ReWind

Keeping wind turbines out of landfill

Seminar om havvind og miljø

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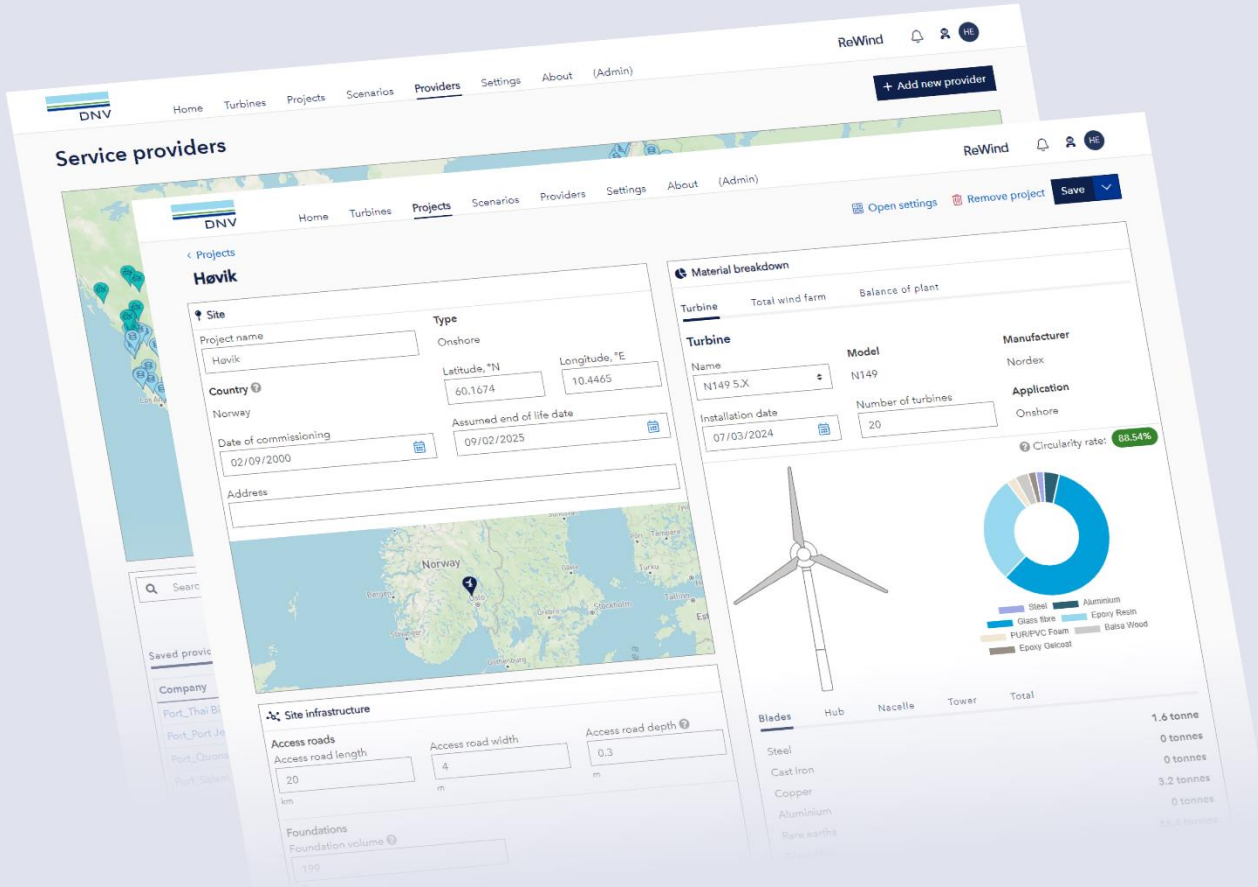
ReWind: End-of-life planning software from DNV

ReWind is an end-of-life modelling platform that:

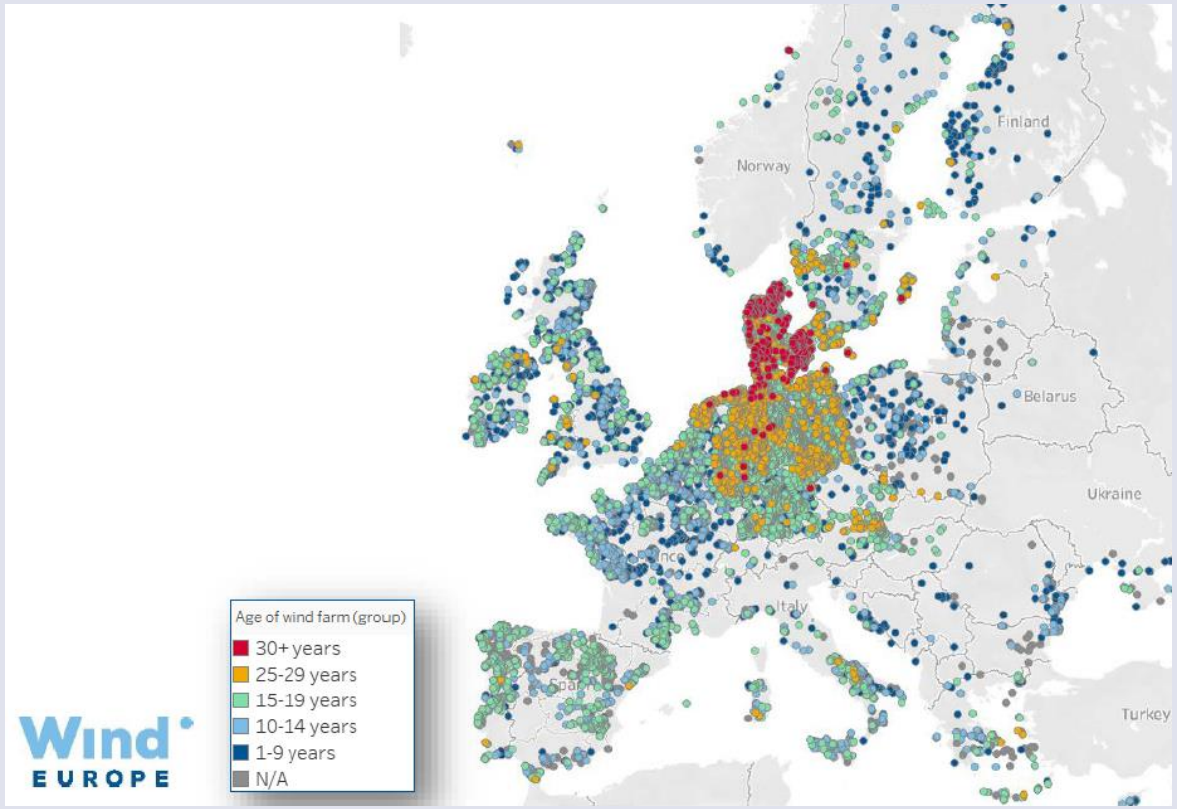
- Provides a full breakdown of the materials in your turbines and balance of plant
- Models the overall circularity of your projects
- Calculates and optimises the cost of decommissioning
- Connects you with the right facilties to execute decommissioning and handle assets at end of life (over 800 different facilties)
- Helps to ensure no assets end up in landfill



