared to a 260% efficient heat pump is therefore **marginally in favour of heat pumps**, with a cost of useful heat of €0.149/kWh for gas boilers versus €0.145/kWh for air source heat pumps
- The capital cost of heat pump technologies remains higher than the cost of a gas boiler. This acts as disincentive to engage in electrification, particularly given the similar operational cost
- Looking at industrial process heat requirements, which are often for steam or higher-grade heat, the situation is similar. Industrial users are likely to require an e-boiler to produce this higher-grade heat. E-boiler efficiencies are around 99%, higher than gas boilers but lower than heat pumps
- Industry faces much lower electricity and gas prices than smaller users, but the ratio of electricity cost to gas is still around 2x
- This leaves industry facing much higher costs to use e-boilers than gas boilers, though as we go on to discuss, operating these assets flexibly (only part of the time) can considerably reduce the costs

Figure 7: Comparison of energy efficiency of heating and transport, various fuels

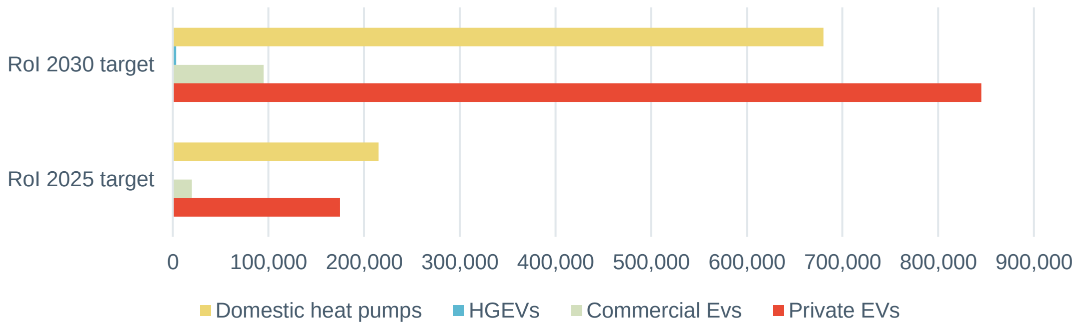


Source: SEAI

In Ireland, EV and heat pump rollout is expected to be significant over the studied period, driven by government targets

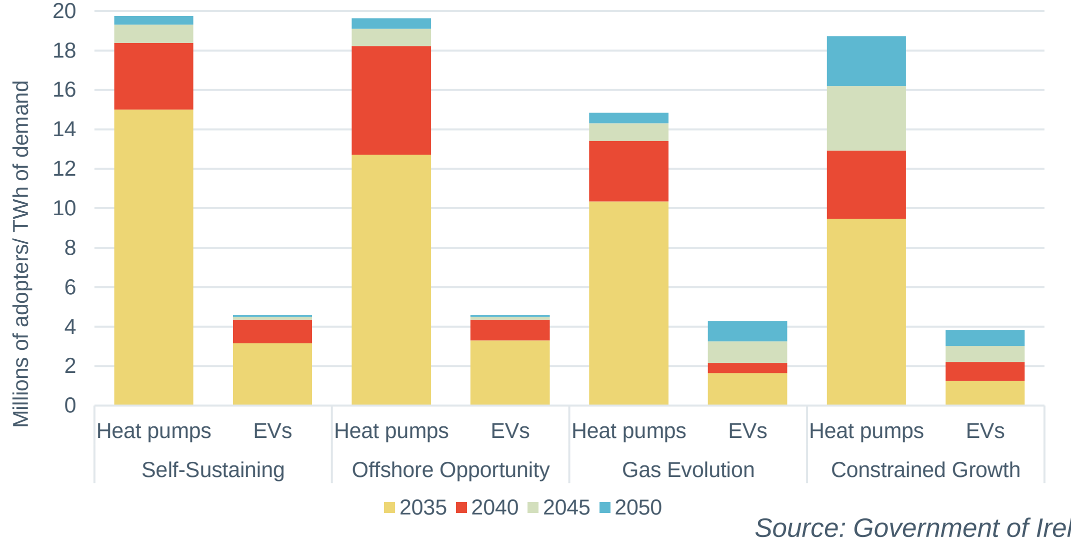
- Ireland published its *Climate Action Plan 2024* in December 2022. Alongside other elements, it includes targets for rolling out electrified heat and transport for 2025, 2030, and beyond
  - These targets include rollout of 175,000 private EVs by 2025, and 845,000 by 2030, as well as 20,000 and 45,000 commercial vehicles and 700 and 3,500 heavy goods electric vehicles (HGEVs) respectively
  - Heat pump targets are 215,000 in 2025 and 680,000 in 2030, with 45,000 and 400,000 of these retrofitted to existing buildings respectively. The remainder would be fitted to new buildings
  - This would see ~25% of households electrically heated by 2030
- Northern Ireland's Department for the Economy published its net zero energy *Action Plan 2024* in March 2024, though this did not discuss EV and heat pump targets. The expected 5-year Climate Action Plans, due by end-2023, do not appear to have been published to date
  - The previous Energy Strategy, published in draft form in 2021 by the Department for the Economy, similarly set no targets
- System Operator EirGrid and SONI's 2023 *Tomorrow's Energy Scenarios* report presents four potential future visions of the All-Island energy markets, including generation and demand
  - Heat pump demand increases significantly under all scenarios by 2035, to up to 15TWh/year and at least 6.5TWh/year, rising to the mid or high teens in all scenarios
  - EV adoption reaches a peak of 4.6mn in the scenarios driving green growth, Self-Sustaining and Offshore Opportunity, and around a sixth lower in the lower transition scenarios, with a much slower trajectory of growth

Figure 8: Republic of Ireland targets for EV rollout and heat pump adoption



Source: Government of Ireland

Figure 9: Tomorrow's Energy Scenarios forecasts of EV and heat pump adoption



Source: Government of Ireland

Methodology

Our modelling compares two scenarios, with a more and less rapid transition towards net zero heating and transport

Figure 10: Modelling scenario description

Element	Fast Transition	Slow Transition
Domestic and commercial heat pumps	Faster rollout	Slower rollout
Heat pump flexibility	More flexibility	No flexibility
Flexible industrial e-boilers	Present	Not present
EVs	Faster rollout	Slower rollout
EV charging flexibility	More flexible	Less flexible
Generation fleet	Standard CI Central assumptions	Standard CI Central assumptions
Grid reinforcement	Standard CI Central assumptions	Standard CI Central assumptions
Non heat and transport demand forecast	Standard CI Central assumptions	Standard CI Central assumptions

Our approach adjusts our market-leading wholesale price forecasts to include the impacts of additional demand flexibility from heat and transport

- We have deployed our Benchmark Power Curve (BPC) capability to model the impact of increasing the amount of flexible power consumption from EVs, heat pumps and industrial heat demand which is connected to the Irish electricity system
- Cornwall Insight's BPC is a comprehensive linear optimisation model that delivers long-term power price forecasts informed by leading regulatory, market, and policy expertise. The All-Island (AI) Single Electricity Market (SEM) model covers Northern Ireland and the Republic of Ireland, with a transmission line linking the two systems
- For this report, we have made updates to key inputs for the BPC to reflect the two scenarios described above. Specific amendments have been based on the Climate Action Plan and Generation Capacity Statement for 2030, extrapolated to 2040 based on SEAI forecasts, cross-checked against and supplemented by the Tomorrow's Energy Scenarios (TES) view published by EirGrid and SONI
- This allows us to understand the potential impacts of increased electrification of heat and transport. We have then applied our adjustments to five key inputs (continues overleaf):

1. **Electrical heating demand from heat pumps**

   Our BPC electricity demand model has been updated to test high and low annual demand scenarios from heat pumps. This demand model considers overall heating demand per year and the forecast levels of uptake for heat pumps out to 2050. In order to understand the potential impact of heat pump flexibility, we have applied an alternative demand profile for heat pumps deployed in customer segments that are expected to participate in flexibility opportunities in our high scenario

