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IEA Wind TCP Task 45

Deliverable 4.1
**Preliminary summary of
policies, legislation,
guidelines and initiatives
that address the end-of-
life of wind turbine
blades**



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Preliminary summary of policies, legislation, guidelines and initiatives that address the end-of-life of wind turbine blades



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WIND TURBINE BLADES AT END-OF-LIFE

A preliminary summary of policies, legislation, guidelines, and initiatives that address reuse, recycling, repurposing, and disposal

IEA Wind Task 45 – Work Package 4.1

December 2022

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EXECUTIVE SUMMARY

This document represents the ‘6-month preliminary report’ deliverable from the Work Package 4 working group. The purpose of this report is to review and summarize *existing* legislation, standards, and certification schemes related to recycling glass fiber composites. Readers should consider this report a current ‘snapshot in time’ of legislation, policies, rules, and standards – to the extent they exist – in various countries around the world. This preliminary report is intended to help inform members in other Work Package groups about the state of the policy and regulatory landscape related to blade recycling. The information assembled herein does not reflect an exhaustive review of legislation and policies in every country but reflects the conditions in select major wind energy markets. The WP4 working group acknowledges the lack of content from Asia Pacific, Africa, and Indian subcontinent countries, with hope for expanded participation from industry members in these regions.

In the process of performing this task, the working group identified a wide range of legislation, policy, regulations, standards, industry initiatives, company goals, and procurement tenders that sought to influence and increase recycling efforts while also adding restrictions on landfill disposal. Due to the wide variability of the information, we elected to broadly organize the findings in the following groups:

- “Hard Law” Measures – Correspond to enforceable laws or regulations where civil or criminal legal actions could result from lack of compliance. Technical design standards are included here given their role for ensuring safety and reliability is achieved in wind turbine designs and standards are ‘enforced’ via the certification process.
- “Soft Law” Measures – Corresponds to publicly announced, non-binding initiatives from turbine manufacturers, project owners, industry organizations, governments, and/or environmental organizations. This category also includes guidelines and recommended practices.
- Tender Requirements – Increasingly, tenders for procuring electrical power, are including provisions that attempt to address end-of-life actions when the wind power project(s) needs to be decommissioned. Tender requirements are an interesting area where recycling, reuse, and/or landfill ban requirements can be established relatively easily as contractual obligations that must be met during decommissioning.

Four observations may be made in respect of the findings of this preliminary study.

1. Landfilling and incineration remain the most common disposal practices for turbine blades in many countries, including most Member States within the EU and across North America. Few jurisdictions have a legal regime in place that is dedicated specifically to decommissioned turbine blades. Within the European Union, for instance, as a general observation, there is, at present, limited legislation in place to regulate treatment of composite or blade waste, both at EU and Member State level. French law provides the exception for blade waste explicitly and directly and may be considered a global leader in this regard.
2. It was found to be far more common for legal jurisdictions to deploy their general ‘waste’ laws to deal with the treatment of composites at end-of-life, but without making specific reference to turbine blades within the legal framework or associated guidance for industry.
3. A handful of EU Member States – Germany, Austria, the Netherlands, and Finland – have not only enacted rules making clear references to composite waste in their domestic waste laws

but have prohibited the landfilling and incineration of composites. However, as has been recognized in the Netherlands, with rising incineration costs and industrial scale alternatives often being unavailable, a landfill ban will have significant financial implications for the sector.

4. Despite the lack of legislation in many countries dealing with end-of-life turbines, a number of companies within the sector have committed to an array of voluntary initiatives in this regard. These measures include immediately ceasing the landfilling of blades, recyclability targets for blades that increase with rigor over several years, prohibiting export to foreign markets for landfilling or disposal, and a drive for fully recyclable blades by a specified deadline (e.g., 2030). The Corporate Social Responsibility (CSR) practices of the sector, thus, provide a crucial means of addressing the gap in ‘hard law’ measures across the globe.

ACKNOWLEDGEMENTS

We wish to express our gratitude to the following IEA Task 45 members who contributed to this preliminary document.

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1 INTRODUCTION

Research on wind turbine blade recycling has been ongoing for more than a decade, but recycling solutions are still rare, and the few existing solutions are not implemented on large scale. As a result, in many countries recycling solutions for wind turbine blades are not available. The technical difficulty of recycling glass fibre reinforced thermoset composite, the low cost of landfill and the precise assessment of waste volume are some of the challenges preventing the implementation of sustainable recycling solutions. To tackle these various challenges, the expertise of several disciplines and a unified approach across countries have been assembled in an international effort under the IEA Wind Task framework, specifically Task 45 – Enabling Wind Turbine Blade Recycling.