The context

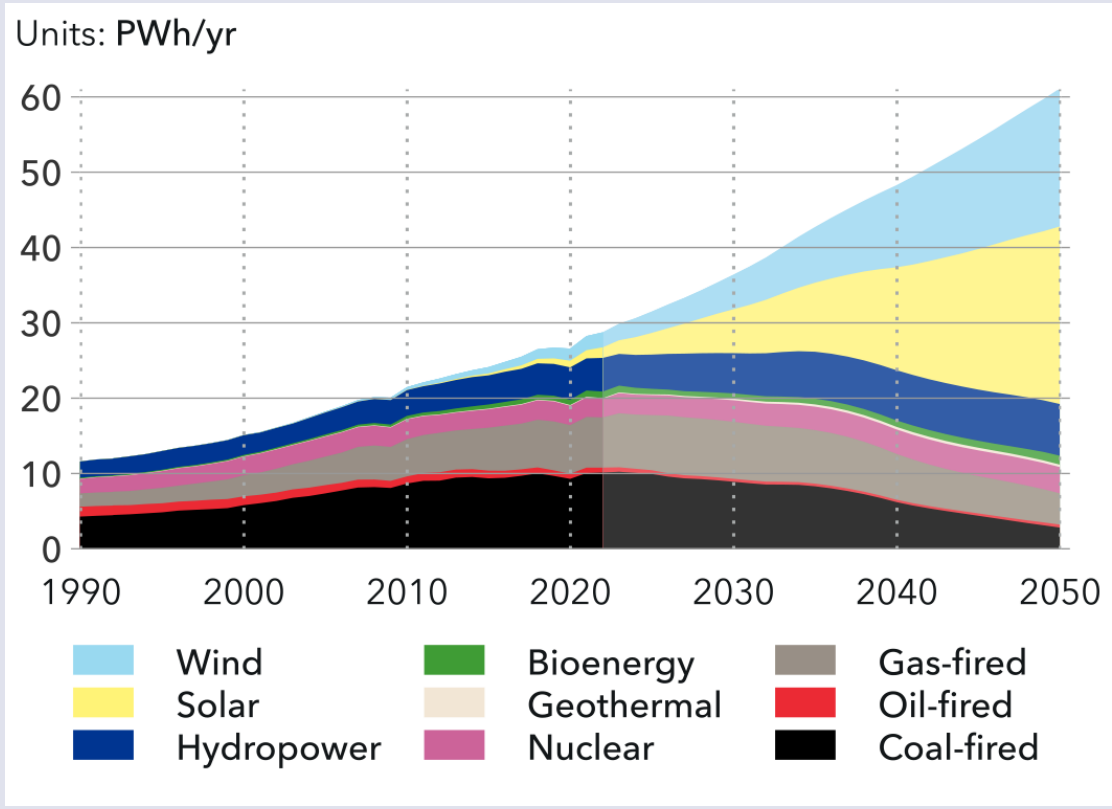
Background image - Wind turbines are piling up in landfill – Bloomberg Front Page Feb 2023

Market today



Over 34k wind turbines are >15 years old.

Future market



Wind capacity forecasted to grow by over 650% for Europe to reach its climate goals

Offshore wind auction pre-qualification criteria

4C	Waste, recycling and reuse	The project shall contribute to good waste management, with a particular emphasis on recycling.
		
		The applicant must have a plan for waste management, recycling and reuse of larger elements in the energy installation.
			• Waste management plan, including:
			  ○ Use of materials and chemicals
			  ○ Waste management and planned measures to combat pollution, including microplastics
			• Estimated proportion of recyclable materials specified for turbine, turbine blades, turbine towers,

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Norwegian Ministry of Petroleum and Energy

		The applicant will be assessed on the quality of the plan, including proposed measures, as well as documented experience and expertise relating to similar work.	floaters and internal cables. Description of the applicant's experience of waste management, recycling and reuse in previous projects. **Maximum of four pages.**

