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More Power to You:

A Guide to Repowering in Ireland

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Executive Summary

With Ireland's wind fleet maturing, this report was written to examine the potential for repowering in Ireland. For the purposes of this report, repowering refers to the complete dismantling and replacement of turbine equipment at a wind farm, with existing infrastructure on site such as roads and grid connection equipment being reused where possible. The number and layout of the turbines will usually change, and the foundations will most likely need to be replaced. Installed capacity does not necessarily have to increase when a wind farm is repowered, but generally it does.

Wind Turbines are typically designed to operate for 20-25 years. As turbines near end-of-life, repowering provides an alternative to decommissioning that can provide a host of benefits. Chief among them is the ability to continue using productive wind farm sites that were commissioned first. Installing modern technology on these sites can also vastly increase their installed capacity and annual energy production. Repowering can also; be cheaper than new builds, reduce the number of turbines in a wind farm, result in lower energy costs and prices, and increase our energy security.

Age is the best indicator for repowering potential, as older wind farms can generally gain more from repowering. Typically, wind farms are repowered at near to 20 years old. There is no optimal age that can be applied in all cases, however. This is demonstrated in Figure A, which shows that the average age for repowering across Europe has ranged from 9 to 27 years. Repowering viability is case-specific and depends on, inter alia, wind turbine condition, O&M costs, expected technological evolution, current and future access to finance, relevant support schemes and site-specific considerations.

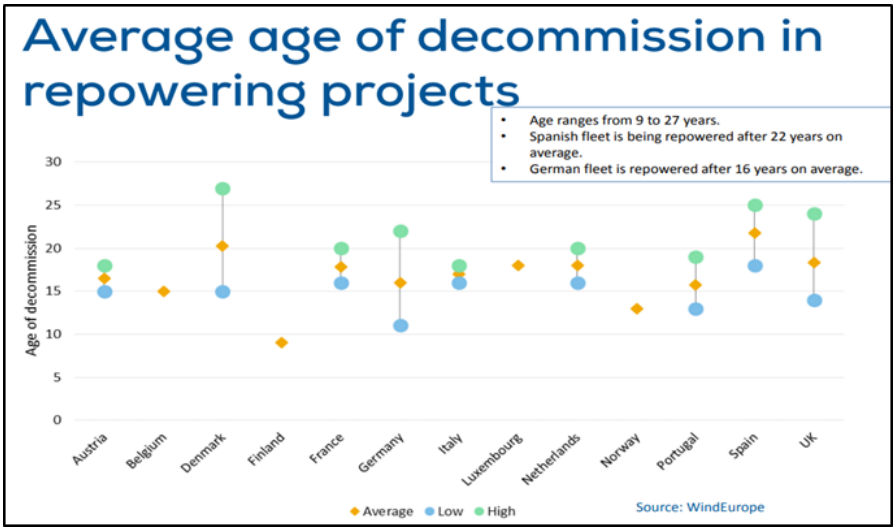

Figure A - Average Age of Decommissioning in European Repowering Projects

Figure B, below, shows the age profile of Ireland's currently installed onshore wind fleet as of 2020, 2025 and 2030. Assuming a repowering age of 20, in 2020, Ireland will not have a huge amount of capacity that would be expected to repower. 115 MW (3 per cent of today's installed capacity) will be aged 20 or over in 2020. By 2025, however, 422 MW (11 per cent) will be 20 or older. Looking further ahead to 2030 and almost 1,400 MW or 40 per cent of today's installed capacity will reach this age bracket. While it cannot be expected that every project that reaches 20 years old will repower, it is also likely that projects under the age of 20 will repower.

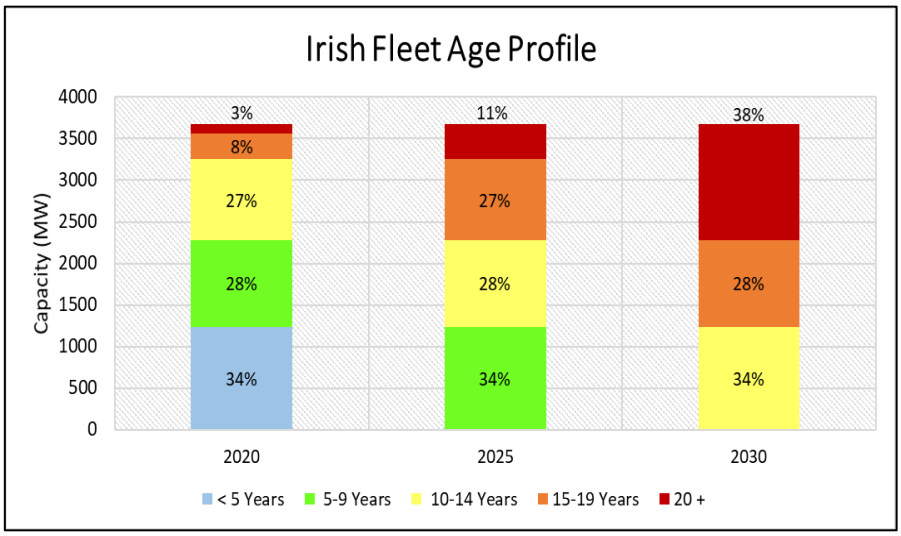

Figure B - Age Profile of Ireland's Onshore Wind Fleet as of 2020, 2025 & 2030

IWEA's most recent pipeline survey of the future onshore and offshore wind generation development for Ireland, completed in September 2019, has found that projects with an existing capacity of at least 285 MW are currently planning to repower in the coming decade, with 140 MW of this planned to repower up to 2022. Current plans are to increase this 285 MW to 470 MW, representing a 65 per cent total increase in capacity. All of this suggests that repowering could be a key enabler for Ireland's 2030 renewable electricity and emissions reduction targets.