The purpose of IEA Wind Task 45 on wind turbine blade recycling is to identify and mitigate the barriers to the recycling of wind turbine blades. The task will focus on three main areas:

- The technical aspects of recycling wind turbine blades;
- The analysis of the recycling value chain and its environmental, social and economic impact; and
- The standards, certification and legislation framing the activities related to recycling wind turbine blades.

IEA Task 45 is divided into four work package groups, each with specific action plans, areas of focus, and deliverables, when combined will form the final deliverable. The work packages are as follows:

- WP1 Management, coordination and dissemination
- WP2 Technical focus
- WP3 Analysis and Value chain
- WP4 Standardization, certification and legislation focus

1.1 Preliminary Report from Work Package 4

This document represents the ‘6-month preliminary report’ deliverable from the Work Package 4 working group. The purpose of this report is to review and summarize *existing* legislation, standards, and certification schemes related to recycling glass fiber composites. Readers should consider this report a current ‘snapshot in time’ of legislation, policies, rules, and standards – to the extent they exist – in various countries around the world. This preliminary report is intended to help inform members in other Work Package groups about the state of the policy and regulatory landscape related to blade recycling. The information assembled herein does not reflect an exhaustive review of legislation and policies in every country but reflects the conditions in select major wind energy markets. The WP4 working group acknowledges the lack of content from Asia Pacific, Africa, and Indian subcontinent countries, with hope for expanded participation from industry members in these regions.

1.2 Content and Terms

In the process of performing this task, the working group identified a wide range of legislation, policy, regulations, standards, industry initiatives, company goals, and procurement tenders that sought to influence and increase recycling efforts while also adding restrictions on landfill disposal. Due to the wide variability of the information, we elected to broadly organize the findings in the following groups:

- “Hard Law” Measures – Correspond to enforceable laws or regulations where civil or criminal legal actions could result from lack of compliance. Technical design standards are included here given their role for ensuring safety and reliability is achieved in wind turbine designs and standards are ‘enforced’ via the certification process.
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2 ‘HARD LAW’ MEASURES

This section will review legislation from select jurisdictions that pertains to not only decommissioned wind turbine blades but composite waste more generally. Indeed, very few jurisdictions have a legal regime dedicated specifically to decommissioned turbine blades, with French law providing the exception (see section 2.1.2). Whilst regulatory approaches in North America, Australasia, and Europe will be examined, particular focus will be placed on the European Union and those Member States (Austria, Germany, Finland, the Netherlands, and France) which have adopted a progressive approach to the treatment of composites at end-of-life.

2.1 Europe

Landfilling and incineration remain the most common disposal practices for turbine blades in many European countries.¹ As a general observation, it can be said that there is, at present, ‘limited’ legislation in place to regulate treatment of composite or blade waste, both at EU and Member State level.² Germany, Austria, the Netherlands, and Finland are the outliers, making clear references to composite waste in their domestic waste laws.³ They prohibit the landfilling and incineration of composites.⁴ As we shall see shortly, France has now implemented legislation setting out recycling targets for wind turbines as a whole and, most importantly for the purposes of this report, the rotors. These five countries will be considered in further detail below, in their own separation sub-sections, given that their regulatory approaches are at the forefront of ‘hard law’ measures that are applicable to blade waste.

Despite the lack of hard law measures in many European countries banning the landfilling of composite waste, as we shall see in Section 3, leading companies within the sector, such as Vattenfall, have committed to a landfill ban on blades.⁵ The Corporate Social Responsibility (CSR) practices of the sector, thus, provide a crucial means of addressing the gap in ‘hard law’ measures across the globe.

2.1.1 The European Union

The most pertinent EU waste law will be the Waste Framework Directive (WFD). As a Directive, its requirements have been transposed into the national laws of the Member States by means of separate legislation. Member States can, however, implement more onerous legal obligations than those set in a Directive, but they cannot, generally, implement less strict measures.

The WFD sets out what waste is, as understood under EU law, and how it should be managed. It is the primary piece of waste legislation within the EU. It lays down measures to protect the environment and human health by preventing or reducing the generation of waste, the adverse impacts of the generation and management of waste and by reducing overall impacts of resource use and improving

¹ Angela Nagle, Emma Delaney, Lawrence Bank and Paul Leahy, ‘A Comparative Life Cycle Assessment between landfilling and Co-Processing of waste from decommissioned Irish wind turbine blades’ (2020) 277 *Journal of Cleaner Production* 123321, 2

² cefic, EuCIA and Wind Europe, *Accelerating Wind Turbine Blade Circularity* (May 2020) 17 <<https://windeurope.org/wp-content/uploads/files/about-wind/reports/WindEurope-Accelerating-wind-turbine-blade-circularity.pdf>>.