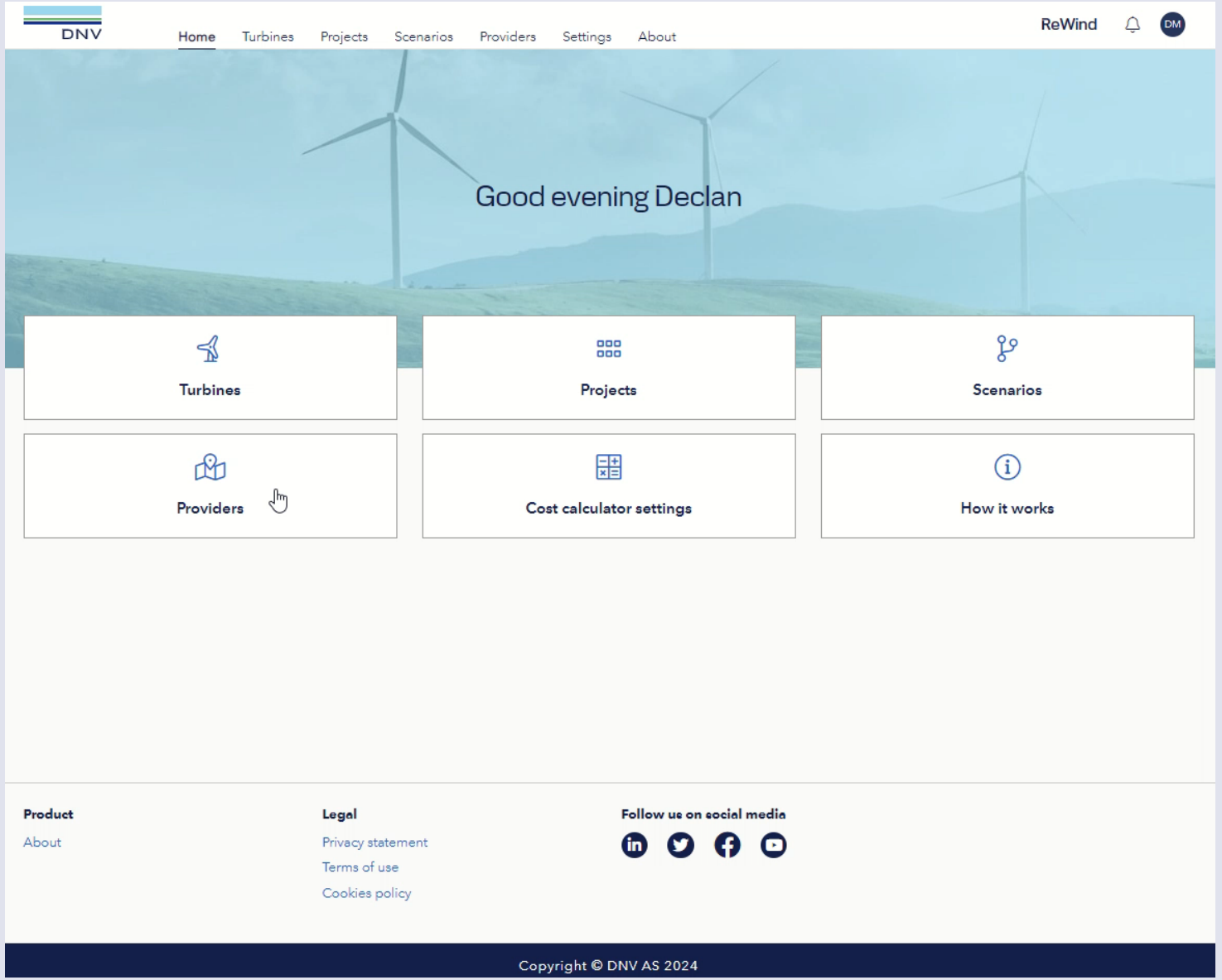
DNV

ReWind an end-of-life decision making tool

1 Wind farm material breakdown

2 Decommissioning cost calculator

3 Supply chain database



Challenges facing the offshore wind industry in Norway

3 Key Challenges

1. Understanding the breakdown of materials in an offshore wind farm
2. Identifying and filling gaps in the downstream supply chain
3. Optimising the cost of decommissioning and maximising end of life value

