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IS THERE AN AFTERLIFE FOR WIND INSTALLATIONS IN ITALY: LESSONS LEARNT

Short Version

Dr Carla De Laurentis & Dr Rebecca Windemer

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About the Authors

Dr Carla De Laurentis is a Senior Lecturer in Environmental Management at the University of West of England with a background in economic development, innovation and the role of policy in promoting local and regional development. Since 2007, she has developed a research interest in the mechanisms that lead to an effective diffusion of renewable energy and investigated some of the challenges that electricity infrastructure networks are facing to incorporate the increasing number of renewables. She is currently leading two research projects that are looking at understanding the factors that influence decision making in managing the end-of life of wind infrastructure and the waste management options for wind turbines. Carla is a Fellow of the Higher Education Academy. She teaches on a range of sustainability and energy transition modules at both undergraduate and postgraduate levels.

Dr Rebecca Windemer, formerly a Senior Lecturer in Environmental Planning at the University of West of England, is Planning and Community Lead at Regen (a not-for-profit centre of renewable energy expertise). Rebecca's research has focused on how we should make decisions regarding our ageing onshore renewable energy infrastructure, particularly looking at the repowering of onshore wind farms in the UK. She has also researched the impact of national policy change for developing new onshore wind farms in England. Her research findings have been used by policymakers, industry and communities. Rebecca is a member of the Bristol Advisory Committee on Climate Change, and is a member of the South West Royal Town Planning Institute Regional Activities Committee.

ABSTRACT

Ageing onshore wind infrastructures are an emerging environmental sustainability issue globally and have international significance in relation to the solutions for existing infrastructure in the UK and beyond. Europe has approximately 34,000 onshore turbines coming to the end of their lifespan; Italy is among the pioneering European countries in wind power which results in a high proportion of ageing onshore wind capacity.

This report presents the results of an-depth analysis of secondary documents and expert interviews conducted in Italy, discussing how end-of-life decisions for onshore wind farms are being made and what influences them. The report identifies a number of technical, economic and regulatory factors which are influencing end of life decision making.

The research is relevant as it shows that the timing of end-of-life decisions and the consequent decisions regarding the future of existing turbine materials, and waste management opportunities, involves technical as well as analytical, financial and political questions.

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PROJECT OVERVIEW

The challenge of what to do with an ageing onshore renewable energy infrastructure is particularly acute in Italy, an early leader in wind farm development. At the end of 2000, Italy was among the five countries with the biggest installed windfarm capacity. The Italian Association of Wind Energy (ANEV) estimates that approximately 1.5GW of capacity could be decommissioned by 2025, a figure that is expected to be five times higher by 2032.

This project investigated the question of what to do with ageing onshore wind infrastructure. This has waste management and economic implications as well as impacting decarbonisation goals. What is particularly pressing for industry and policy makers alike is not only to identify the scale of the potential environmental problem but also to understand when a turbine has reached the end of its productive lifetime and to consider the moments in the life of a wind turbine (WT) in which this waste stream will materialise. Drawing on pioneering research in Italy, the findings of this project provide a rounded understanding of EoL decision making and emerging solutions for ageing wind infrastructure.

This project identifies how end-of-life decisions for onshore wind farms in Italy are being made and what influences them. The research highlights a number of key technical, economic and regulatory factors that influence EoL decision making. This is valuable as it suggests there is a need to distinguish between the end of technical life and the operational and economic life of wind turbines – it is the latter that can also influence the waste stream.

METHODS

In order to explore the EoL of Italian wind farms, we firstly conducted a review of academic and industry literature. This literature review provided an overview of the different EoL options and challenges for onshore wind farms. Energy transition policies and the legislative/regulatory regime play an important role in influencing decision-making for EoL management of wind infrastructure, we therefore reviewed national level policies in Italy for onshore wind development, particularly on ‘repowering’ (including revamping’), ‘life-extension’, and ‘decommissioning’. Italian policies on the circular economy, particularly around composite materials and onshore WTs, were also reviewed.

Interviews were then conducted with 15 expert stakeholders involved in EoL decision-making. These included wind farm owners, developers and operators of Italian wind farms as well as relevant policymakers, consultants, and industry organisations. The interviews were semi-structured, seeking to understand interviewee perspectives on the regulation of the EoL of wind farms and waste management for turbine materials. The interview guide was designed around thematic blocks (background information, EoL wind energy projects, decommissioning considerations and waste management and circular economy for wind energy).

KEY FINDINGS

There are a number of lessons from the research. We summarise these here. A full report is also available here: Is there an afterlife for wind installations in Italy? - Projects | UWE Bristol.