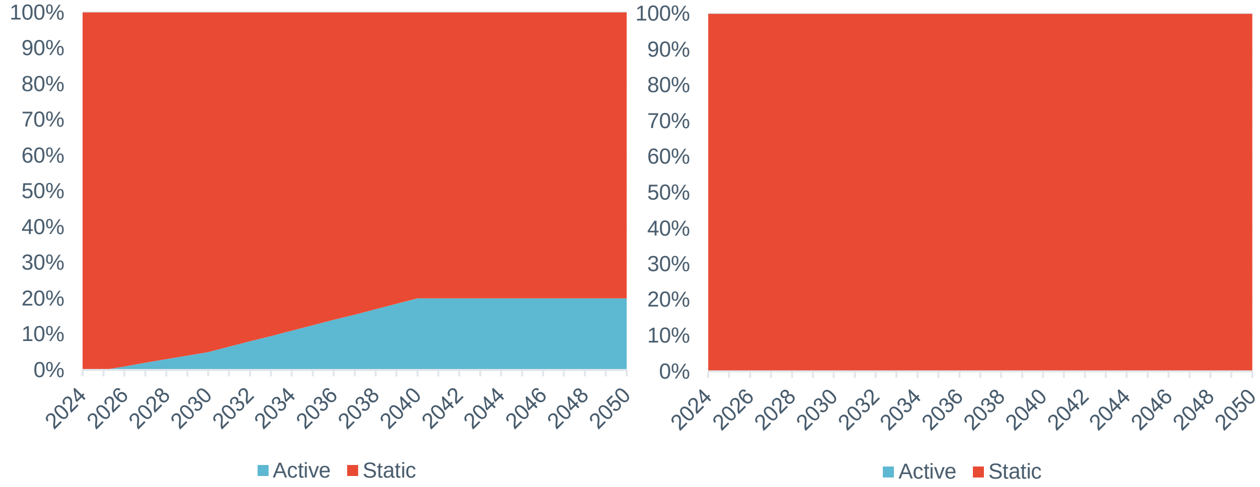
   In the Fast Transition scenario, an element of heat pump demand is made flexible, able to respond to price signals. However, this flexibility is relatively limited, with heat pumps able to avoid the peak demand window only, rather than targeted peak generation periods

Figure 11: Heat Pump Demand (TWh)

Heat Pump Demand (TWh)	Self-Sustaining	Gas Evolution
2035	11.63	8.36
2040	14.62	10.41
2045	14.89	10.69
2050	14.83	10.78

Source: Tomorrow's Energy Scenarios 2023

Figure 12: Share of heat pump flexibility, Fast Transition (left) and Slow Transition (right)



Source: Cornwall Insight

Adjustments have also been made for EV take-up

2. **EV uptake**

   We take projected numbers of EV adopters from two TES scenarios for this report – Self-Sustaining for the Fast Transition, and Gas Evolution for the Slow Transition

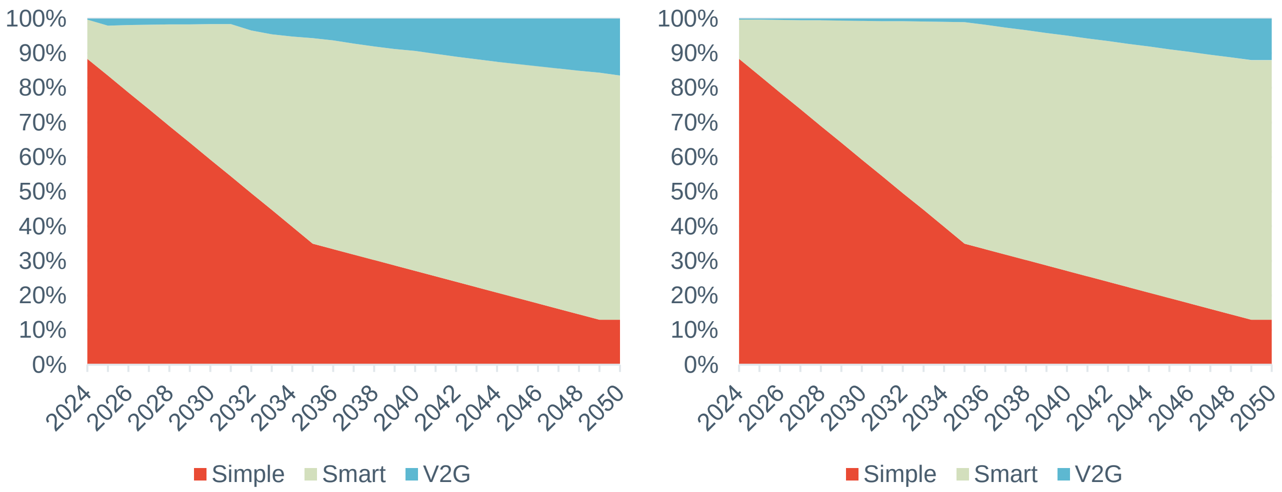
   Additional uptake of EVs provides flexibility to the electricity system, with EVs able to charge throughout the evening and overnight, or for a share of the fleet during the day

3. **EV potential to support grid**

   Similar to EV uptake, demand flexibility potential from Vehicle to Grid (V2G) capacity contributes to overall system flexibility and can help to increase utilisation of renewable energy generation and lower prices. EVs including V2G capabilities effectively function as behind-the-meter batteries which are not available at all times, but which generally act to reduce electricity demand during peak hours and increase it at off-peak times

   The level of flexibility, segmented as simple, smart and vehicle-to-grid (V2G) charging, also differs, with smart EV charges targeting high-generation, low demand periods, while V2G are even more flexible and also act to shift domestic load away from peak demand periods to peak generation periods

Figure 13: Share of EV simple, smart and V2G charging, Fast Transition (left) and Slow Transition (right)



Source: Cornwall Insight

Figure 14: EV Uptake (millions)

Millions of EVs	Self-Sustaining	Gas Evolution
2030	1.36	0.73
2035	2.35	1.20
2040	3.15	1.55
2045	3.30	2.40
2050	3.40	3.15

Source: Tomorrow's Energy Scenarios 2023

Highly flexible heat load completes the picture, offering significant resource to directly displace natural gas burn at industrial sites

4. **Heat Storage**

   We have also introduced additional heat flexibility via the use of e-boilers and heat storage assets, in both the domestic and industrial and commercial sectors. These represent flexibility from hot water and process heating, heat networks, and other sources of highly flexible heat demand

   This heat storage has a 98% efficiency, with a 6-hour duration, and acts to shift some demand from high demand periods to high generation periods

5. **Industrial heat demand**

   Industrial heat is largely provided by fossil fuel burning. While typical fuel sources are gas, kerosene or fuel oil gas burning, the industry standard assumption is of 85% efficient natural gas boilers. We have supplemented these in our modelling with 99% efficient electrical boilers, which – when economically efficient – will displace this gas burn. 1GW of these assets is assumed to be in place by 2030, growing to 2GW by 2040. This reflects the fact that much of Ireland's industrial heat demand is eminently suitable to benefit from these assets

   These boilers are a key resource in delivering benefits to the system, acting to absorb low cost – especially excess – renewable electricity generation. In order to minimise costs and maximise utility, the assets are modelled as fully flexible, with no requirement to run at any time. Ireland's industrial heat demand is considered particularly suitable for these assets. 1GW of these e-boilers are added to the system by 2030, rising to 2GW by 2040, under the Fast Transition scenario, with this not added under the Slow Transition scenarios

   They are not exposed to Imperfections Charges, as they are assumed to be dispatched by the System Operator to benefit the system like generation turn-down or storage import assets might be. We also assume that they are not exposed to non-commodity costs, for the same reason. We set out on the next pages some notes on a potential implementation methodology to support these assets

   Importantly, without mitigation of these costs, these boilers would not be built, and would not offer benefits to the system and all users

- Overall, demand flexibility has been increased significantly in the high flexibility scenario as a result of these updates, which our initial expectations suggest will increase the amount of renewable generation which can connect to the system, stabilise prices, and reduce congestion and constraint