³ *ibid.*

⁴ *ibid.*

⁵ Vattenfall, ‘Vattenfall commits to landfill ban and to recycle all wind turbine blades by 2030’ (Press Release, October 13, 2021) <https://group.vattenfall.com/uk/newsroom/pressreleases/2021/vattenfall-commits-to-landfill-ban-and-to-recycle-all-wind-turbine-bladesby-2030>

the efficiency of such use.⁶ This is seen to be crucial for the transition to a circular economy and for guaranteeing the Union's long-term competitiveness.⁷

The definition of 'waste', set out in Article 3(1), is one of the key concepts of the WFD as it determines what falls under the Directive's scope.⁸ It also plays an important role in determining the scope and application of other EU legislation that directly governs waste management, such as the Landfill Directive (1999/31/EC). Under article 3(1) WFD, 'waste' means any substance or object which the holder discards or intends or is required to discard'. The terms 'substance' and 'object' are to be treated as autonomous terms of waste legislation and are to be interpreted 'broadly'.⁹ A key term within the definition is 'discard'. However, the WFD does not provide a definition or clarification on the exact meaning of it.¹⁰ It appears that the disposal of blades would fall into the 'intention to discard' category. The European Commission, in its guidance on the WFD, utilises the following example to illustrate that particularly category: 'In its decommissioning plan in the event of future closure, an operating site indicates that it will send off-site for appropriate disposal or recovery any of its stock of raw materials that cannot be returned.'¹¹ Whilst turbine blades may not be considered a 'stock of raw materials', the logic would indicate that presuming that the pertinent regulator within a relevant Member State has mandated that the developer/owner provide a decommissioning plan, in which the means of disposing of the blades was set out, then this would satisfy the 'intention' category.

Another important decision is whether waste should be classified as 'non-hazardous waste' or 'hazardous waste'. Wind turbine blades will be treated as 'non-hazardous' for the purposes of the WFD (arts 3(2) and 3(2)(a)) and, more likely, 'construction and demolition waste'. Art 2c defines the latter as 'waste generated by construction and demolition activities'.

The waste hierarchy (shown in Figure 2-1) is the cornerstone of European waste policies and legislation.¹² Its primary purpose is to minimise adverse environmental effects from waste and to increase and optimise resource efficiency in waste management and policy.¹³ Article 4(1) sets out the hierarchy, providing that it shall apply 'as a priority order in waste prevention and management legislation and policy':

- a) prevention (non-waste),¹⁴
- b) preparing for re-use,
- c) recycling,
- d) other recovery, e.g., energy recovery, and
- e) disposal.

⁶ OJ L 312 Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives, art 1.

⁷ WFD, art 1.

⁸ Commission, *Guidance on the interpretation of key provisions of Directive 2008/98/EC on waste* (2012) 9 https://ec.europa.eu/environment/pdf/waste/framework/guidance_doc.pdf (hereafter Commission, *WFD Guidance*).

⁹ *ibid* 9.

¹⁰ *ibid* 10.

¹¹ *ibid* 11.

¹² *ibid* 48.

¹³ *ibid* 48.

¹⁴ Technically, 'prevention' is not a waste management operation because it concerns substances or objects before they become waste.



Figure 2-1 Waste Hierarchy

Source: European Commission, *Waste Frame Directive* <https://ec.europa.eu/environment/topics/waste-and-recycling/waste-framework-directive_en>

This hierarchy lays down a priority order of what constitutes the best overall environmental option in waste legislation and policy.¹⁵ Under article 4(2), Member States are required to ‘take measures to encourage the options that deliver the best overall environmental outcome, including permitting specific waste streams to depart from the hierarchy where this is justified by life-cycle thinking on the overall impacts of the generation and management of such waste.’ However, as we have seen, landfilling (*disposal*) and incineration (*recovery*) remain the most common disposal practices for blades in many European countries,¹⁶ meaning that blade waste is generally near the bottom of the hierarchy.