Despite the benefits mentioned above, and the others discussed in this report, there are potential barriers that could complicate or prevent the repowering of many Irish wind farms. This could lead to needlessly large capacities decommissioning or operating inefficiently in the future. Many barriers to repowering have been seen across Europe, but it is thought that the ones that could be the most relevant here include; the absence of a regulatory framework for repowering, planning constraints, the presence of Natura 2000 sites, and a lack of available grid capacity. The fact that repowering projects are already in the pipeline emphasises the need to address these potential barriers.

To prevent these potential barriers from materialising and slowing repowering over the next decade, this report makes some recommendations. Some of these are included below, with a more complete list contained at the end of this report.

1) Government should look to clearly define repowering, to avoid any ambiguity. This should be a more precise definition than the one in the Renewable Energy Directive. A potential wind farm repowering definition is given below;

'renewing wind farms by the complete decommissioning and replacement of wind turbine generator equipment at a site for the purposes of replacing or increasing capacity and/or increasing the efficiency of the installation. Existing site infrastructure like grid connection equipment may be retained and reused where possible.'

2) Government should also look to implement the requirements of the Clean Energy Package, as they relate to repowering, which include:

   - Implementing simplified and less burdensome authorisation procedures for renewable energy projects;
   - Establishing one designated authority for the permit-granting process;
   - Putting in place a simplified permit-granting process for repowering, not exceeding one year;
   - Estimating the renewable energy trajectories by which renewable energy targets up to 2030 will be reached, separated as new and repowered capacity.

   When calculating the capacity to be repowered up to 2030, it is recommended that Government sets a target repowering volume which should be achieved.

3) It should also be ensured that repowering projects can compete in RESS auctions on a level-playing field with new builds and are not subject to any strict pre-conditions. In the future, when there is more demand, repowering-specific auctions could be considered.

4) In relation to grid, a lack of capacity must not prevent or limit projects. Given the timelines needed to deliver transmission infrastructure, a more proactive approach to transmission network upgrades is needed. This would benefit new projects as well as repowering ones.

Implementing these recommendations would ensure that Ireland takes a more proactive approach to repowering than has been seen across Europe. This would leave us best placed to benefit from the numerous potential benefits associated with it. With projects already in the pipeline, not facilitating repowering would be a missed opportunity for Ireland and make the Government's ambitious target of 70 per cent renewable electricity by 2030 all the more challenging.

1 Introduction

Wind turbine generators (WTGs) typically have a design life of 20-25 years. They can operate beyond this but can also become obsolete much earlier. As WTGs reach the end of their design lives, three options are available; repowering, lifetime extension (LTE), or decommissioning.

The re-cast Renewable Energy Directive 2018/2001[1] (RED II) defines repowering as: ”renewing power plants that produce renewable energy, including the full or partial replacement of installations or operation systems and equipment for the purposes of replacing capacity or increasing the efficiency or capacity of the installation”. This is a very broad definition. For more clarity, a distinction should be made between repowering and LTE, as they relate to wind farms (WFs).

LTE involves upgrading or replacing necessary parts to enable WTGs to operate beyond their design life. Generally, for LTE projects, the layout of the WF remains the same. LTE allows the continued use of productive wind sites, can lower the levelised cost of energy (LCOE) and can increase return on investment. It is a lower risk, shorter-term alternative to repowering.

Repowering involves the complete decommissioning and replacement of old WTG equipment at a site, with existing infrastructure like roads and grid connection equipment being retained and reused where possible. New foundations are likely to be required and the layout and number of WTGs normally changes. The dismantling process for wind farms can typically take 6 – 12 months but new turbines can be erected as old ones are dismantled, in some cases. Repowering returns a WF back to the start of the life-cycle process[2] and can significantly increase installed capacity.

Ireland’s Climate Action Plan 2019[3] (CAP) has set a target of 70 per cent electricity from renewable energy sources (RES-E) by 2030. This target will be challenging as the CAP forecasts electricity demand will increase by 50 per cent above existing levels in the next decade. Much of this will be driven by large energy users such as data centres. The electrification of the transport and heating sectors will also drive demand. Repowering could be a key enabler to reaching these targets but it is not mentioned in the CAP.

The EU’s Clean Energy for all Europeans Package (CEP) prescribes provisions for repowering that must be transposed into law the by 30 June 2021. Ireland’s National Energy and Climate Plan (NECP) draft does not address these provisions, however.

[1] Re-Cast Renewable Energy Directive 2
[2] IWEA Life-Cycle of an Onshore Wind Farm
[3] Climate Action Plan

If not properly addressed, barriers may arise which could render repowering less attractive to operators. This may lead WF operators to turn to LTE, or to simply decommission, and miss out on the benefits of repowering. Every WF decommissioned that could have been repowered will represent a net loss of renewable energy capacity and make achieving the Government's 2030 targets more difficult.

This report will outline some of the reasons why repowering should be seriously considered and discuss some potential barriers that may prevent it. Measures that can be taken to support repowering will also be identified and the age of Ireland's onshore fleet will be examined.

2 The Benefits of Repowering

Repowering has many associated benefits. Some of these will be discussed below.

2.1 Continued and More Efficient Use of Operational Sites

Repowering allows operational sites with good wind resources to continue operating and contributing towards renewable energy targets.

Installing new WTGs can significantly increase installed capacity, given the scale of the increase in WTGs power ratings since older sites were energised. Figure 1 shows the increase in average WTG power rating in Ireland since 1992. Repowering projects in the UK and Europe have on average more than doubled capacity[4,5].