1. Factors influencing EoL decision making

The research revealed a range of factors influencing when EoL decisions are taken. These factors have been grouped under the following categories (see table 1 for a summary):

- technical and design life
- economic and business models
- legislative and regulatory (including planning)
- business environment.

Technical and design life: The design life of a WT- along with its components – can undoubtedly impact when EoL decisions are taken. The standard design lifetime of a WT is at least 20 years according to the International Electrotechnical Commission (IEC) standard (IEC, 2005). Nevertheless, this can be extended to 35 years with a good level of ongoing maintenance, and with renovation and repair. A total of 1625 MW of onshore wind has been installed in Italy between 1991-2005, corresponding to 133 plants and 2083 turbines, which are considered reaching their end of technical design life.

The standard design life of these plants, however, is not the only technical factor affecting EoL decisions. The timescale under which WTs approach the end of their operational lifetime is not uniform. Real data on site performance will determine the 'age' of the turbine. Performance and age will depend on the wind conditions in the specific sites that can affect the performance of turbine components. Parts will wear out more quickly in sites with stronger wind speeds and at times WTs can become damaged during the operation life.

Ongoing maintenance can impact the 'age' / lifespan of components and high-quality maintenance is key for extending the life of the site. Maintenance could be provided by turbine manufactures upon agreement or via dedicated maintenance teams. Maintenance plans including parts replacement are often supported by detailed site assessment and monitoring. Replacements to WT components have to be on a like-for-like basis, as the wind farm planning authorisation will permit the generation of a certain amount of power. To actually change the type of components would require new permission.

A challenge to such replacement is the availability of replacement parts, particularly for older turbines, therefore affecting life-extension opportunities. In terms of waste management, some operators are stockpiling older turbines on site to guarantee a supply of spare parts to prolong WT's life.

The certification / guarantee on the equipment can also influence the timing of EoL decisions. For example, many older WT components in Italy have a 20-year guarantee, requiring parts to be replaced after this point. A strategic approach used from some developers is to seek the extension of the service life of the asset and de-risk life-time extension by working with suppliers to guarantee life certificate extensions and re-certify the assets. Where this cannot be provided by suppliers, some organisations work with professional bodies that provide lifetime extension certification and related verification and inspection tasks. Yet, maintenance can be costly, suggesting many economic factors can also affect EoL management and decision making.

Table 1: Factors influencing EoL decision making options- a summary

Factors	Examples
Technical	- Design life of the WT components (including the guarantee on components); - Damage to parts may create need for EoL decisions to be taken early; - Parts will wear out more quickly in sites with stronger wind speeds; - Good levels of maintenance may enable turbine components to last longer; - Calculations and assessment regarding life-extension and repowering; - Wind availability
Economic	- Financial incentives that make an EoL option more viable; - Duration of original business model for the wind farm; - Sale of wind farm to a new owner; - Data and best practices availability; - Change in subsidies and decreases in output due to turbine age;
Legislative/ regulatory	- Policies for wind energy / wider energy or climate change targets; - Policies for circular economy; - Country waste management legislation and introduction of landfill band; - Changes in national land designations; - Support for EoL markets (e.g. incentive for repowering projects);
Environmental planning	- Planning / operational licences may require turbine removal at a certain time; - Land use agreement and ability to re-negotiate; - Availability/ scarcity of sites for reaching energy targets; - Opposition to repowering or life-extension may impact the decision that is taken;
Business environment	- Industry collaboration; - Wind operators driving action; - Industry push for best-practice.

Economic and business models: Specific factors under this category includes, operation costs, electricity markets, subsidies, incentive schemes and power purchase agreements. Lifetime decisions will differ depending on the economic evaluation of the sites and their performance. These economic evaluations are in turn influenced not only by the site wind conditions but also by the business model associated with the original wind farm's business case. operators point

Italian wind farm to the discrepancy whereby some original business models are designed for 15 years, even though turbines may last for up to 30 years.

Key, in the decision-making process, is the real-time information on wind and the experience and data availability at existing sites. Decisions, therefore, can be affected by how well the site is performing and whether the increase in energy production (e.g. from repowering) is sufficient for the economic sustainability of the investments.

Critically, EoL decision making may be different when financial incentives affect existing sites. The strike price that the wind farm operators have secured through auctions and power purchase agreements will also have a similar impact on the economic and financial sustainability of EoL options. The possibility for repowering projects in Italy to participate in auctions represents another opportunity for the economic and financial sustainability of sites. Furthermore, the decisions around EoL will also be influenced by waste management options and the cost of waste collection and landfill policies related to the discarded blade/s.