Commission Decision 2000/532/EC establishes the European List of Waste (LoW),¹⁷ a key document for classification of waste. As a Decision, the LoW is binding in its entirety and addressed to Member States directly. It does not require transposition into their national laws. According to the May 2020 report, *Accelerating Wind Turbine Blade Circularity*, ‘composite blade waste is most often categorised as plastic waste from construction and demolition with the code 17 02 03.’ 17 02 03 is classified as non-hazardous waste. Different codes may be used at the national level.¹⁸

2.1.2 France

There have been significant developments in France relating to the reuse and recycling of wind blades. Article 20 of the Order of 22 June 2020 amending the Order of 26 August 2011 on electricity production installations using wind mechanical energy within an installation subject to declaration

¹⁵ Commission, *WFD Guidance* (n 8) 48.

¹⁶ Nagle et al (n 1) 2

¹⁷ OJ L 226, 2000/532/EC, Commission Decision of 3 May 2000 replacing Decision 94/3/EC establishing a list of wastes pursuant to Article 1(a) of Council Directive 75/442/EEC on waste and Council Decision 94/904/EC establishing a list of hazardous waste pursuant to Article 1(4) of Council Directive 91/689/EEC on hazardous waste.

¹⁸ See cefic et al (n 2): 07 02 13 waste plastic from organic chemical processes; 10 11 03 waste glass-based fibrous materials from thermal processes; 10 11 12 waste glass other than those mentioned in 10 11 11 from thermal processes; 10 11 99 wastes not otherwise specified from thermal processes; and 12 01 05 plastics shavings and turnings from shaping and physical mechanical surface treatment of metals and plastics.

under heading 2980 of the legislation on installations classified for the protection of the environment,¹⁹ provides that:

- on 1 July 2022, at least 90% of the total mass of dismantled wind turbines, including foundations, when all foundations are excavated, or 85% where the excavation of foundations is subject to a derogation, must be reused or recycled.
 - by 1 July 2022, at least 35% of the mass of the rotors must be reused or recycled.

And where wind turbines, for which the complete authorization dossier is submitted after the following dates and wind turbines put into service after that date as part of a significant modification of an existing installation, must have at least:

- after 1 January 2024, 95% of the total mass of dismantled wind turbines, all or part of the foundations included, must be reusable or recyclable
- Rotor specific requirements are:
 - after 1 January 2023, 45% of the mass of the rotor must be reusable or recyclable, and
 - after 1 January 2025, 55% of the mass of the rotor must be reusable or recyclable.

In France, since January 2022, landfilling waste containing more than 30% of plastic is not allowed. This legislation is part of the anti-waste law and is affecting ‘end of life’ (EoL) wind turbine blade waste. The cost of landfills for composite materials varies significantly in Europe.²⁰

In France (as in many other countries), a decommissioning obligation fund is set aside in the beginning of the project in order to cover the cost of the dismantling processes at EoL (Be, Finland, Fr, Germany, It, Netherlands, Sweden, Ireland, Denmark and UK).²¹

- **France:**
 - Legal framework exists for repowering: 2 regimes “Porter à Connaissance” & “Nouvelle Autorisation Environnementale » like Green Field project
 - PPE: target on shore from 17.6 GW in 2020 up to 26.8 GW – 33, 95 GW in 2028
 - **Guideline of Asset Management edited in October 2021:**
 - Good practice and REX for lifetime extension and wind farms assets management
 - Guidelines for end of life issues: Example of one dismantling: wind farm Port La Nouvelle
 - **Lots of constraints for managing a repowering**
 - **End of life Peak is planned in 2025**
 - **Decommissioning needs to be prepared in terms of waste management**

Figure 2-2 Decommissioning Example in France

¹⁹ Arrêté du 22 juin 2020 modifiant l'arrêté du 26 août 2011 relatif aux installations de production d'électricité utilisant l'énergie mécanique du vent au sein d'une installation soumise à déclaration au titre de la rubrique 2980 de la législation des installations classées pour la protection de l'environnement. The text of the legislation can be found here: https://www.legifrance.gouv.fr/loda/article_lc/LEGIARTI000042064061

²⁰ “The complex EoL of wind turbine blades: A review of the European context”, Beauson, J., et al. (2021) <https://www.twobirds.com/en/news/articles/2020/france/france-stronger-environmental-and-recycling-obligations-for-french-wind-farm-operators>

²¹ *ibid.*

- **For the end-of-life of a wind farm**, French law (ministerial decree) demands, especially since 1 July 2020:
 - The **dismantling of existing installations** (including grids) and a **total excavation of foundations** (except if the global environmental assessment is negative: the prefect can then decide an exception and authorizes a partial excavation);
 - The **demolition and dismantling wastes treatment** for the whole wind farm components: **recycling**, reuse, elimination in the authorized sectors;
 - **Recycling of installations**: from 1 July 2022 → 90% of the total mass of WTG must be recycled or reused (including at least 35% for rotors' mass);
 - **Return to green field** with similar properties earths.