Figure 15: Dispatch of industrial e-boilers

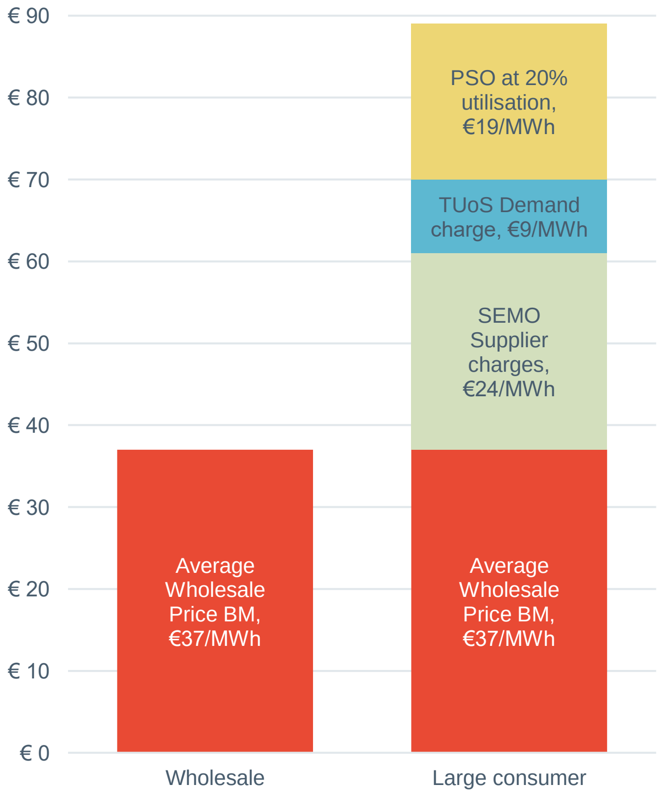
$$\frac{Electricity\ price}{99\%} < \frac{(Natural\ gas\ price + Carbon\ price)}{85\%}$$

Source: Cornwall Insight

A potential market solution to encourage flexible demand was suggested three years ago, but never fully studied. Our modelling includes assets on this basis

- Balancing Mechanism Code modification proposal Modification_07_21 considered implementing a change to capacity and imperfection charges for flexible heating demand users. The modification suggested that making volumes of dispatchable demand available to the Transmission System Operator to be constrained up or down would enable additional renewable penetration on the system, by absorbing power which would otherwise be dispatched down
- The solution would have defined dispatchable demand assets as generating units with the ability to be dispatched in negative values, i.e., to import from the system on the instruction of the System Operator, in the same manner as pumped hydro and battery assets but with unlimited duration
- It also would have carved dispatchable demand assets out from Maximum Import Capacity for relevant sites, effectively exempting the assets from import charges. Due to the nature of dispatch, additional network investment would be only in last-mile connections, paid for by the demand sites
- The modification was primarily considering large industrial electricity demand for heating, which could be considered as a more certain or more highly dispatchable form of demand than the other demand being modelling for WEI and Ireland Electrified under this project, from domestic heat and EV chargers. Given the larger number of smaller sites, which may not be available at all times to alter their behaviour, consideration of some form de-rating factor may be advisable
    - The original solution examined electric boilers which could, during high renewable generation periods when curtailment of generation would be required, displace continual year-round generation of steam from fossil sources by absorbing excess electricity in an e-boiler. Other demand sources may be more limited temporarily by demand for heat and/or connection of EVs
- **Our study includes industrial e-boilers, which are not exposed to these charges, consuming power at the wholesale price to displace natural gas burn and effectively acting as a system service provider rather than a conventional demand user**
- The operation of these assets is expected to reduce dispatch down of renewable generation, reducing overall carbon emissions at a low cost to the Irish energy consumer

Figure 16: Example consumption charges

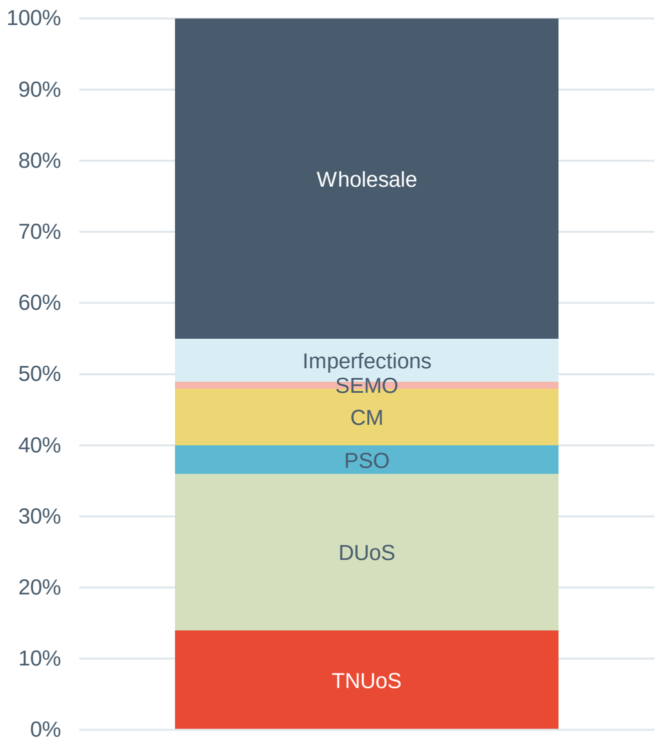


Source: Mod_07_21

Charges and levies make up a significant share of the electricity for consumers

	Charge	Summary	% of non-commodity stack	% of total bill
NETWORKS	Transmission Network Use of System (TNUoS)	Transmission use of system charges are used to recover the costs incurred by the transportation of bulk power across the system interconnecting to the low power distribution system Charges are levied on several bases, including capacity charges and volumetric charges	24-34%	12-17%
NETWORKS	Distribution Use of System (DUoS)	Distribution use of system charges are the cost of operating and investing in the electricity network during the lifetime of the connection Charges are levied on several bases, including capacity charges and volumetric charges	43-52%	22-26%
POLICY	PSO Levy	It recovers funds that support renewable generation, currently the renewable electricity Feed-In tariff (REFIT) and the renewable electricity scheme (RESS)	0-15%	0-8%
POLICY	Capacity Market (CM)	Scheme to ensure system has enough capacity to meet maximum demand	14-19%	7-10%
MARKET	Market Operator charge	Market operator charges recover the operational costs of SEMO's balancing market functions, along with capital related costs including a rate of return	~1%	~1%
MARKET	Imperfections charge	The imperfection charge is used to recover costs that cannot be recovered through other charges in imbalance settlement	10-13%	5-7%
	Wholesale	The cost of wholesale power purchase		45-50%