Importantly, the wind industry has suffered from a number of economic challenges, including inflation in commodity prices and other input costs that have given raise to the price of WTs, affecting the viability of some planned EoL options. Additionally, the recent increase in wholesale electricity prices compensated for increased operational costs of old wind turbines, affecting the rate of decommissioning projects underway.

Legislative and regulatory (including planning): The end of financial support mechanisms makes EoL options for existing wind farms very pertinent. Changes in government policy and financial support might lead to EoL decisions being taken earlier than the standard life of a site. Re-powering and life-extensions can be explicitly supported from governments. In Italy, for instance, the National Energy and Climate Plan states that repowering existing wind farms offers a key opportunity to increase power capacity and contribute towards achieving 2030 targets.

Permitting / operational licences and land use agreements are also important for EoL. In some instances, in Italy, operating licences have been issued for 20 years. In these cases, if there are no terms for an extension of the licence, then decommissioning might be the only option. Additionally, depending on the type of rights the wind farm operators have on the land on which they operate. The end of land use contracts and whether they can be extended will impact on EoL decision-making processes

Changes in these authorisations (permitting regulations for modifications, simplification of authorisations and permitting timing) have started to positively influence repowering of some sites. Introduced in early 2023, it is the changes in the environmental impact analysis, to be undertaken on a differential basis from existing plants, that are expected to contribute to an increase in repowering projects. This however suggests that the EoL decisions will also be affected by the current authorisation granted to the site and the current or revised land designation since early developments in wind energy.

Business environment: Central to progress on the EoL and material recovery for onshore wind in Italy has been the role of industry and industry associations in driving the EoL agenda's forward. The wind sector in Italy has been collaborating on providing potential responses to the challenge of WT waste materials – in particular the question of what to do with the blades that currently cannot be recycled.

Those representing the sector include Elettricità Futura, the main renewable energy association, ANEV, the wind energy association, and Assocompositi, the industry association for composite material. These organisations have published a position paper (ANEV et al., 2021) to discuss and ensure the sustainable and circular management of EoL WTs. The position paper resulted from a working group in which over forty companies in the sector participated. This was coordinated by leading companies in the Italian and global markets – Enel, ERG, Vestas and Enercon – as pioneers in the adoption of EoL strategies. This supported collaborative learning and sharing of best practice.

One key take away is the recognition that re-use and repurposing are unlikely to be large scale solutions given the expected volumes of wind farms that will reach EoL. There is also a recognition that blade waste is an increasing problem e.g. in 5-7 years there could be a significant amount of waste fiberglass.

While industry efforts have successfully influenced policy change for repowering (e.g. simplification of authorisation and shortening the time allocated for a decision on planning applications and permits), industry actors have highlighted that there is a key gap in national level policy / activities in Italy regarding waste treatment. This relates in particular to fiberglass. Industry actors and associations have identified a need to understand the costs and

opportunities for this material. Nevertheless, the opportunity to address a legislative vacuum on wind farm waste through pushing for a policy decision are yet to be captured.

2. Relevance and impact of the work conducted

In summary, the above discussion represents examples of the factors that are influencing decision making around EoL. These factors are also affecting options and opportunities around what can be done about these emerging waste issues. While discussing the important and emerging issues of managing EoL for wind infrastructure, the research has revealed that identifying EoL instances and the consequent waste issues is not straight forward as it will not always occur at the end of a wind farms projected life.