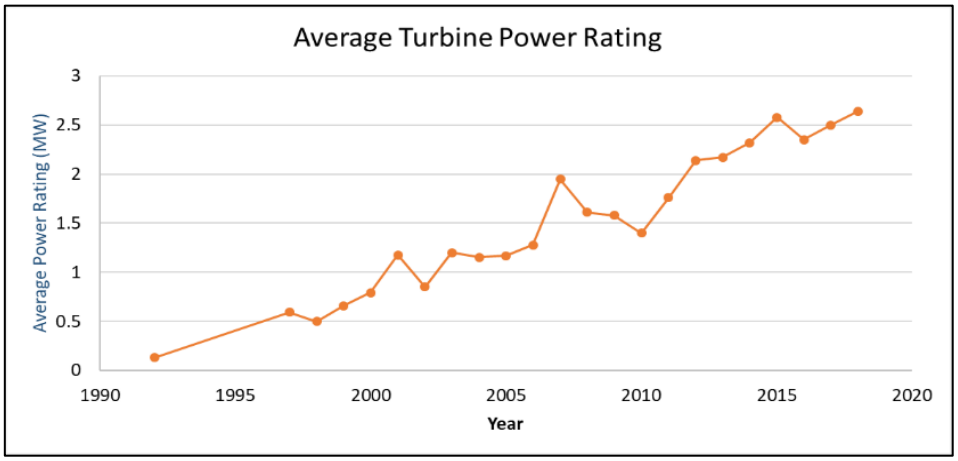

Figure 3 - Increase in Average Turbine Power Rating in Ireland (1992-2018)

Newer WTGs are also more efficient, can operate better at lower wind speeds, can aid site controllability and can provide improved ancillary services such as greater operating reserve provision.

[4] An assessment of end-of-life decision making for commercially managed onshore wind schemes
[5] WindEurope Wind Energy in Europe: Outlook to 2023

Combining modern technology with greater knowledge of site and wind characteristics, and improved forecasting technology, can significantly increase capacity factors and annual energy production.

2.2 Potentially Cheaper than New Builds

Repowering can allow the reuse of existing infrastructure at a site. Road and grid connection infrastructure should already be in place, although they may need upgrading. With a streamlined permitting process, as called for in RED II, the cost of permits should also be cheaper. This should, under the right circumstances, make repowering cheaper than building a new WF, under the right circumstances.

The costs of repowering projects in the UK to date have been comparable to new builds[6]. This shows the need to put an enabling framework in place and remove barriers, so that potential cost advantages can be fully capitalised on.

2.3 Fewer Turbines and Better Integration

In the UK, the average repowered wind farm has 40 per cent less turbines compared to the original project[7]. Across Europe the figure is one third[8]. A planned repowering project in Donegal will replace 25 WTGs with just 12, while increasing capacity from 15 MW to around 60 MW[9]. Removing WTGs can reduce visual and wildlife impacts[10]. Siting practice has also improved since older WFs were commissioned. One reason behind Denmark's support for repowering was to site the new WTGs in a more structured, integrated manner[11].

2.4 Lower Energy Costs and Prices

Combining modern technology with appropriate market and regulatory arrangements should reduce energy costs[12] and cause prices for consumers to fall, especially as auctions replace feed-in tariffs[13]. Modern technology should also lessen grid integration problems and provide a higher quality of power to the grid.

Repowering also enables a WF owner to avoid the necessity of making expensive repairs to ageing machines, high O&M costs, problems due to scarcity of parts for outdated turbines and reliability drops.

[6] RenewableUK Onshore Wind: The UK's Next Generation
[7] An assessment of end-of-life decision making for commercially managed onshore wind schemes
[8] WindEurope Wind Energy In Europe: Outlook to 2023
[9] An Bord Pleanála
[10] Policies and design elements for the repowering of wind farms
[11] Integration of Wind Energy in Power Systems
[12] WindEurope Repowering and Life Extension
[13] Unexpected Rapid Fall of Wind and Solar Energy Prices

2.5 Employment

Projects will also provide jobs. Estimates of employment in other countries from wind deployment vary from 0.50 jobs/MW[15] to 2.79 jobs/MW[16] and beyond. While it is hard to predict precisely, repowering is another avenue through which onshore wind can provide employment.

2.6 Potential to Avail of Financial Support

Most WFs built in Ireland initially received financial support from the Annual Energy Requirement (AER) scheme or via the Renewable Energy Feed-in-Tariff (REFiT). Both support schemes run for 15 years, therefore WFs receiving support in 2005, will no longer qualify in 2020. WFs commissioned earlier will already be outside their support period.

Assuming repowered WFs will be eligible to compete in Renewable Energy Support Scheme (RESS) auctions, as expected, they will be able to secure financial support. This will be revealed in the RESS detailed design. If repowered sites have lower LCOEs, as is expected, their inclusion in RESS should also drive more competitive auctions.

IWEA has raised the need for policy to provide a level playing-field for repowering in auctions[17]. This would ensure repowering projects can compete in auctions similar to new projects and are not excluded or subject to any strict pre-conditions.

Corporate power purchase agreements (CPPAs) are another avenue through which repowered WFs could receive support. CPPAs can provide price certainty for electricity producers which mitigates a lot of the risk involved in the project. The CAP aims to meet 15 per cent of electricity demand by renewable sources contracted under CPPAs by 2030[18].

2.7 Increasing Energy Security

Oil crises in 1973 and 1979 motivated many countries to deploy wind initially. Now, with a global push to decarbonise, an over-reliance on domestic or foreign fossil fuels could be problematic. A prime reason for Spain incentivising wind and repowering was to increase energy security. In 2017, Ireland's energy import dependency was 66 per cent[20]. Repowering can increase energy security and enhance the return/risk profile of aggregate power supply[21].

[15] Ex post analysis of economic impacts from wind power development in U.S. counties
[16] Direct employment in the wind energy sector: An EU study
[17] IWEA Response to DCCAE's 'Ireland's Draft NECP'
[18] Climate Action Plan
[20] Link to SEAI's Energy in Ireland 2018 Report
[21] Exploring the mean-variance portfolio optimization approach for planning wind repowering actions in Spain

2.8 Increased Public Support

While opposition to wind farm development is falling due to improved community engagement practices by industry and a greater awareness of the threat of climate change, there can still be challenges around community acceptance of new renewable energy infrastructure. With repowering, however, the local community will have already had a WF in operation for a number of years and will be familiar with the technology.

Repowering could also provide an opportunity for communities to benefit more from WFs in their area through new community benefit schemes and for local authorities to benefit from increased commercial rates contributions.

3 The Barriers to Repowering

Although it has many potential benefits, which have been outlined, repowering projects can still face many barriers. Some of the potential barriers to repowering are discussed below.