Figure 17: Total retail bill breakdown, large industrial user



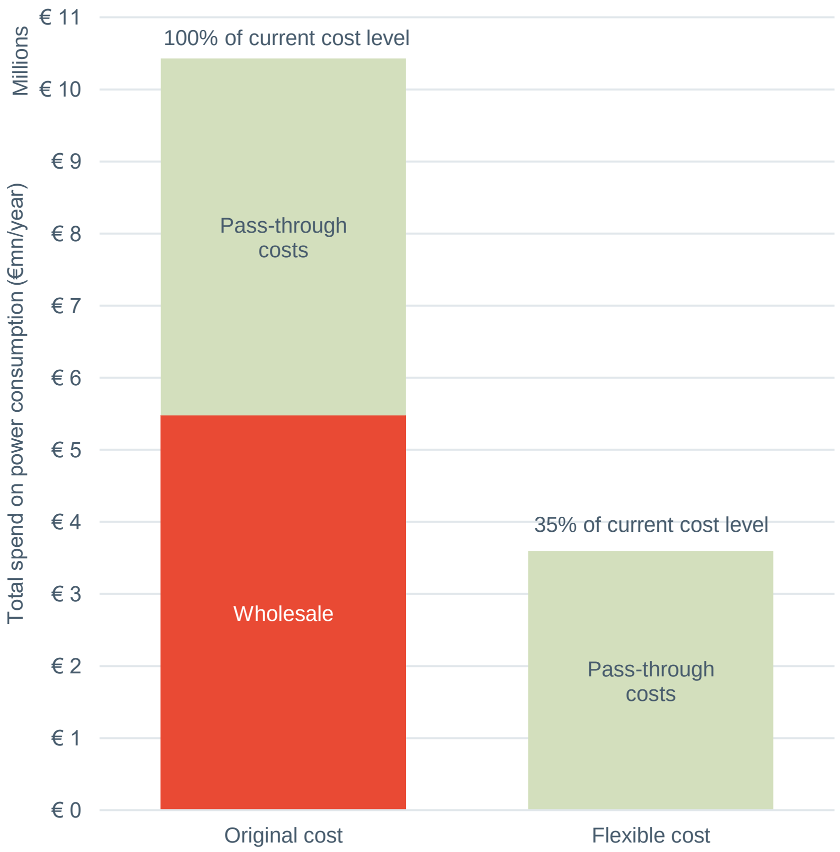
Source: CI and WEI

- Savings on the Imperfections and some network charges could present highly flexible demand with a cost saving of around 15%
- In addition to savings on these costs, very flexible industrial heat assets would benefit from reductions in the cost of wholesale power. If dispatched up by the System Operator to mitigate constraint, these users would be paying almost zero cost for the wholesale power element, as any value offered over €0/MWh would be present a more economically efficient option than dispatching-down wind assets at a €0/MWh price. This brings the overall saving to around 65%

These costs reduce the importance of wholesale price signals and make it more expensive to electrify

- Non-commodity costs are mostly not time-of-use, and apply to power consumed at all times of the day. This results in variable wholesale prices having lower impact on the total bill being paid than would otherwise be the case, and reduces the incentive to consume flexibly. These also increase the total cost of power consumption, making electrification of heating uneconomic for many user, particularly when comparing the costs of direct electrical heating to the costs of gas heating
- Reforming some of these charges, particularly Capacity and Imperfections charges, to reward the flexibility electrification can bring to the grid, could reduce import costs and enable investments in electrification of heat and transport. Assets which are fully flexible and available for dispatch by the system operator could justifiably see a reduction of these charges
- These costs make up around 24-32% of the pass-through costs, as shown on *page 18*. We have modelled a reduction of 100% of these costs, for relevant highly flexible industrial e-boilers, to demonstrate the value of these assets to the system – if industry could be provided with a viable economic case to build and connect these assets in suitable locations
- The structure of this cost relief – whether positioned as an up-front exemption or provided as a rebate – is not considered in this paper. We note that various models are operated internationally; for example, GB provides Energy Intensive Industries with exemptions from non-commodity charges on an exemption basis, and provides a rebate on a share of grid fees on one-year arrears basis
- It will be important for the consumption of relevant flexible units to be metered separately from other consumption on the same site, and for the system operator to be able to dispatch assets as it requires on a system management basis. In many ways, this consumption should be treated as closer to generation turn-down or BESS demand than conventional electricity demand, as it is providing a system service. The system operator should also be incentivised to turn up this flexible demand ahead of turning down renewable generation as a preference, as we assume that these find a similar position in the merit order with generation not compensated to be turned down and flexible demand not charged to be turn up

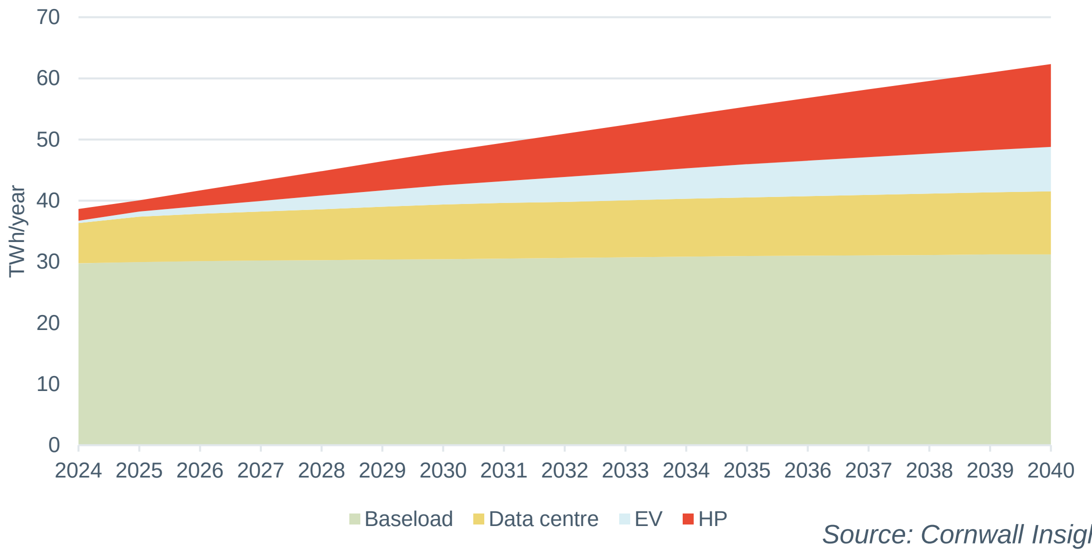
Figure 18: Example large industrial user annual bill, for System Operator-dispatched flexible power consumption



Source: CI and WEI

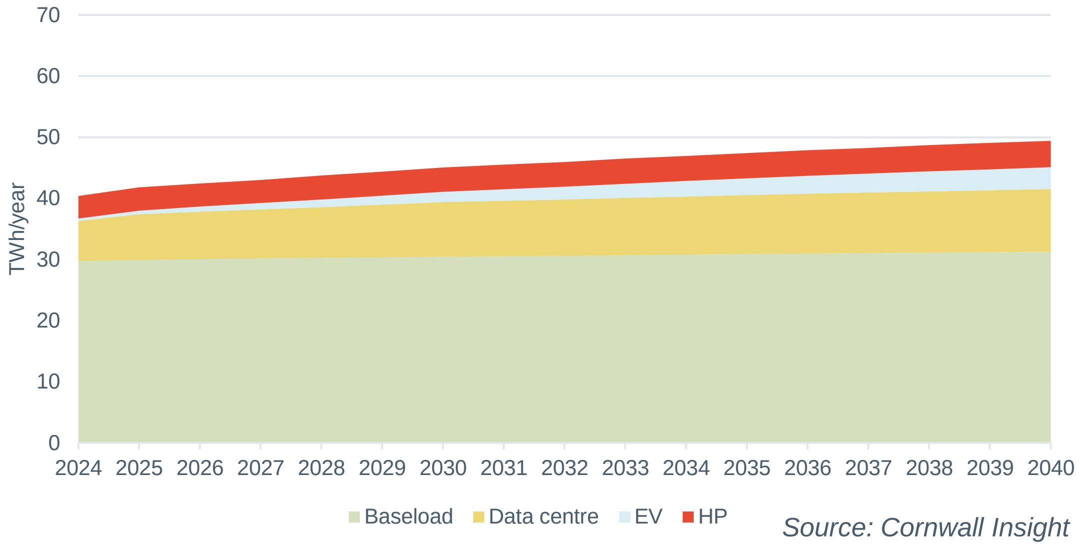
Our demand scenarios have much higher power consumption under the Fast than Slow scenario

Figure 19: Annual demand curves, TWh/year, Fast Scenario



Source: Cornwall Insight

Figure 20: Annual demand curves, TWh/year, Slow Scenario



Source: Cornwall Insight

- While baseload and data centre demand are constant between the scenarios, EV demand and heat pump demand are much higher in the Fast Transition scenario. EV demand is 86% higher in 2030, 96% higher in 2035, and 103% higher – over double – in 2040. However, we note that by 2050, when the EV transition is largely complete, we forecast EV demand only 8% higher in the Fast scenario
- Heat pump demand grows more slowly in the short-term, only 37% higher in 2030, but ends much higher, at 130% higher in 2035 and 215% – over triple – in 2040. Unlike EV demand, by 2050 heat pump demand continues to be forecast to be higher under the Fast scenario, at 183% higher
- In addition to the raw increase in demand, additional heat pumps, electric boilers and EV chargers result in more flexible demand being available, beneficial in a high-renewables system
- Note that these forecasts exclude the very flexible industrial e-boiler demand, as this is assumed in the core scenario to be met by natural gas burning rather than electricity, and which are dispatched only to provide a service to the system