Figure 2-3 End-of-life project requirements in France



Figure 2-4 Life extension requirements in France

2.1.3 Germany

A ban on direct landfilling waste with a total organic content higher than 5% came into force in 2009. Considering blades contain organic compounds (due to the resin that binds the glass fibres), they cannot be landfilled. In response to this regulatory constraint a technical solution was developed for handling bigger amounts of glass fibre-reinforced polymers waste called the “cement kiln route” or cement co-processing.

There is an existing association called RDR (Repowering, Demounting, Recycling) Wind e.V., with members from industry branches

- Wind industry
- Waste disposal and recycling
- Logistics
- Construction Industry
- Services

They have initiated DIN SPEC 4866 “Sustainable dismantling, disassembly, recycling and recovery of wind turbines”. Which was released in August 2020. This Spec comprises some paragraphs regarding rotor blades. Specifically:

5.5.11 Cutting of the rotor blades on site for transport

6.2.2 Classification using waste codes as per AVV: For blades it is 17 02 03, 17 09 04, 10 11 03

6.3 Implementation

a) Rotor Blades

Annex B (informative) Research and development on the recovery of rotor blades

2.1.4 Finland

The EU regulation for ban of landfilling polymeric materials came into force in Finland 2018. However, national manufacturing industry, i.e. companies producing polymeric waste (GFRP), still get annual permits for landfilling in case “there is no viable other solution for recycling for them”. Permits are given by local ELY-offices²². In Finland there are service providers who collect the polymeric waste from those who may have it and bring it to certain incineration plants who mix it in ratio less than 10% with other combustible materials (wood, textile, etc.) and burn it mainly in energy production. But this way of dealing with the material is not a sustainable long term solution as service providers eventually wish not to continue doing this²³.

2.1.5 The Netherlands

Since 2020, the Netherlands has regulated (banned) landfilling of thermoset composites. However, with rising incineration costs and no industrial scale alternatives available, this landfill ban is not sustainable. Therefore, Dutch law makes the exception that landfill disposal is still allowed when there is no economical alternative other than landfilling.

Also, because of the low caloric values of thermosets, exporting composites is not allowed with standard permits. Thermosets are deemed as low-economic value and therefore need special permits to export.

Above mentioned “issues” are soon thought to be overcome by new development of 3 different composite recycling plants.

²² Centre for Economic Development, Transport and the Environment, n.d., source: <https://www.ely-keskus.fi/> [viewed 2021-12-09]

²³ Yle, *Båtindustrins avfall grävs fortfarande ner - ingen vill investera i återvinningen*, 2019, source: <https://svenska.yle.fi/artikel/2019/12/17/batindustrins-avfall-gravs-fortfarande-ner-ingen-vill-investera-i-atervinningen> [viewed 2021-12-09]

2.1.6 Ireland

As an EU Member State, Ireland is required to implement and apply EU waste law, including the WFD. To date, Ireland has not chosen to ban the disposal of blade waste to landfill.²⁴ However, commentators anticipate the enactment of new laws, similar in nature to the End-of-Life Vehicles Directive, which imposes mandatory requirements of specified percentages of a vehicle to be reused or recovered.²⁵ The French legislation, discussed in section 2.1.2 offers an interesting model for this.

2.1.7 The United Kingdom

Whilst the UK has now departed from the European Union, the applicable legal framework that it will deploy in relation to composite waste is (still) derived primarily from EU waste law. Indeed, the current legislation dealing with waste was the legislation that the UK was required to implement to enact the requirements of the WFD. English and Welsh law was updated on 1 October 2020, via the Waste (Circular Economy) (Amendment) Regulations 2020, to include changes to the WFD made in 2018. At present, there is no law applicable within the UK banning the disposal of blade waste into landfill. Indeed, in the UK, landfill disposal has been found to dominate EoL routes for composites for almost 90% of the composites.²⁶ It, thus, seems that blade waste will take a similar route.