3.1 Lack of an Enabling Regulatory Framework

A lack of specific regulation to enable the development of repowering has been an issue across Europe. In the UK, in 2015 and 2016, when subsidies were removed and planning regulations were tightened, there was a large drop in applications for new WFs[23]. This was despite the fact that the cost of onshore wind was falling and was among the cheapest forms of new-build energy in the UK in 2019[24]. These changes also damaged the repowering market. Repowering in Spain and California also slowed following changes in regulation.

At present, Ireland has no specific regulatory framework to facilitate repowering. In its response to Ireland's draft NECP, IWEA has called for the inclusion of a strategy for repowering in Ireland's final NECP[26]. This strategy should include implementing the requirements of the Clean Energy Package and allowing repowering projects to compete in RESS auctions. The other recommendations from this report should also be considered.

3.2 Lack of a Clear Definition

Something as simple as the definition of repowering can cause issue. A recent legal dispute in England centred around the National Planning Policy Framework guidelines for English councils which require new WFs to be in areas identified as suitable in the development plan. Exceptions are included for

[23] Repowering the UK's oldest wind farms
[24] RenewableUK Onshore Wind: The UK's Next Generation
[26] IWEA Response to DCCAE's 'Ireland's Draft NECP'

repowering, but the term is not defined. The council defined it as rebuilding or replacing WTGs while the owner argued that it includes LTE, which the Planning Inspectorate agreed with. This demonstrates a lack of clarity and a need to define precisely what repowering is.

3.3 Planning Restrictions

Land and planning restrictions can inhibit repowering. Additional space is required as WTGs get taller. Most repowering projects will use fewer WTGs which should free up some additional space, but onerous setback distances based on tip height could also be a barrier for repowering sites. Due to stricter setback distances, environmental standards, permitting procedures and planning and approval processes, it is estimated that 40 per cent of sites in Germany will not be eligible for repowering[28].

IWEA recommends that Ireland's new Wind Energy Development Guidelines (WEGs) contain some exemptions for repowering. If not, projects otherwise suitable for repowering may be unviable. The WEGs must strike a balance between addressing the concerns of local communities and tackling climate change by facilitating the development of renewable energy[29].

Figure 2, below, shows all the special areas of conservation (SACs) and special protection areas (SPAs) in Ireland, designated Natura 2000 sites under the Habitats and Birds Directives. WFs are not excluded in these sites[30], but developments likely to affect them must undergo special assessment procedures and introduce necessary safeguards for species and habitats[31]. Safeguards can involve creating new habitat areas for species in the site[32]. Using IWEA data, it is estimated that more than 1 GW of capacity is located in or within 1 km of a Natura 2000 site. These projects will have to undergo stricter assessment to repower which could be a major deterrent.

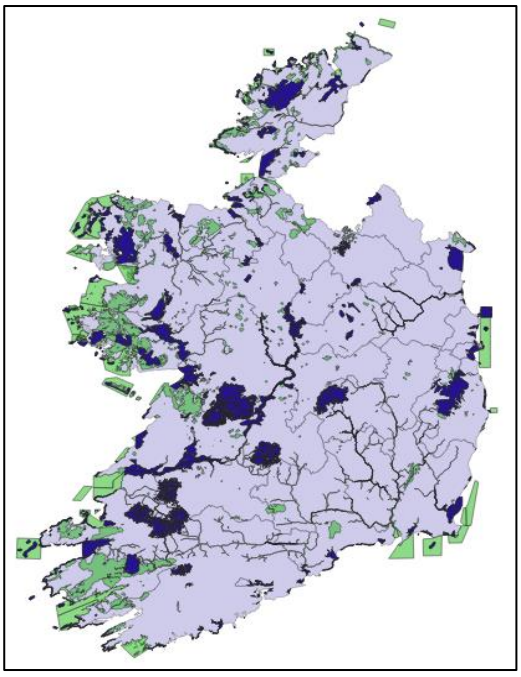

Figure 4 - Map of All Irish SACs (Green), SPAs (Blue)

[28] WindEurope - Wind energy in Europe: Outlook to 2022
[29] IWEA's High-Level Policy Requests March 2019
[30] Wind Energy Developments and Natura 2000
[31] Guidance document on wind energy developments and Natura 2000
[32] WindEurope on EU Natura Legislation

3.4 Lack of Available Grid Capacity

A lack of available grid capacity could be a major barrier that prevents repowering or limits increases in capacity. Sites with available grid capacity at the connection point will have a clear advantage. Smaller WFs connected to the distribution grid may also limit the capacity added in repowering to avoid having to get new connections to the transmission grid.

This is not just a potential problem for repowering. A lack of grid capacity could also hamper new builds. This could be a major issue as EirGrid estimates that at a forecasted median demand level, there is not adequate generation capacity to meet demand for Ireland from 2026, once Moneypoint closes. Should any other plant close this could give rise to earlier deficits[33].

This indicates a clear need for action from EirGrid to avoid a lack of grid capacity preventing both repowering and new projects. IWEA has stated that EirGrid must have the mandate and resources to expand the transmission system at a national level and to build on the DS3 Programme[34].

3.5 High CAPEX and Lack of Support

Given the high levels of investment needed, repowering has a high level of associated risk. If extensive upgrades to existing assets are needed, this risk is increased. This could tempt WF owners to continue producing electricity with their existing capital, avoiding investment and cuts in production during the decommissioning and repowering process. Repowering should still be less risky than a greenfield investment, given site and wind knowledge and the potentially lower investment required.

As FiTs are replaced by auctions across Europe and in Ireland, financial support for wind energy will fall. After the first wind power auction in Germany in 2017 the cost of supporting wind energy fell from up to €90/MWh to less than €50/MWh[35]. This is a positive for the State and for the consumer, but if the financial supports fall faster than costs, some projects may become harder to complete.

It is crucial that policy provides a level playing-field in RESS auctions for repowering WFs. IWEA has already raised this issue[36]. If economic incentive is lacking, owners will not repower. This was shown in California where a great deal of repowering took prior to changes in the federal production tax credit introduced in 1999 which dramatically slowed repowering rates[37].