Results

Key takeaways

Wholesale prices for consumers decrease in the Fast Transition scenario compared to Slow, by up to 5.6%

Additional highly flexible consumption reduces wholesale power prices, benefiting all consumers

- In 2030, the relatively small difference in demand between the two scenarios paired with the additional flexibility arising from the 1GW of industrial boilers results in a **3.3% discount in electricity prices**. By absorbing more cheap power, industrial boilers would tend to decrease average prices in the Fast Transition scenario
- By 2035, the difference in prices has fallen, as the higher level of demand on the system in both scenarios is absorbing much of the cheaper power, and gas costs have fallen. The average annual forecast price is €0.37/MWh or 0.8% lower in the Fast than in the Slow Transition scenario
- In 2040, forecast prices increase slightly again. This is due to several factors: demand has increased significantly with a relatively steady pace of renewable buildout and slightly less CCGT on the system as additional plants begin to close. In addition, carbon prices are expected to have increased by 2040, making fossil-generation more expensive
- The relative gap in price between the two scenarios widens by 2040 to 5.6%, with the **Fast Transition scenario at a discount of €3.81/MWh** compared to the Slow scenario

Figure 22: Average Annual Wholesale Power Prices, €/MWh

€/MWh	Fast	Slow	Discount	Discount %
2030	€77.16	€79.78	-€2.62	3.3%
2035	€47.66	€48.03	-€0.37	0.8%
2040	€63.95	€67.76	-€3.81	5.6%

Source: Cornwall Insight

Figure 21: Average Monthly Prices

Source: Cornwall Insight

Along with the decrease in average prices, the number of low-priced hours increases, increasing the opportunity for flexible assets

This results in a virtuous cycle where other users are encouraged to be more flexible in their consumption and see similar benefits

- **The number of hours with very low power prices also increases significantly** under the Fast Transition scenario over time. This increases from 102 hours of power cost under the gas and carbon cost in 2030, to 250 in 2035, to 407 in 2040
- This indicates that there is opportunity for additional very flexible consumers to absorb this power at low cost to displace gas burn, for example
- The increase in curtailment, discussed later in this section, also supports this theory, as these very-flexible demand units could switch on to absorb volumes of power, rather than the SO paying to turn off these generators or otherwise dispatching them down

Figure 23: Number of hours with power prices under level, 2030, €/MWh

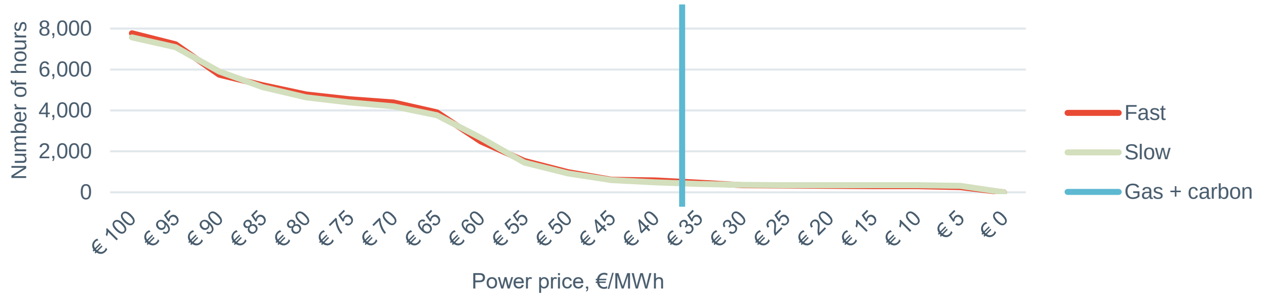


Figure 24: Number of hours with power prices under level, 2035, €/MWh

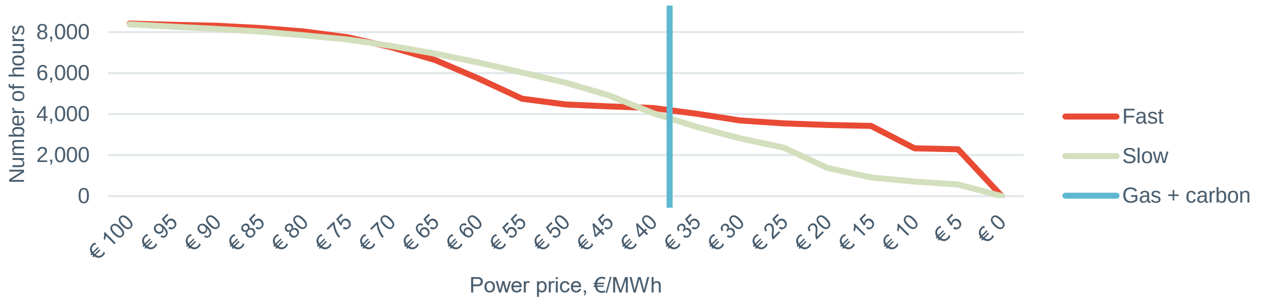
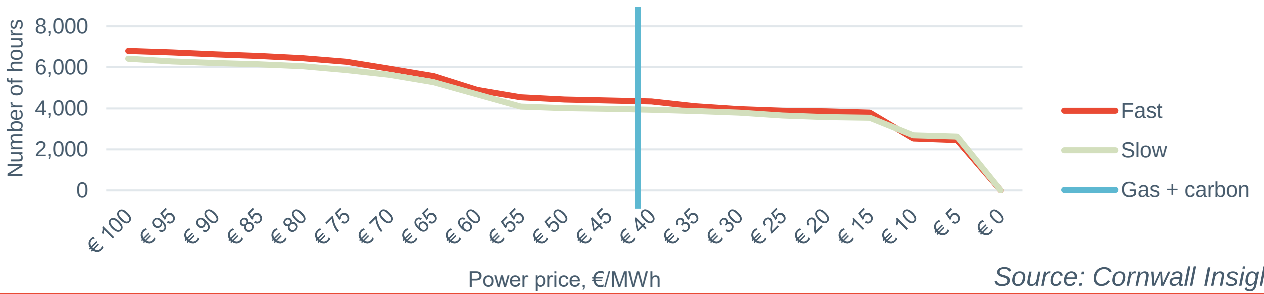


Figure 25: Number of hours with power prices under level, 2040, €/MWh



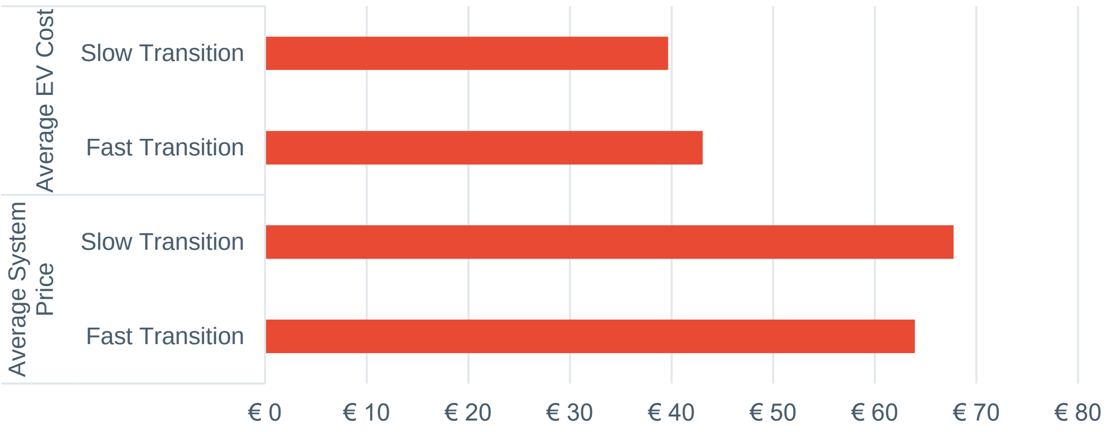
Source: Cornwall Insight

Benefits for EVs increase, with lower costs to charge despite the higher demand

As flexible consumption, EV charging costs are lower than average power consumption costs, and also result in lower carbon emissions