2.2 Australasia

2.2.1 New Zealand

New Zealand has a progressive approach to environmental law and regulation and so it a worthy subject of study. However, at present, it has not enacted a law prohibiting the landfilling of wind turbine blades or, indeed, composite waste. The legislation that would apply to blades is the Waste Minimisation Act (WMA) 2008. The purpose of that Act is to encourage waste minimisation and decrease waste disposal to protect the environment and provide environmental, social, economic, and cultural benefits.²⁷ It was, however, recently described by the Ministry of the Environment (MfE), as ‘no longer fit-for purpose’ and that it was ‘not driving the changes needed to achieve a circular economy’.²⁸ In September 2021, the MfE published its *National Plastics Action Plan*²⁹ where it sets out a strategy to reduce plastic use, make plastic more circular and minimise use where it harms the environment.

Under s 5(1) WMA 2008, ‘waste’ is defined as anything disposed of or discarded and includes a type of waste that is defined by its composition or source (e.g., construction and demolition waste). The New Zealand Waste list (L-Code) adopts similar approach to categorisation of construction and demolition wastes as the EU waste list. It is likely that the code ‘17 02 03 Plastic’ would cover wind turbine blades. That code, as per the approach in the EU, is treated as non-hazardous waste.

Under s 25 WMA, a levy may be imposed on waste disposed of to raise revenue for promoting and achieving waste minimisation and increase the cost of waste disposal to recognise that disposal imposes costs on the environment, society, and the economy. The operator of a disposal facility must pay the levy on waste disposed of at the facility (s 28(1)). The levy is currently set at \$10 per tonne

²⁴ Nagle et al (n 1), 2

²⁵ *ibid*

²⁶ Al Amin Mohamed Sultan and Paul Tarisai Mativenga, ‘Sustainable location identification decision protocol (SuLIDeP) for determining the location of recycling centres in a circular economy’ (2019) 223 J Clean Prod 508, 520.

²⁷ Waste Minimisation Act 2008, S 3.

²⁸ *ibid*.

²⁹ Ministry for the Environment, National Plastics Action Plan for Aotearoa New Zealand (Wellington: Ministry for the Environment 2021), <https://environment.govt.nz/assets/publications/National-Plastics-Action-Plan.pdf>

(excluding GST) on all waste sent to landfill. However, at present, it only applies to municipal landfills that take household waste, with no levy on 90% of the country's landfills.³⁰ The levy would not, therefore, seem to apply to blade waste. The levy has, however, recently been expanded to cover additional landfill types, including construction and demolition fills, which may be presumed to comprise one form of landfill which may accept retired wind turbine blades. The Waste Minimisation (Calculation and Payment of Waste Disposal Levy) Amendment Regulations 2021 came into force on 13 May 2021 and amend the Waste Minimisation (Calculation and Payment of Waste Disposal Levy) Regulations 2009. For Construction and demolition fill (class 2), the levy will be \$20 from 1 July 2022, increasing to \$30 from 1 July 2024. It is, however, essential that the levy only functions as an economic instrument. It cannot prescribe a change in behaviour, only incentivise it. It is unclear whether the increase in levy will alter behaviour of those charged with dealing with blades at end-of-life.

2.2.2 Australia

There is not currently a ban on the landfilling of blade waste, or composite waste more generally, in Australia. The applicable federal law that would govern blade waste is the Recycling and Waste Reduction Act 2020 No. 119, 2020. Under s 15, 'waste material' is defined as: anything (including a substance or mixture of substances) that is:

- a) discarded, rejected or left over from an industrial, commercial, domestic or other activity; or
- b) surplus to or a by-product of an industrial, commercial, domestic or other activity; or
- c) prescribed by the rules.

Waste material can be a gas, liquid, solid or energy, or a combination of any of them and it does not matter whether it is of value or it is or may be processed, recycled, re-used or recovered (s 15).

2.3 North America

2.3.1 The United States

Resource Conservation and Recovery Act is the Federal law that provides authority to control hazardous and solid waste in the U.S. Amendments to this Act address solid waste, waste minimization, and phasing out of land disposal of hazardous wastes. Wind turbine blades are not expressly addressed in the federal law, therefore a determination must be made when recycling or disposing blades as to the legal status of the material. Federal law and regulations are the minimum requirements. States and local governments can enact more stringent requirements. There are currently no laws or regulations that mandate recycling of wind turbine blades, nor are there currently bans on landfilling blade waste in the U.S.

Title 40, Code of Federal Regulations (CFR), Subtitle D – Non-Hazardous Waste: Most wind turbine blades fall into this regulation since they are typically not considered 'Hazardous Waste' under Subtitle C. The rationale for blades being excluded from Hazardous Waste regulation is:

- Wind turbine blades are not formally "Listed Wastes" – thus are not considered Hazardous Waste
- Wind turbine blades do not meet the 'Characteristic Waste' criteria of ignitability, corrosivity, reactivity, toxicity, and mixed radiological waste.