[33] EirGrid All-Island Generation Capacity Statement 2019-2028
[34] IWEA's High-Level Policy Requests March 2019
[35] Unexpected Rapid Fall of Wind and Solar Energy Prices
[36] IWEA Response to DCCAE's 'Ireland's Draft NECP'
[37] Wind Power Project Repowering: Financial Feasibility, Decision Drivers, and Supply Chain Effects

3.6 IWEA Survey

As part of the work for this report, a repowering survey was sent out to the IWEA membership to reveal any areas of interest and levels of experience among members. The survey identified that there is still little experience with repowering here, as would be expected.

The survey also contained questions on potential barriers to repowering. Planning, grid and route to market were identified as the main areas of concern for repowering in Ireland. On the planning side, apart from those issues mentioned above it was thought that finding new WTGs to fit existing land envelopes and not defy planning restrictions could restrict the repowering of certain sites.

In relation to grid, concerns were raised that an overcomplicated grid process and delayed grid infrastructure upgrades could slow repowering. There was also uncertainty over how connection charges would be applied and whether or not repowered WFs would retain firm access.

The importance of allowing repowering projects to compete for support in RESS auctions was also raised.

4 Repowering Supports

As highlighted, many potential barriers to repowering exist. These can be mitigated with the right policy framework. This section will look at some provisions that have been made for repowering in Europe.

4.1 EU Position

The RED II was released under the CEP, in 2018. It calls for simplified and less burdensome authorisation procedures for renewable energy projects and the establishment of one designated authority for the permit-granting process. The directive also calls for Member States to facilitate repowering by ensuring a simplified permit-granting process, not exceeding one year, with allowances for a year-long extension in 'extraordinary' circumstances. These provisions must be transposed into national law by 30 June 2021.

This timeline would be a vast improvement as the planning and permitting phase of a WF can typically take 4-8 years at present[39]. This is mainly due to the timeframes required to go through the planning process and time lost between submitting a grid connection application, receiving a grid connection offer and receiving consent for the grid connection.

[39] IWEA Life-Cycle of an Onshore Wind Farm

The Governance Regulation[40], also under the CEP, obliges Member States to estimate the renewable energy trajectories by which they expect to reach overall renewable energy targets up to 2030, separated as new and repowered capacity.

Member States must publish NECPs in accordance with the CEP. Ireland has not addressed repowering in its NECP draft[41]. In its response to the draft[42], IWEA has called for the inclusion of a strategy for repowering. The response also raises the importance of repowering as a cost-effective option that can avoid some of the sunk costs of a new project.

In its draft NECP, Italy has identified a need to promote repowering to use more efficient technology, to exploit excellent wind conditions and to limit soil consumption[43]. It also calls for a simplified permitting process, particularly for environmental permits, where the variation in the impact relative to the existing situation can be measured, rather than starting a fresh assessment.

4.2 Provisions for Repowering in Other Jurisdictions

Denmark, Germany and Spain have used FiTs and repowering certificates to support repowering in the past. There are unlikely to be used here as Ireland moves to RESS auctions for renewables support.

In Spain – in addition to a repowering FiT – where WF capacity was increasing by less than 40 per cent, developers did not have to apply for a new grid connection. At a regional level, governments gave priority to repowering sites over greenfield sites when granting permissions[44].

Scottish Planning Policy[45], 2014, states that WF sites should be suitable for use in perpetuity and that the current use of a site as a WF should be a material consideration for repowering proposals.

Scotland's Onshore Wind Policy Statement[46], 2017, indicates the Government's support for repowering as a cost-effective way to reach decarbonisation targets. The publication proposes to assess repowering applications on a case-by-case basis and decide the appropriate level of environmental assessment and monitoring required. It also states plans for the Scottish Government to liaise with Scottish Natural Heritage to develop guidance on repowering applications.

[40] EU Governance Regulation
[41] Ireland NECP Draft
[42] IWEA Response to DCCAE's 'Ireland's Draft NECP'
[43] Italy Draft NECP
[44] Policies and design elements for the repowering of wind farms
[45] Scottish Planning Policy
[46] Onshore wind: policy statement

In England, the National Planning Policy Framework[47], 2018, states that repowered WTGs should not be subject to the same planning constraints as new onshore WFs.

In 2018, the Danish Government signed an energy agreement planning to reduce the number of onshore WTGs from 4,300 to 1,850 by 2030[48], as it focuses on offshore. At the same time, Denmark aims to have at least 100 per cent RES-E by 2030. IWEA will be monitoring these developments and investigating if supports will be put in place to encourage repowering.

In 2019, Italy signed a Ministerial Decree granting new incentives for renewable energy sources. It indicates that auctions will be held specifically for 'refurbished' wind, hydro or sewage treatment gas plants. A budget of 620 MW is set for refurbished plants. To qualify, plants must have reached at least 2/3 of their life-cycle and not be benefiting from State incentives. Successful projects will receive support in the form of a premium on top of the market price[49].

Policy should remove unnecessary administration barriers, such as having to apply for all new planning and grid permits and give asset owners flexibility to make decisions based on project-specific characteristics. Member states should define a suitable national regulatory framework, in cooperation with industry.

5 When to Repower

Deciding when to repower is highly linked to the age of the installations. Generally, older WFs can gain the most from repowering. The second-hand value of WTGs also falls with time. Other factors need to be considered, however. WTG condition, expected technological evolution, current and future access to finance, relevant support schemes and site-specific considerations are all important factors when deciding whether to repower or not. Before any project is undertaken, its economic feasibility must be ensured.

Figure 3 shows that the average age of decommissioning for repowering projects in Europe has ranged from nine years to 27. On average German WFs repower after 16 years while Spanish WFs do so after 22. This shows that there is no optimal age for repowering that can be applied in all case. Decisions are project specific.