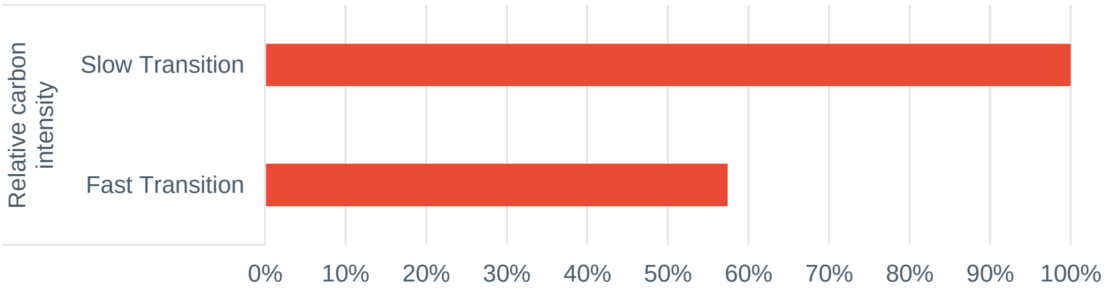
- Within the Fast Transition scenario, we assume an additional 1.58 million EVs deployed by 2040. This is an increase of 102% compared to the Slow Transition scenario
- This increased rate of EV deployments results in a total EV demand increase of 2.5TWh in 2040 in the Fast Transition scenario. There is also 2GW of industrial e-boilers operating in the Fast Transition scenario which are not present in the Slow Transition scenario
  - This reduces the amount of excess and very cheap electricity available to charge the EVs, and results in a slightly higher EV charging cost under the Fast than the Slow transition – €3.43/MWh more on average
  - However, costs are substantially lower than the average annual system price in each scenario, €20/MWh cheaper in the Fast Transition scenario and €28/MWh cheaper in the Slow Transition scenario
- In order to estimate the potential carbon intensity of EVs, the granular hourly generation profile has been compared against the carbon intensity of the grid at that time. In the Fast Transition electrification scenario, a larger portion of EVs are optimising to charge when prices are lower (usually due to higher renewable penetration)
- As a result, EVs in the Fast scenario charge with an **average annual carbon intensity 42.6% lower** than in the Slow electrification scenario in 2040

Figure 26: Cost of EV charging, average wholesale price in 2040 (€/MWh)



Source: Cornwall Insight

Figure 27: Relative carbon intensity of EV charging in 2040



Source: Cornwall Insight

Industrial e-boilers deliver approximately carbon and financial savings, 170,000 tonnes of carbon and €31mn in 2030, rising to over 670,000 tonnes of carbon and 137mn in 2040

Exempting industrial e-boilers from fees, allowing deployment, creates huge financial savings and carbon cost reductions

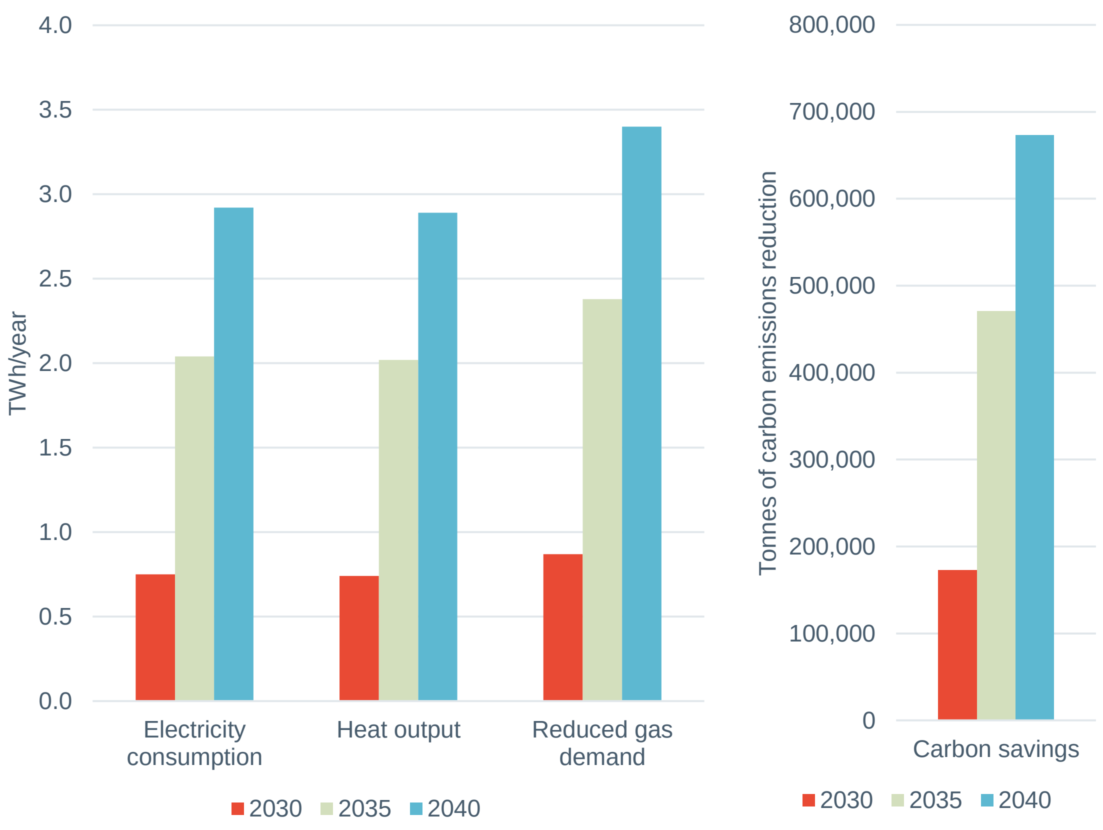
- Our modelling shows that the **industrial e-boilers save significant amounts of carbon emissions** by partially displacing natural gas burn for heating
- Factoring in efficiency, the 2.92TWh of electricity forecast to be consumed by these assets in 2040 displaces around 3.4TWh of natural gas demand
- With natural gas burn reduced by this amount, around **670,000 metric tonnes of carbon would not be emitted**, due to the deployment of flexibility
- In terms of financial savings, we calculate that the industrial users would pay around €3.4mn for this power. This is mostly due to the **very low average price being paid, around €1.2/MWh**
- In comparison, **around €137mn is saved by these industrial users** in reduced gas burn, with a forecast gas price of €22.44/MWh and an EU ETS price of €90.61/tonne
- This also has benefits for the balance of trade, with less spent on foreign gas imports, from €10mn in 2030, to €35mn in 2035, and €61mn in 2040

Figure 29: Annual electricity spend and avoided gas and carbon spend

	Electricity spend	Avoided gas and carbon spend
2030	€1,422,838	€31,462,919
2035	€2,443,433	€89,684,665
2040	€3,477,277	€137,246,829

Source: Cornwall Insight

Figure 28: Carbon savings from gas displacement



Source: Cornwall Insight

Curtailment falls due to the additional dispatchable flexibility, resulting in less wasted renewable generation

Increased flexible power consumption reduces dispatch down of renewable generation, reducing wastage of power by consuming it locally. Further location-based studies are required, but national results are extremely encouraging

Figure 30: Curtailment comparison between Fast Transition and Slow Transition scenarios

	2030		Increase in Utilisation	2035		Increase in Utilisation	2040		Increase in Utilisation
Solar	Fast	Slow		Fast	Slow		Fast	Slow	
Forecast generation (GWh)	4,041	3,979		5,436	5,818		6,640	6,668	
Potential generation (GWh)	4,101	4,101		5,827	6,438		7,574	7,574	
Utilisation	99%	97%	1.5%	93%	90%	2.9%	88%	88%	-0.4%
Onshore Wind	Fast	Slow		Fast	Slow		Fast	Slow	
Forecast generation (GWh)	23,681	23,526		27,298	27,498		30,499	30,352	
Potential generation (GWh)	23,924	23,924		28,786	29,241		33,749	33,749	
Utilisation	99%	98%	0.6%	95%	94%	0.8%	90%	90%	0.4%
Offshore Wind	Fast	Slow		Fast	Slow		Fast	Slow	
Forecast generation (GWh)	13,127	12,702		36,575	35,061		43,500	38,980	
Potential generation (GWh)	13,374	13,374		39,466	39,016		54,730	54,730	
Utilisation	98%	95%	3.2%	93%	90%	2.8%	79%	71%	8.3%
Total "Wasted RE"	549	1,192	**-54%**	4,770	6,320	**-25%**	15,414	20,054	**-23%**