³⁰ Ministry for the Environment, *Overview of the waste disposal levy* (undated) <https://environment.govt.nz/what-government-is-doing/areas-of-work/waste/waste-disposal-levy/overview/>

Wind turbine blades *can be* excluded from the definition of Solid or Hazardous Waste – when they become a ‘secondary material generated then transferred for reclamation’. Thus, there is a legal path for blades to be excluded from solid and hazardous waste regulations when they are handled as a ‘secondary material in reclamation’

As an industrial Solid Waste, blades in the U.S. most often are disposed in municipal landfills that are permitted to receive solid waste such as blades. The municipal landfill will have certain physical constraints the blades must be cut to for proper placement. These physical constraints vary based on the receiving facility.

2.3.2 Canada

There is not currently a ban on the landfilling of blade waste, or composite waste more generally, at a federal level, provincial or municipal level. Most composite waste is not recovered and is, instead, landfilled or incinerated.³¹ Recycling has, however, been recognized as a desirable waste management option to deal with composite wastes, with the potential to recover value from the waste materials rather than being disposed in landfill or incineration.³² Whilst the Canadian Government is currently working with all levels of government, industry, NGOs, academia and Canadians to take action on plastic waste,³³ there have been no signals to date that blade waste has been earmarked for particular attention.

³¹ Herman Heng, Fanran Meng and JonMcKechnie, ‘Wind turbine blade wastes and the environmental impacts in Canada’ (2021) 133 Waste Management 59, 59

³² *ibid.*

³³ The Government of Canada, Zero plastic waste: Canada’s actions (undated) <https://www.canada.ca/en/environment-climate-change/services/managing-reducing-waste/reduce-plastic-waste/canada-action.html>

3 ‘SOFT LAW’ MEASURES

This section corresponds to publicly announced, non-binding initiatives from turbine manufacturers, project owners, industry organizations, governments, and/or environmental organizations. This category also includes guidelines and recommended practices.

3.1 Turbine Manufacturers and Project Owners

3.1.1 Vattenfall

Announced a ban on landfilling blades already in 2021, a target to recycle 50% of all used blades by 2025 and an aim for 100% by 2030.

3.1.2 Ørsted

Ørsted has committed to reuse, recycle or recover all blades in its global portfolio of onshore and offshore wind farms upon decommissioning. Landfilling and disposal - as defined by the 2008 EU directive on waste, including incineration without energy recovery – are no longer acceptable alternatives. Export to foreign markets for landfilling or disposal is also prohibited.

In case recycling options are not sufficiently developed by the time blades have to be disposed of, landfilling is still not an option, and the blades will be stored temporarily.

3.1.3 Siemens Gamesa RE

Siemens Gamesa RE has announced a goal to manufacture fully recyclable blades by 2030.

3.1.4 Vestas

Vestas has announced a new circularity roadmap to reach zero-waste turbines by 2040 including 100% rotor recyclability by 2030.³⁴

3.1.5 LM Windpower (a subsidiary of General Electric)

Announced in November 2021 to produce zero waste blades by 2030:

“...In practice, this means we aim to send no excess manufacturing materials and packaging to landfill and incineration without energy recovery by 2030.

At LM Wind Power, nearly one third of our operational carbon footprint comes from waste disposal. As a responsible company we are looking forward to either reusing, repurposing, recovering or recycling all the waste from our blades.”³⁵

³⁴ Source 3.1.1. to 3.1.4.: Presentation of Windeurope, Marylise Schmid, at BWE conference Recycling of Rotor Blades, 25.10.2021.

³⁵ <https://www.lmwindpower.com/en/sustainability/zero-waste-blades>

4 TENDERS

As reported in Recharge News article: *Recyclable blades 'have role to play' in upcoming offshore wind tenders: Siemens Gamesa*³⁶, tender requirements are beginning to include qualification requirements or evaluation criteria intended to encourage reuse, recycling, or other more sustainable actions for blades at end of life. Early examples of recyclable blades are also expected to be deployed in operating turbines in 2022. The approach and criteria in tenders remain very broad. For example, the next offshore tender round in France, eight (8) percent of the points of the selection criteria will count towards wind turbine recyclability. In the Netherlands, the upcoming auction for the Hollandse Kust West area in the North Sea will have ‘ecology’ as an innovation theme where responders are encouraged to demonstrate how their offering best protects ecology. While this is a very broad theme, use of recyclable blades, or other measures to avoid landfill or incineration of blades at end of life, could be envisioned in responses. In the UK, the last round of CfD has introduced criteria on low carbon footprint and low carbon products. Although not specifically referencing wind turbine blades, responders that utilized recyclable blades or include end of life reuse or recycling of blades (along with various other project components), would expect to increase their chance of meeting these criteria.