[47] National Planning Policy Framework
[48] Danish Energy Agreement
[49] FER1 Decree 2019: Incentives Regime for Renewable Energy Plants

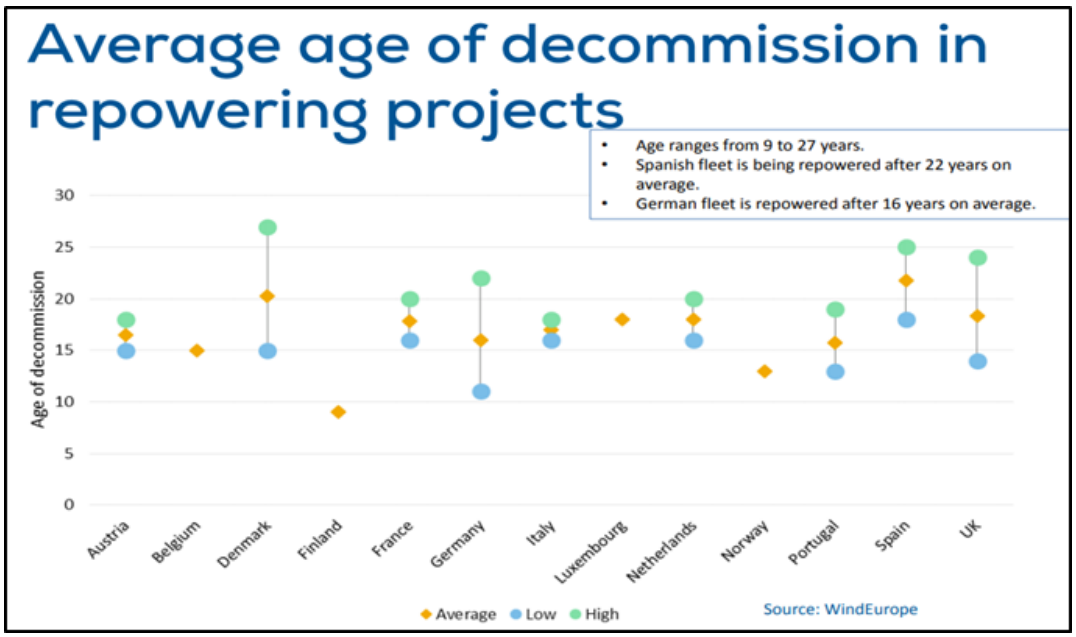

Figure 5 - Average Age of Decommission in European Repowering Projects

6 Potential Repowering Volumes in Ireland

The SEAI's Wind Energy Roadmap for 2011-2050[55], states that repowering will be key to sustaining the Irish wind industry while warning that preparation is needed for this. The roadmap predicts repowering could contribute over 15 GW to Irish capacity up to 2050, with volumes growing steadily from 2030.

Apart from this research, there does not seem to be any official studies looking into potential repowering volumes in Ireland. The following section uses IWEA data to give an indication of what volume of repowering can be expected over the next decade, and beyond.

6.1 IWEA Data

6.1.1 Pipeline Survey

IWEA carries out pipeline surveys of Ireland's future onshore and offshore wind generation development every six months. The most recently completed survey in September 2019 has found that projects with an existing capacity of at least 285 MW are currently planning to repower in the coming decade, with 140 MW of this planned to repower up to 2022. This 285 MW is planned to increase to 470 MW, representing a 65 per cent total increase in capacity from repowered projects planned for Ireland.

[55] SEAI Wind Energy Roadmap 2011-2050

6.1.2 Wind Farm Data

This section will look at Ireland's onshore wind capacity, using data from IWEA, and assess its age profile and repowering potential up to 2030. The data used consists of 3,675 MW of onshore installed capacity.

Figure 4 displays the age profile of Ireland's onshore capacity up to 2030. In 2020, Ireland's wind fleet will be relatively young, with 34 per cent (1,239 MW) less than 5 years old and 62 per cent (2,279 MW) under 10. As early as 2025, the outlook changes, as 38 per cent (1,396 MW) of today's capacity will be aged 15 or older.

By 2030, 66 per cent (2,436 MW) will be 15 years old or over and 38 per cent (1,396 MW) will be 20 years or older. These age profiles are mapped out using the same colour code as Figure 4 in Figure 5, Figure 6 and Figure 7. This is a high-level assessment and does not account for capacity that will be installed or decommissioned from 2020 on, but it highlights how much of today's fleet will begin reaching the latter stages of life before 2030. This would suggest repowering will have an important impact on Ireland's wind capacity and RES-E generation targets for 2030.