Source: Cornwall Insight

- Curtailment/ dispatch-down shows significant reductions from the Slow Transition to the Fast Transition. The increased volume of highly flexible demand allows dispatch to reduce wasted (i.e., dispatched down) renewable energy levels between the two scenarios by **54% in 2030, 25% in 2035 and 23% in 2040**
- Financial and carbon benefits are discussed on the next page

Consumer benefits also arise from lower carbon emissions, particularly in the heat and transport sectors

More renewable generation is able to access a system with more flexible consumption, reducing average carbon emissions

- **Carbon Emissions fall on average across the modelling period**, with more low-carbon power able to access the system due to the flexible demand added
- However, in the later years, there are a few monthly periods where emissions are slightly higher for the electricity system. This is due to the generally higher demand for power, which results in more gas-fired power generation operating in some months
- These figures do not account for the reduced carbon emissions elsewhere in the economy, due to replacement of gas heating and ICE vehicles with electrified versions
  - See page 24 for a discussion of this in the context of highly-flexible industrial e-boilers – we forecast carbon emissions reductions of this in the range of 170,000 tonnes in 2030, rising to 670,000 tonnes in 2040
  - **Each additional heat pump saves around 2 tonnes of carbon emissions a year**, and **EVs around 1.2 tonnes a year –** the increased numbers of vehicles and heat pumps were inputs to the modelling, however, and are not included in the emissions savings below which are only for the electricity system

Figure 31: All-Island electricity system carbon emissions (kg/MWh)

2030	Fast	Slow		2035	Fast	Slow		2040	Fast	Slow	
Jan	301.1	323.0	-21.9	Jan	357.8	361.4	-3.7	Jan	313.0	352.3	-39.3
Feb	295.7	316.9	-21.1	Feb	327.9	357.2	-29.3	Feb	312.2	336.8	-24.6
Mar	301.1	349.2	-48.1	Mar	298.1	314.5	-16.3	Mar	307.8	310.5	-2.7
Apr	312.6	322.7	-10.0	Apr	352.7	348.8	3.9	Apr	291.9	298.9	-7.1
May	308.9	320.3	-11.4	May	290.0	308.3	-18.2	May	284.9	282.3	2.6
Jun	323.8	326.4	-2.6	Jun	205.8	227.2	-21.4	Jun	265.5	316.2	-50.7
Jul	333.5	336.3	-2.9	Jul	230.4	231.4	-1.0	Jul	248.8	259.5	-10.7
Aug	328.4	331.3	-3.0	Aug	226.7	274.1	-47.3	Aug	248.0	257.6	-9.5
Sep	331.5	332.7	-1.3	Sep	257.7	254.5	3.2	Sep	310.4	283.6	26.8
Oct	303.6	319.8	-16.2	Oct	286.8	295.2	-8.4	Oct	273.1	305.1	-31.9
Nov	298.8	321.7	-22.9	Nov	305.1	343.0	-37.9	Nov	290.0	308.4	-18.4
Dec	290.4	323.0	-32.6	Dec	271.2	305.3	-34.1	Dec	253.4	308.1	-54.6
Av saving	**314.6**	**326.0**	**-11.4**	**Av saving**	**284.2**	**301.7**	**-17.6**	**Av saving**	**283.2**	**301.6**	**-18.3**

Source: Cornwall Insight

A benefit could also arise from lower bidding prices in future RESS auctions, as lower constraint levels are factored into pricing of new assets

- By reducing dispatch down, flexible consumption may help to mitigate increases in future RESS auction prices
- Renewable developers consider how much revenue will be generated per annum, to meet the costs of the project and requirement for investment returns
- They therefore factor the expected level of uncompensated constraint into their auction bids, as this reduces income
- All other things being equal, a project with 45% dispatch down will require a bid-price over 80% higher than an equivalent asset with no uncompensated dispatch down
- A less extreme example, 20% dispatch down, shows an asset requiring a bid-price only 25% higher than an asset with a firm connection with no uncompensated dispatch down
- These examples show that reducing expectations for future dispatch down reduces the prices which developers need to bid into future RESS auctions
- This could allow lower costs to feed through into the PSO levy in the future, reducing the impact of future RESS and ORESS auctions on Irish consumers
- Further studies are required to understand the implications of reducing network congestion on RESS auction bidding

Figure 32: Example RESS auction prices, illustrating benefits of lower dispatch down

0% dispatch down: $100 \times (1-0) = 100$

To earn €5,000/ year from 100MWh, price required: $\frac{€5{,}000}{100} = €50.0$

20% dispatch down: $100 \times (1-0.20) = 80$

To earn €5,000/ year from 55MWh, price required: $\frac{€5{,}000}{80} = €62.5$

45% dispatch down: $100 \times (1-0.45) = 55$

To earn €5,000/ year from 55MWh, price required: $\frac{€5{,}000}{55} = €90.9$

Source: Cornwall Insight

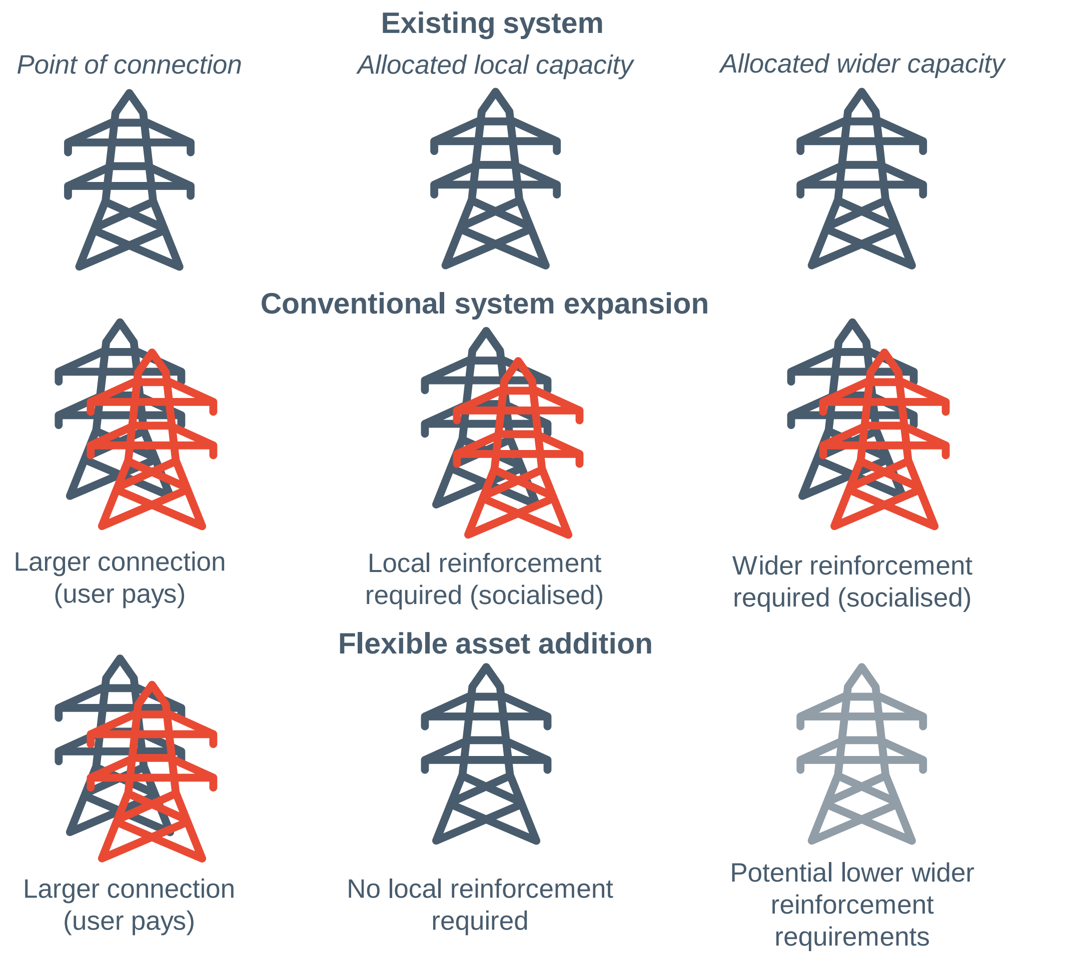
Minimising forecast dispatch down – and hence maximising output – from renewable plant in development allows lower bid prices in future auctions. This helps manage future cost-recovery from Irish electricity consumers