Challenges

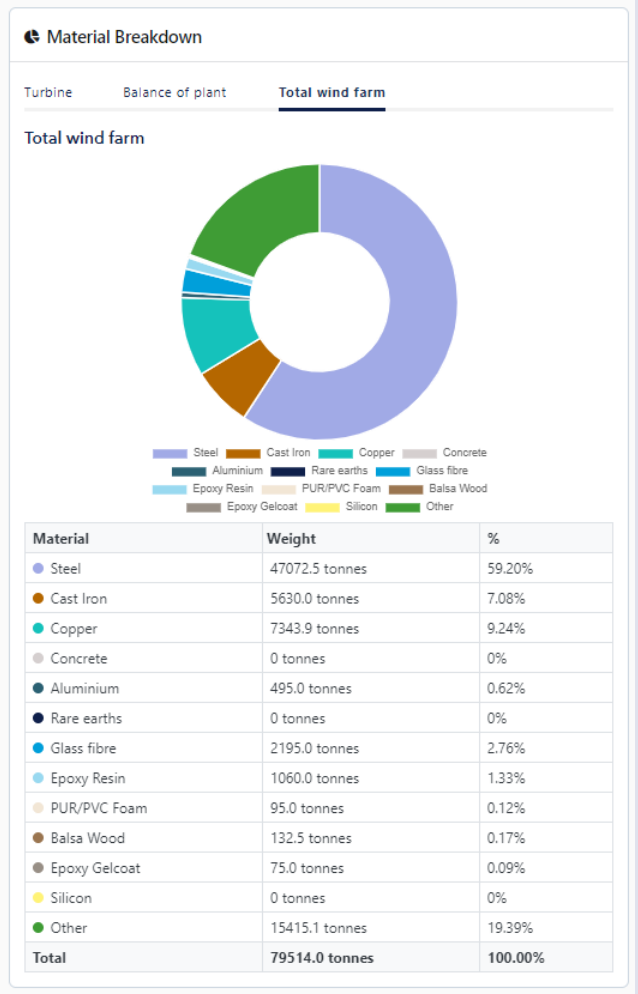
1. Understanding the breakdown of materials in an offshore wind farm

Typical wind farm material breakdown

- Steel is the dominant material in an offshore wind farm
  - Both in the turbines as well as foundations (floating too)
- Over 85% of a typical wind farm material breakdown is metals
- Composites in blades and rare earth materials are of concern

Why do we need to understand a breakdown of the materials?

- To offset the environmental impact during design and operations
- To maximise the value of the asset at end of life
- For effective participation in offshore auctions



Material	Weight	%
Steel	47072.5 tonnes	59.20%
Cast Iron	5630.0 tonnes	7.08%
Copper	7343.9 tonnes	9.24%
Concrete	0 tonnes	0%
Aluminium	495.0 tonnes	0.62%
Rare earths	0 tonnes	0%
Glass fibre	2195.0 tonnes	2.76%
Epoxy Resin	1060.0 tonnes	1.33%
PUR/PVC Foam	95.0 tonnes	0.12%
Balsa Wood	132.5 tonnes	0.17%
Epoxy Gelcoat	75.0 tonnes	0.09%
Silicon	0 tonnes	0%
Other	15415.1 tonnes	19.39%
Total	**79514.0 tonnes**	**100.00%**

