



WHEN TRUST MATTERS

Re:Wind

Accelerating Sustainability in Decommissioning

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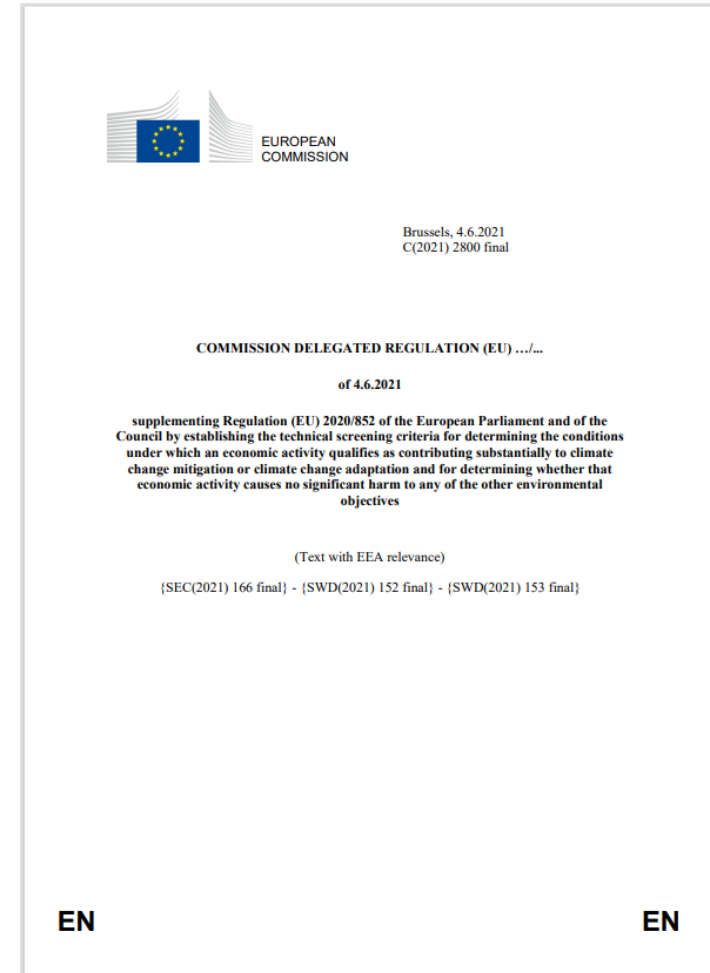


Why should I recycle my wind warm components?

Introduction

Context

- In Europe Alone over 20,000 turbines are 15 or more years old.
- This is expected to generate over 30,000 tonnes of waste per year by 2025
- WindEurope recently called for a ban on the use of landfill for all turbine components
- The EU taxonomy requires stakeholders to ensure turbine components are recycled responsibly



What do I need to do to make
sure my wind farm is sustainably
decommissioned ?

Sustainable Decommissioning

Make a decommissioning plan

- Plan should be made 5+ years in advance of end of life
- Should also be considered at the start of a projects life
 - ESG and cost

Answer a simple set of questions

1. What materials will I encounter?
2. What regulations do I need to follow?
3. How much is this going to cost?

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What materials will I encounter?

And how much of each of these materials?

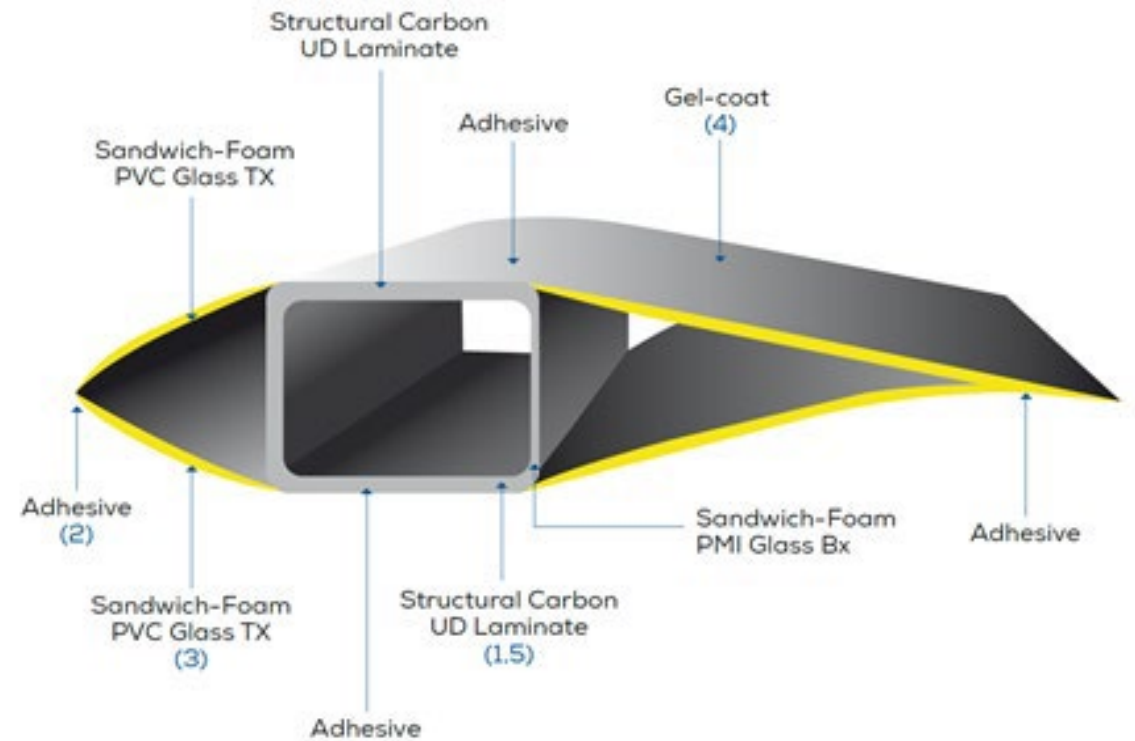
- Plan the equipment and facilities needed to process these materials
- Accurately estimate the value of scrap material
- Identify any potential harmful or hazardous material
- **Lack of data is a big issue facing decommissioning projects**