We would not expect consumers to be exposed to higher capacity costs for the additional demand capacity of industrial e-boilers

Allowing flexible connections to consume excess generation locally would not increase, and could decrease, total network costs – if flexible consumption is suitably located to maximise benefits

- Turning to network capacity costs, we note that in usual circumstances, offering industrial users large additional connection capacities would drive significant additional costs into the system from requirements to build new transmission and potentially distribution system assets
- These would arise from both the last-mile connection, which the users gaining additional capacity would be expected to fund, and the wider system, where distribution and transmission assets would be reinforced to cope with the higher demand levels and the need to meet these under all system conditions. This would be paid for by all electricity network users through increases to network charges
- However, in the case of flexible e-boilers, only dispatched by the System Operator to soak up excess local power generation, the need for wider system reinforcement disappears. There may even be cost-savings, as reinforcement which might have been required to flow this power to other users is reduced. Potentially, other investments providing flexibility to mitigate dispatch down, such as storage and interconnection, may also not be required on a national basis
- The case for exempting industrial users from additional capacity charges for increased connection capacity, to be used solely for system-supporting e-boilers, is therefore strong
- Further power flow modelling is required to understand both the potential savings in grid reinforcement costs that would otherwise be needed to support generation investment, and the best locations for development of highly flexible heat demand, to consume local renewable generation rather than dispatching this down

Figure 33: Illustration of network capacity impacts



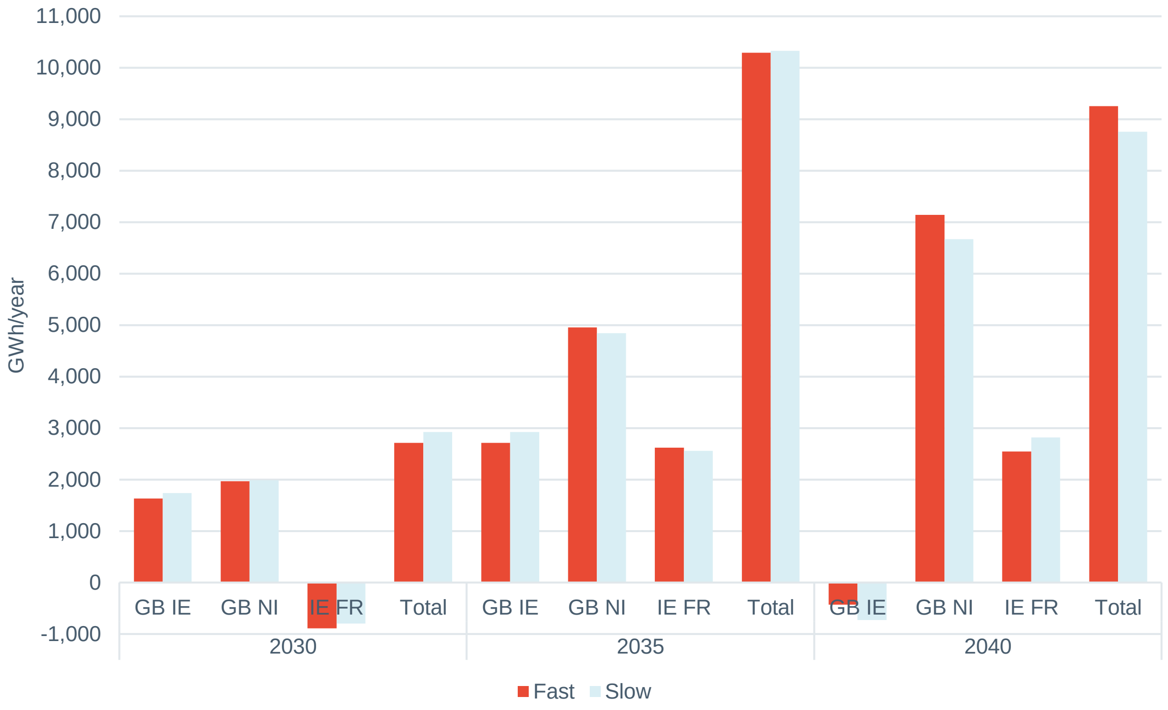
Source: Cornwall Insight

The impacts on intra-regional power flows are minimal, though exports are slightly lower in the short term and imports lower in the long term

- The graph on the left shows the net flows within the system, with Ireland being a net exporter in both scenarios in 2030, 2035 and 2040. The Fast Transition scenario sees slightly lower exports than Slow in 2030, roughly equal in 2035, and higher in 2040
- Furthermore, the total power flows are very similar in both scenarios, as are the number of hours of congestion on each of the interconnectors, both for export and import
- This does not present a clear story in terms of benefits of drawbacks of the additional flexible power demand from electrified heating and transport
- However, it could indicate slightly lower need for additional interconnection in the future, resulting in lower capital investment requirements
- Again, a full power flow study is required to understand implications here

Consuming more of the power generated in Ireland locally could cut the need for interconnection, reducing investment need and embedded carbon emissions in interconnector buildout

Figure 34: Interconnector Net Flows in 2030, 2035 and 2040, GWh/year



Source: Cornwall Insight

Considerable societal benefit could arise from lower carbon emissions and lower costs to industry

Our study considered the outturn results of increasing the level of flexible electrification of heat and transport on the Irish energy system

- This was based on a comparison between a faster pace of heat pump and EV rollout, and a slower pace
- In our faster pace study, we also considered the impact of rolling out flexible industrial e-boilers, displacing natural gas demand at times of high renewable generation. This dispatchable demand sees cost reductions of around 65%, versus average prices, due to levy exemptions and low wholesale prices

Curtailment of renewable energy volumes was found to fall considerably, as flexible power demand absorbs more of this energy

- This otherwise-curtailed generation would be at times of high overall renewable generation output, which coincides with low wholesale electricity prices
- Lower curtailment would result in lower Imperfections charges, for generation which is compensated for being dispatched down
- Reduced curtailment forecasts could also allow developers to bid lower prices into future RESS auctions, reducing levy costs to consumers

Network **congestion** and constraints are also forecast to decrease, as power may be consumed closer to the point of generation by flexible demand

- This would provide no Imperfections charge benefits
- Network reinforcement requirements may be lower, as might need for investment in other sources of flexibility like interconnection and batteries

Carbon savings are seen in the electricity sector, but also in the wider economy by replacing fossil fuels with lower-carbon electrically-powered devices

- Carbon savings from flexible industrial e-boilers are forecast at 170,000 tonnes in 2030, rising to 670,000 tonnes in 2040, from 1GW and 2GW of e-boilers respectively
- These boilers also provide considerable financial savings to industry, rising from around €30mn in 2030 to over €130mn in 2040

Considerable emissions savings would be delivered at little or no cost to the consumer, **industry would benefit from substantially reduced heat costs**, and with less gas imported from abroad, balance of trade would improve

- Imperfections charges are expected to fall due to reduced curtailment of renewable generation

Next steps to establish the case for electricity bill cost-exemptions to enable the introduction of highly flexible demand, to provide system benefits, could include: a detailed study of potential network reinforcement cost-savings based on assets introduced in specific locations, examination of the impact on future RESS auctions of reduced levels of dispatch down, and studies of impacts on other pass-through costs for non-exempt electricity users

Additional Information

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