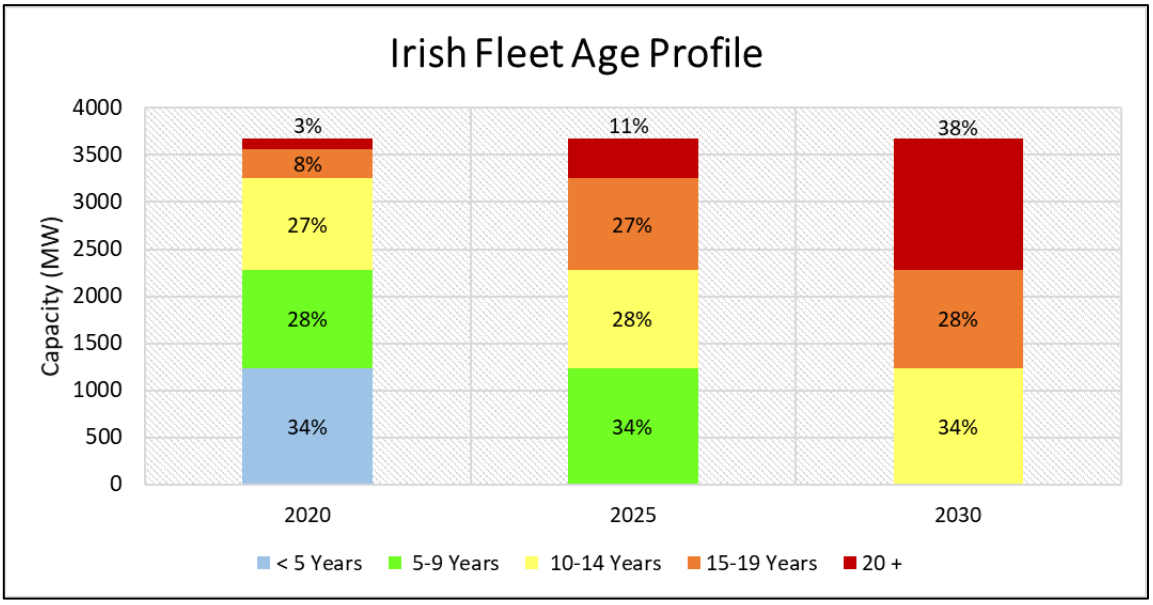

Figure 4 - Age Profile of Ireland's Onshore Wind Fleet as of 2020, 2025 & 2030

Figure 5, below, shows that the majority of older WFs today are on the western side of the country. This suggests most early repowering projects could take place there, in counties like Donegal, Leitrim, Mayo, Kerry and Cork. Looking forward to 2025 and 2030, in Figure 6 and Figure 7, the older WFs are more widely dispersed, so repowering projects should take place nationwide.

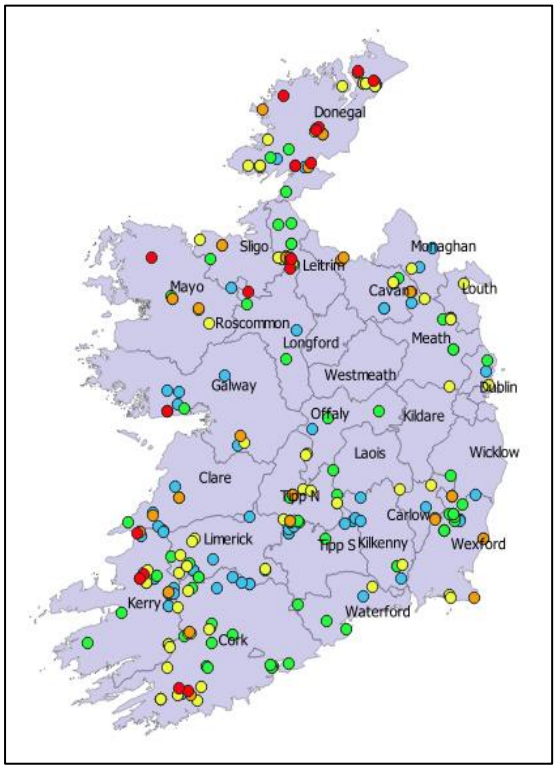

Figure 5 - Map Showing the Age Profile of Today's Wind Fleet in 2020

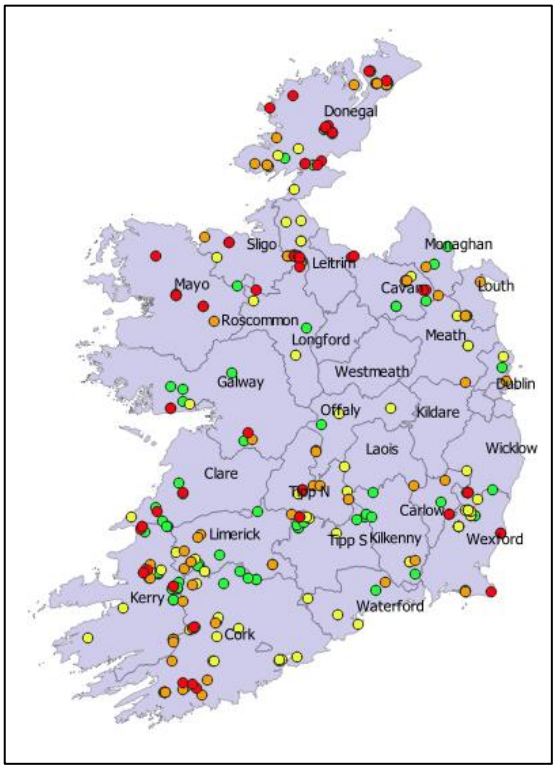

Figure 6 - Map Showing the Age Profile of Today's Wind Fleet in 2025

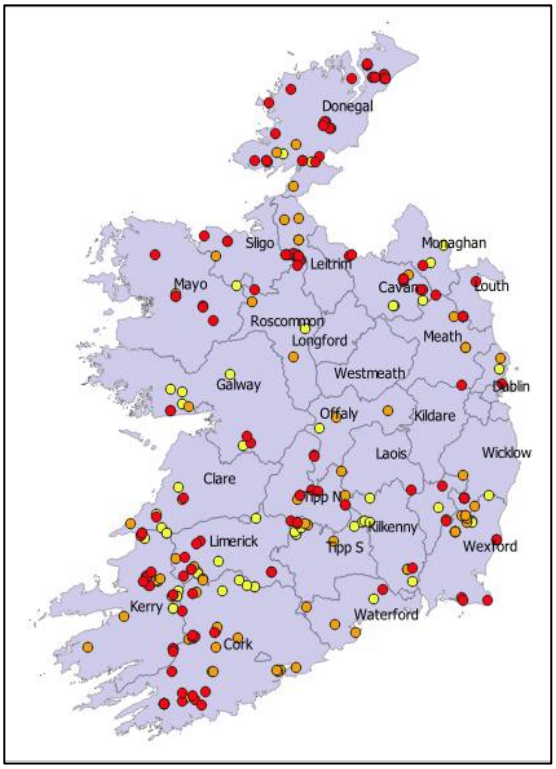

Figure 7 - Map Showing the Age Profile of Today's Wind Fleet in 2030

Legend

- WF aged < 5 Years
- WF aged 5-9 Years
- WF aged 10-14 Years
- WF aged 15-19 Years
- WF aged ≥ 20 Years

Examining Table 1, below, gives further indication of potential volumes to be repowered in the future, and where these projects might be located.