Characteristics		Description
Turbine model		Re:Wind Turbine
Nominal power		3.0 MW
Rotor diameter		80 m
Hub height		70 m
Rotor (blades)	Material	Fibre glass reinforced epoxy, carbon fibres and Solid Metal Tip (SMT)
	Weight	6.5 tn per blade
Hub	Material	Cast iron
	Weight	17.5 tn
Main shaft	Material	Cast iron
	Weight	3.7 tn
Main bearing	Type	Single main bearing: Double-row spherical roller bearing
	Material	Cast iron (housing)
	Weight	0.4 tn
Gearbox	Type	2 planetary and 1 helical
	Material	Iron and steel, cast (housing)
	Weight	16.5 tn
Generator	Type	Induction generator (IG), 4 stage, 690 V, 2000 kV
	Material	Steel, resin and copper
	Weight	6.5 tn
Transformer	Type	Three-phase, dry, 0.690
	Material	Steel, resin and copper
	Weight	5 tn
Main frame	Material	Cast iron
	Weight	41 tn
Nacelle	Material	Cover: GRP, front bedplate: cast iron, rear bedplate: girder structure
	Weight	60 tn
Tower	Type	Tubular steel
	N° of sections	3
	Material	Mainly structural steel
	Weight	125 tn

What materials will I encounter?

Typical Blade Composition:

- Glass fibers – PVC Glass
- Epoxy resin
- Balsa wood
- Carbon fibers and laminates
- Adhesives
- Exterior gel coats



[1] Wind turbine blade cross section structural elements

Gamesa Technology Corp. and Sandia National Laboratories

What materials will I encounter?

And how can they be recycled

- 85-90% of a wind turbines mass can be easily recycled
- Blades are the most difficult but possible
 - Cement co-processing
 - Advanced grinding techniques
 - Re-use: Playgrounds, bike shelters, bridges
- Rare earth materials need to be given special attention



[2] Amnet's worlds first turbine blade bridge, Szprotawa, Poland 2021

1. What materials will I encounter?
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What rules do I need to follow?

Waste Regulations

1. Permit requirements

- Sweden has introduced mandatory recycling of components as permit requirement
- In South Africa Projects are required to complete decommissioning costs studies to acquire permit

2. Waste disposal laws and guidelines:

- EU – pass through to all member states
- National – can improve on EU regulations: Example: Germany

What rules do I need to follow?