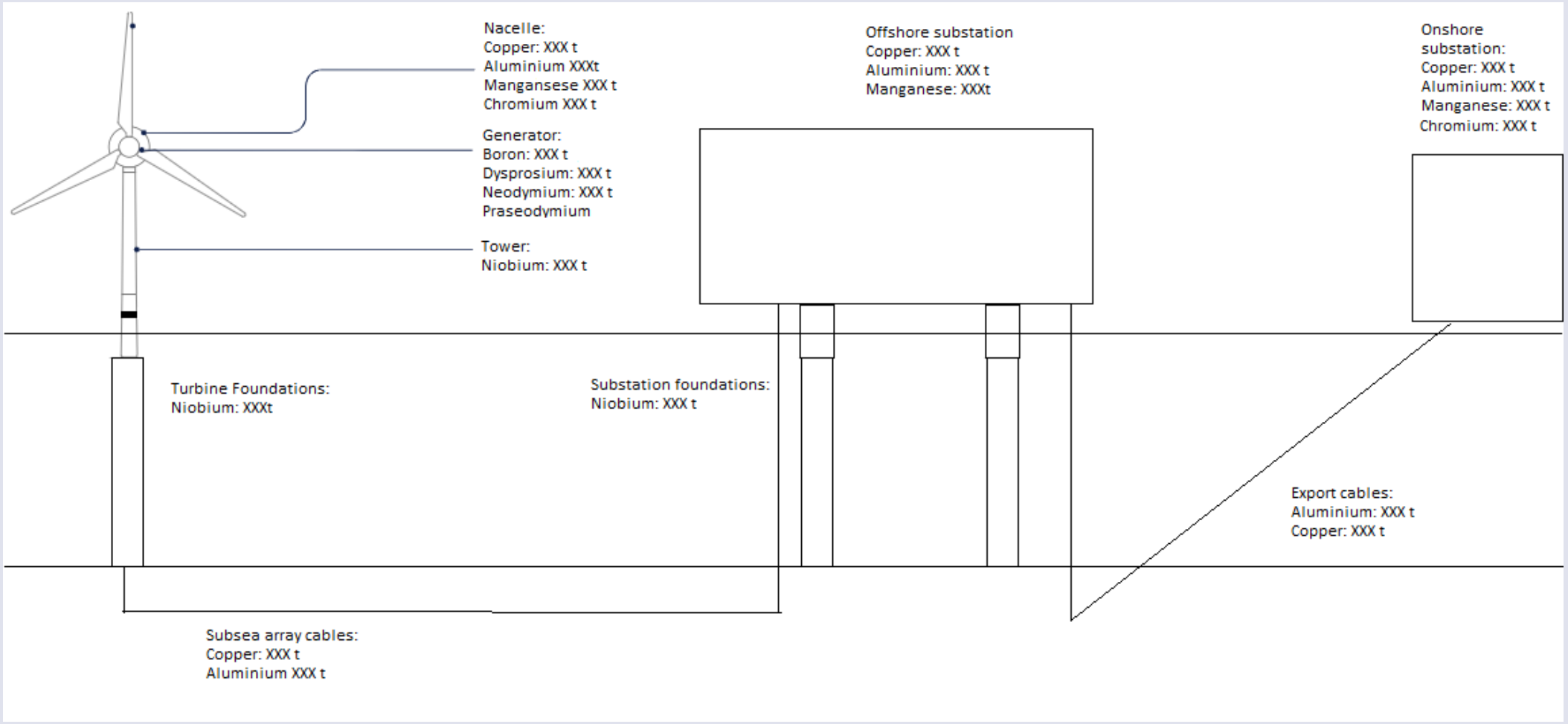
Challenges

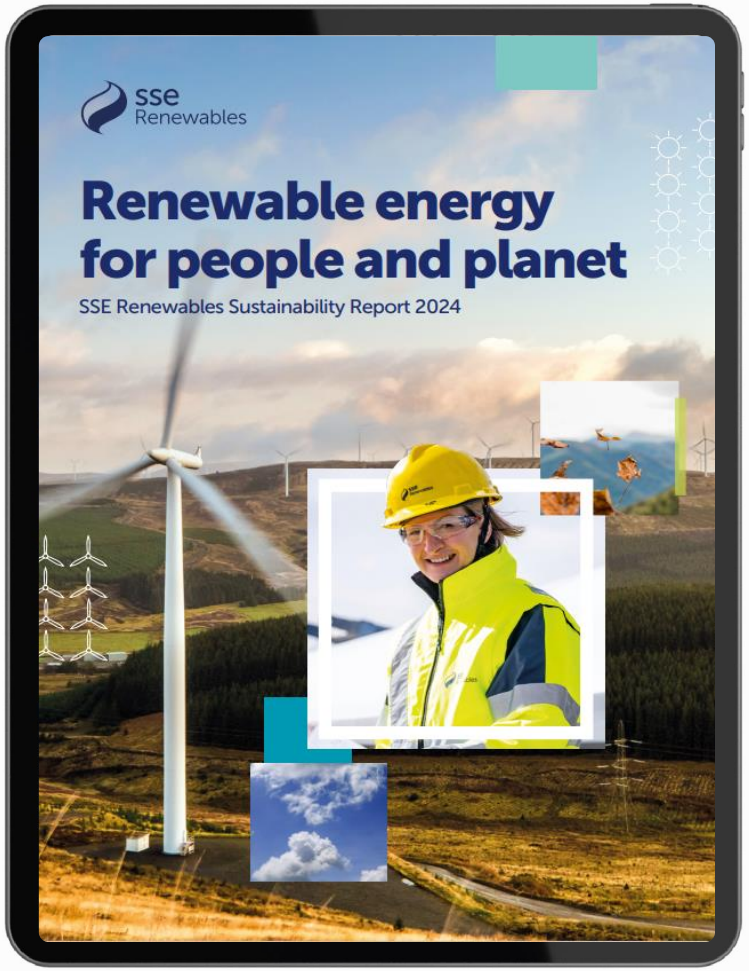
1. Understanding the breakdown of materials in an offshore wind farm