Assuming a repowering age of 20 years, 11 per cent of today's fleet (422 MW) could be expected to consider repowering in 2025. By 2030, this rises to 37 per cent (1396 MW). While it is not realistic to assume all of this capacity will repower, it is also likely that WFs aged 15-19 will also repower. Future repowering developments will be highly dependent on the regulatory framework that is put in place, and how the barriers discussed are addressed.

Table 1 - County-by-county breakdown of Capacity Aged 15 plus in 2020, 2025 & 2030

Year	2020			2025			2030		
Age	15-19	20-24	25+	15-19	20-24	25+	15-19	20-24	25+
	(MW)			(MW)			(MW)		
Galway	8	3	0	60	8	3	41	60	11
Mayo	22	0	6	13	22	6	41	13	29
Sligo	25	0	0	25	25	0	0	25	25
Roscommon	8	11	0	22	8	11	14	22	19
Leitrim	14	6	0	26	14	6	23	26	20
Tipperary	3	0	0	48	3	0	222	48	3
Kerry	14	21	0	192	14	21	102	192	35
Cork	15	11	0	197	15	11	203	197	26
Clare	32	0	0	0	32	0	17	0	32
Waterford	0	0	0	2	0	0	57	2	0
Limerick	0	0	0	105	0	0	77	105	0
Donegal	82	58	0	114	82	58	42	114	140
Cavan	32	0	0	83	32	0	0	83	32
Monaghan	0	0	0	8	0	0	0	8	0
Dublin	0	0	0	0	0	0	1	0	0
Wexford	43	0	0	38	43	0	93	38	43
Carlow	5	0	0	0	5	0	0	0	5
Wicklow	3	0	0	13	3	0	4	13	3
Meath	0	0	0	0	0	0	1	0	0
Louth	0	0	0	4	0	0	0	4	0
Laois	0	0	0	21	0	0	0	21	0
Kilkenny	0	0	0	4	0	0	14	4	0
Offaly	0	0	0	0	0	0	88	0	0
Total (MW)	307	109	6	974	307	115	1040	974	422
% Capacity	8%	3%	0%	26%	8%	3%	28%	26%	11%

All this suggests that repowering will become more prevalent from 2025 on. As mentioned, this is a high-level assessment, and site-specific considerations are important. The fact that projects with an existing capacity of at least 285 MW are currently planning to repower in the coming decade even though there are only 115 MW currently aged 20 or over shows that projects need to be considered well in advance.

7 Recommendations

To support repowering in the future, action needs to be taken now. This section includes recommendations on measure that should be taken now to help repowering develop in the future.

Government should first look to clearly define repowering, to avoid disputes like the one discussed in section 3.2, where there was confusion over what was classed as repowering and what was lifetime extension. This should be a more precise definition than the one in the Renewable Energy Directive. A potential WF repowering definition is given below;

'renewing wind farms by the complete decommissioning and replacement of wind turbine generator equipment at a site for the purposes of replacing or increasing capacity and/or increasing the efficiency of the installation. Existing site infrastructure like grid connection equipment may be retained and reused where possible.'

Government should also look to implement the requirements of the Clean Energy Package. The Renewable Energy Directive calls for:

- Simplified and less burdensome authorisation procedures for renewable energy projects;
- The establishment of one designated authority for the permit-granting process;
- A simplified permit-granting process for repowering, not exceeding one year, with allowances for a year-long extension in 'extraordinary' circumstances.

Additionally, in accordance with the Governance Regulation, also under the Clean Energy Package, Government should estimate the trajectories by which they expect to reach renewable energy targets up to 2030, separated as new and repowered capacity. It is recommended that when this repowered capacity is being calculated, a target volume for 2030 is set by Government. This would ensure repowering is on the agenda and give a clearer sense of potential repowering volumes up to 2030.

It should also be ensured that repowering projects can compete in RESS auctions on a level-playing field with new builds and are not excluded or subject to any strict pre-conditions. In the future, when there is more demand, repowering specific auctions could be considered, similar to in Italy.

In relation to grid, a lack of capacity must not prevent or limit projects. Given the timelines needed to deliver transmission infrastructure, a more proactive approach to transmission network upgrades is needed. This would benefit new projects as well as repowering ones. Clarity will also be needed over how connection charges will be applied and whether or not repowered WFs will retain firm access.

As discussed in Scotland and Italy, repowering applications should be assessed on a case-by-case basis to decide the appropriate level of environmental assessment and monitoring required. The variation

in the impact relative to the existing situation should be measured, rather than starting a fresh assessment.

This is not an exhaustive list of recommendations, but these measures should mitigate some of the major barriers to repowering. All the measures discussed in section 4 should be considered.

8 Conclusion

Ireland has not yet had to deal with large numbers of WFs nearing the end of their design lives, but will have to do so in the near future. To reach its 70 per cent renewable electricity target by 2030, Ireland cannot afford to needlessly lose capacity through avoidable decommissioning or have a large percentage of the fleet operating inefficiently because of a lack of Government policy to support repowering. Repowering can be a key enabler for Ireland reaching its 2030 targets by increasing our renewable energy production, and it has a host of associated benefits.

Many barriers to repowering exist, however. These include; a lack of an enabling regulatory framework, the presence of Natura 2000 sites, planning restrictions and a lack of available grid capacity. To ensure repowering and its associated benefits can be fully captured, these potential barriers need to be addressed.

With the Clean Energy Package, the EU has highlighted the need for countries to make provisions for repowering. Ireland should take heed of this and take a proactive approach to repowering, which could contribute significantly to 2030 targets and set an example within Europe. Measures that could be taken to encourage repowering include:

- defining and addressing repowering in our National Energy and Climate Plan;
- providing a level playing-field for repowering farms in RESS auctions;
- upgrading grid capacity;
- ensuring repowering projects don't have the same planning constraints as new builds;
- reducing the need for new grid connection permissions;
- speeding up the permitting and authorisation process;
- establishing one designated authority for the permit-granting process.

Implementing some or all of these measures would place Ireland in an ideal position to facilitate the repowering of a generation of Irish wind farms, delivering clean, cheap energy to electricity consumers across the island.