Tender requirements may play an increasingly important role as a bridge between ‘hard law’ requirements and ‘soft law’ intentions or targets. Tender requirements can be established more quickly than regulations and/or legislation. They can also accelerate adoption of CSR initiatives or targets by inclusion of meaningful requirements and selection criteria. However, if tender requirements or thresholds advance faster than industry capabilities, there may be unintended consequences, added costs, or other implications that impacts the competitiveness of wind energy.

Tender requirements, informed by guidelines developed through joint industry efforts, may be the process that enables wider development of sustainable products and practices.

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5 OBSERVATIONS AND DISCUSSION OF PRELIMINARY REPORT

Four observations may be made in respect of the findings of this preliminary study.

First, landfilling and incineration remain the most common disposal practices for turbine blades in many countries, including most Member States within the EU and across North America. Few jurisdictions have a legal regime in place that is dedicated specifically to decommissioned turbine blades. Within the European Union, for instance, as a general observation, there is, at present, limited legislation in place to regulate treatment of composite or blade waste, both at EU and Member State level. French law provides the exception for blade waste explicitly and directly and may be considered a global leader in this regard. Under its domestic legislation (i.e., legislation which was enacted by its own legislator, without being a requirement of EU law), which came into force on 22 June 2020, from 1 July 2022, at least 35% of the mass of the rotors must be reused or recycled, increasing to 45% after 1 January 2023 and 55% after 1 January 2025. The strategy of the French government is to implement reuse and recycling targets across a 5-year window, providing time for the sector to plan for, and acclimatize to, its requirements. The downside of this approach, however, is that the reuse and recycling target is ‘capped’ at 55%, meaning that incentive to *exceed* these targets may be less than optimal. Nearly half of the mass of the blade can still, it seems, be landfilled or incinerated. This may be a political compromise to ensure the passing of the relevant legislation.

Second, it was found to be far more common for legal jurisdictions to deploy their general ‘waste’ laws to deal with the treatment of composites at end-of-life, but without making specific reference to turbine blades within the legal framework or associated guidance for industry. The EU’s Waste Framework Directive, the primary piece of waste legislation within the EU, is a prominent example of this practice.

Third, a handful of EU Member States – Germany, Austria, the Netherlands, and Finland – have not only enacted rules making clear references to composite waste in their domestic waste laws but have prohibited the landfilling and incineration of composites. However, as has been recognized in the Netherlands, with rising incineration costs and industrial scale alternatives often being unavailable, a landfill ban will have significant financial implications for the sector. This paved the way for the somewhat troublesome exception in the Netherlands whereby landfill disposal would still be permitted when there is no *economical* alternative other than landfilling. The extent of the ‘ban’ is therefore questionable. The Dutch experience does expose the reality of the creations of landfill bans before the pertinent technological solutions are available at cost tolerable by industry.

Four, despite the lack of legislation in many countries dealing with end-of-life turbines, a number of companies within the sector have committed to an array of voluntary initiatives in this regard. These measures include immediately ceasing the landfilling of blades, recyclability targets for blades that increase with rigor over several years, prohibiting export to foreign markets for landfilling or disposal, and a drive for fully recyclable blades by a specified deadline (e.g., 2030). The Corporate Social Responsibility (CSR) practices of the sector, thus, provide a crucial means of addressing the gap in ‘hard law’ measures across the globe. The major advantage of these type of ‘soft law’ measures is that they span legal jurisdictions, meaning that dominant players in the sector can abide by rules that they set *globally*, without waiting for the jurisdictions in which their infrastructure is located to enact relevant legislation. This could take time, be politically contentious where there is extensive lobbying by the sector and, as a result, fail to go as far as necessary to address the environmental concerns. However, we must bear in mind that these are soft-law measures, meaning that there is no distinct *legal* sanction should the company fail to meet their recyclability targets or breach claims made in their policies (e.g. exporting to foreign markets for landfilling or disposal when they asserted that they would not do this). The tolerability of soft-law measures must, therefore, comprise a significant element of trust by both domestic legislators and society alike.