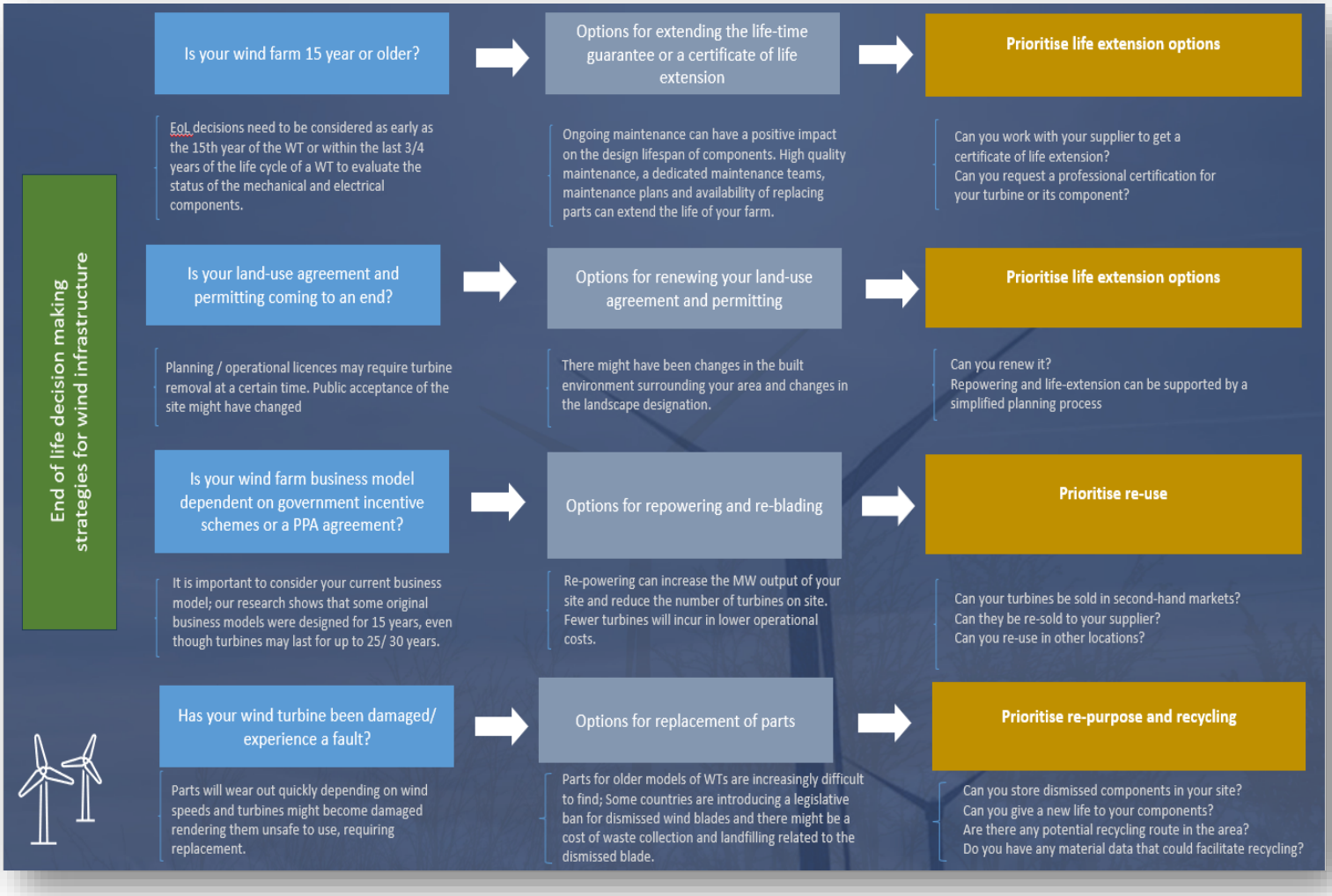
The research highlights the importance of distinguishing between the end of standard life and the end of operational life of a wind farm and how much EoL decisions relate to business models and associated economic factors. Expiring incentives, electricity markets, wholesale electricity prices and the cost of EoL management will influence the EoL decisions at times accelerating decisions on life extension and/or repowering.

There is value in identifying the key technical, economic and regulatory of EoL and these factors raise questions that must be asked before deciding on the most appropriate EoL options. These questions are represented in Figure 1, which summarises the results, highlighting the decision-making process supporting EoL options and the linkages between these EoL decisions and waste management options.

There are a number of lessons from the research. Wind infrastructure EoL represents both an opportunity and a challenge for industry and government departments. Wind industry operators are keen to showcase the environmental credentials of the technology. While Government departments are interested in regulating the way in which long-term EoL impacts are governed.

The Italian case study shows that policy considerations for EoL issues for onshore wind resides in the opportunities life-extension and repowering offer to reach decarbonisation of the energy sector targets. In particular, managing EoL of renewable energy projects represents many cross-sectoral challenges, that require the sharing of best practices and active engagement from the main players from the renewable energy sector and beyond (including building and construction, electrical and electronics, waste).

Figure 1: End of life decision making strategies for wind infrastructure: a summary



Industry and governments alike need to focus more on the management and decommissioning challenges that European and international contexts face. Identifying EoL decision making and assessing consequent waste issues is not straightforward.

The research has shown that when considering waste there are a number of key technical, economic and regulatory questions that must be asked before deciding on the most appropriate EoL option. The findings of this research provide valuable insights and lessons to be learned for countries around the world seeking to address this emerging environmental sustainability issue, as the industry matures. EoL management for onshore wind is a relatively new concern and there are many lessons yet to be learned.

APPENDIX 1

1. Visual Summary of the research: factors influencing end of life

2. Visual Summary of the research: Afterlife options for wind installations