Recycling Component	Applicable legislation	Summary	Links
Concrete	EU Waste Framework Directive (2008/98/EC)	At least 70% of the weight of non-hazardous construction and demolition waste (CDW) must be reused or recycled by 2020.	<p><u>Entire document:</u> https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32008L0098</p>
Metals	EU Waste Framework Directive (2008/98/EC), article 11	Member states shall take measures to promote high-quality recycling and, to this end, shall set up separate collections of waste where technically, environmentally, and economically practicable and appropriate to meet the necessary quality standards for the relevant recycling sectors	<p><u>Entire document:</u> https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32008L0098</p> <p><u>Relevant article in English:</u> https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32008L0098&from=EN#d1e1203-3-1</p>
Composites from blades	EU Circular Economy Action Plan (2020)	<p>Composite blade waste is most often categorised as plastic waste from construction and demolition with the code 17 02 03.</p> <p>The EU strives to circularity with the EU Circular Economy Action plan (2020) and European Strategy for Plastics in a Circular Economy (2018).</p>	<p><u>Entire document [EU circular Economy Action Plan]:</u> https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1583933814386&uri=COM:2020:98:FIN</p> <p><u>Entire document [European Strategy for Plastics in a Circular Economy]:</u> https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1516265440535&uri=COM:2018:28:FIN</p>
Rare earth metals	-	Under the EU Directive rare earth elements are listed as non-hazardous. There is no specific EU legislation.	-
Electric cables	WEEE Directive 2012/19/EU	External electric cables have to be removed and collected separately.	<p><u>Entire document:</u> https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32012L0019</p>
Electric cables	EU Waste Framework Directive (2008/98/EC)	Waste oils must be collected separately (when this is technically feasible) and treated per the waste hierarchy. Furthermore, no harm should be done during the process to human health and the environment. Moreover, waste oils of different characteristics should not be mixed to simplify treatment.	<p><u>Entire document:</u> https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32008L0098</p>

What rules do I need to follow?

Best Practices

- Goal should not be to meet the minimum requirement but to have a positive impact
- EU Taxonomy – do no significant harm
- Possibility for positive publicity and to avoid reputational damage



[3] BBC, October 2021

1. What materials will I encounter?
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- 3. How much is this going to cost?**

How much will this cost?

Why estimate costs?

- Ensure enough funds are set aside for decommissioning
- Accurate valuation during transactions and for financing
- As an input to repowering and life extension business cases

What to consider?

- Disassembly and removal costs
- Project management and overhead costs
- Scrap value



How much will this cost?

Decommissioning percentage of total	Per WTG	% of Total
Turbines disassembly costs	18,413 €	28%
Turbines removal costs	4,335 €	7%
Turbine foundations removal costs	6,327 €	10%
Cable removal costs	436 €	1%
Removal of other on-site constructions	- €	0%
Access roads removal costs	3,516 €	5%
Crane pads removal costs	6,364 €	10%
Reinstate costs	11,922 €	18%
Project overheads costs	14,572 €	22%
Total decommissioning costs	65,886 €	100%

Disassembly costs: (Fictional Turbine)	Per WTG	% of Total
Disassembly costs of rotor (excl mob & demob costs crane)	2,958 €	16%
Disassembly costs of nacelle + hub (excl mob & demob costs crane)	3,211 €	17%
Disassembly costs of tower (excl mob & demob costs crane)	7,852 €	43%
Disassembly costs of transformer (excl mob & demob costs crane)	923 €	5%
Mobilisation and demobilisation of crane + personal + other equipment	3,470 €	19%
Total turbines disassembly costs	18,413 €	100%

Removal costs: (Fictional Turbine)	Per WTG	% of Total
Loading costs turbine towers	460 €	11%
Transport costs of turbine towers	1,192 €	27%
Loading costs turbine blades	151 €	3%
Transport costs of turbine blades	315 €	7%
Loading costs of remaining nacelle and generator	525 €	12%
Transport costs of remaining nacelle and generator	970 €	22%
(De)Mobilisation costs personal + equipment	723 €	17%
Total turbines removal costs	4,335 €	100%

How much will this cost?

Salvage-Disposal	Per WTG
Wind turbines including blades and generators	- 28,332 €
Crane Pads	10,238 €
Foundations	2,536 €
Array	- 426 €
TOTAL	- 15,984 €

Scrap Prices	Units
Scrap steel E3 grade	? /tonne
Scrap generator with copper in it	? /tonne
Scrap aluminium cables	? /tonne
Loose aggregate (roads and crane pads)	? /tonne
Blades disposal	? /tonne
Broken out reinforced concrete (foundation)	? /tonne
Landfill: active waste (blade material)	? /tonne
Scrap Transformer	? /unit

NET DECOMMISSIONING COSTS	
Disassembly and removal	39,392 €
Reinstating ground	11,922 €
Project overhead costs	14,572 €
Salvage / disposal	- 15,984 €
NET DECOMMISSIONING COSTS	49,902 €

Second hand market?

Landfill?

Cement co-processing?

Repurpose?

Novel recycling method?

What can DNV do to help?

Re:Wind

Turbine model and country specific reports

- Turbine materials and weights
- Applicable recycling methods
- Applicable waste and permit requirements
- Decommissioning cost assumptions
- Recommended actions to ensure end of life is approached in a sustainable manner

Active renewables team in Greece:

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RE:WIND
Re:Wind Turbine Recyclability
Assessment
HWEA

Report No.: , Rev. A
Document No.:
Date:



Questions?

Re:Wind

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Northern Europe
Southern Europe & Americas
Greece

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