EU Critical Raw Materials Act:

- Fundamentally offshore wind is a scarce resource problem and will continue to be so
- All modern offshore wind turbines are direct drive and contain a lot of Rare Earth Elements in the permanent magnet
- Being able to map out these materials and waste streams helps to develop a circular industry for processing in Europe

EU Critical Raw Materials List 2023 /REF/		
Aluminium/bauxite	Germanium	Phosphorus
Antimony	Hafnium	Scandium
Arsenic	Helium	Silicon metal
Baryte	Heavy Rare Earth Elements	Strontium
Beryllium	Lithium	Tantalum
Bismuth	Light Rare Earth Elements	Titanium metal
Boron/Borate	Magnesium	Tungsten
Cobalt	Manganese	Vanadium
Coking Coal	Natural Graphite	Copper*
Feldspar	Niobium	Nickel*
Fluorspar	Platinum Group Metals	
Gallium	Phosphate Rock	


Nacelle:
Copper: XXX t
Aluminium XXXt
Mangansese XXX t
Chromium XXX t
Generator:
Boron: XXX t
Dysprosium: XXX t
Neodymium: XXX t
Praseodymium
Tower:
Niobium: XXX t
Offshore substation
Copper: XXX t
Aluminium: XXX t
Manganese: XXXt
Onshore substation:
Copper: XXX t
Aluminium: XXX t
Manganese: XXX t
Chromium: XXX t
Turbine Foundations:
Niobium: XXXt
Substation foundations:
Niobium: XXX t
Export cables:
Aluminium: XXX t
Copper: XXX t
Subsea array cables:
Copper: XXX t
Aluminium XXX t



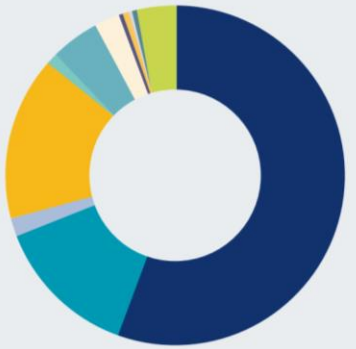
"This innovative package allows owners and operators of wind farms to profile their assets and make informed decisions about the best solutions for end-of-life."

SSE Plc Sustainability Report 2024

ReWind: Understanding the materials embodied in our assets

In 2023/24, SSE Renewables became a pilot partner for the ReWind Tool developed by DNV. This is an innovative software package which allows owners and operators of Wind Turbines Generators (WTGs) to profile their assets and make informed decisions about the best solutions for end-of-life. The tool has the capability to model a full bill of materials for wind turbines, data which is not typically available from Original Equipment Manufacturers (OEMs) for legacy assets.

Over the year, we piloted the ReWind tool on a number of live operational assets to provide validation feedback to DNV and to gain independent and robust profiling of our assets and the materials embodied in them. The ReWind tool is now being used across our onshore and offshore wind fleet to robustly understand the potential full cost of decommissioning, enabling a more holistic view to inform end-of-life decision-making and opportunities for material preservation and sustainable end-of-life options for our wind assets. The ReWind software provides a material breakdown of our assets. Below shows a breakdown for a typical wind farm asset that SSER has in operation.



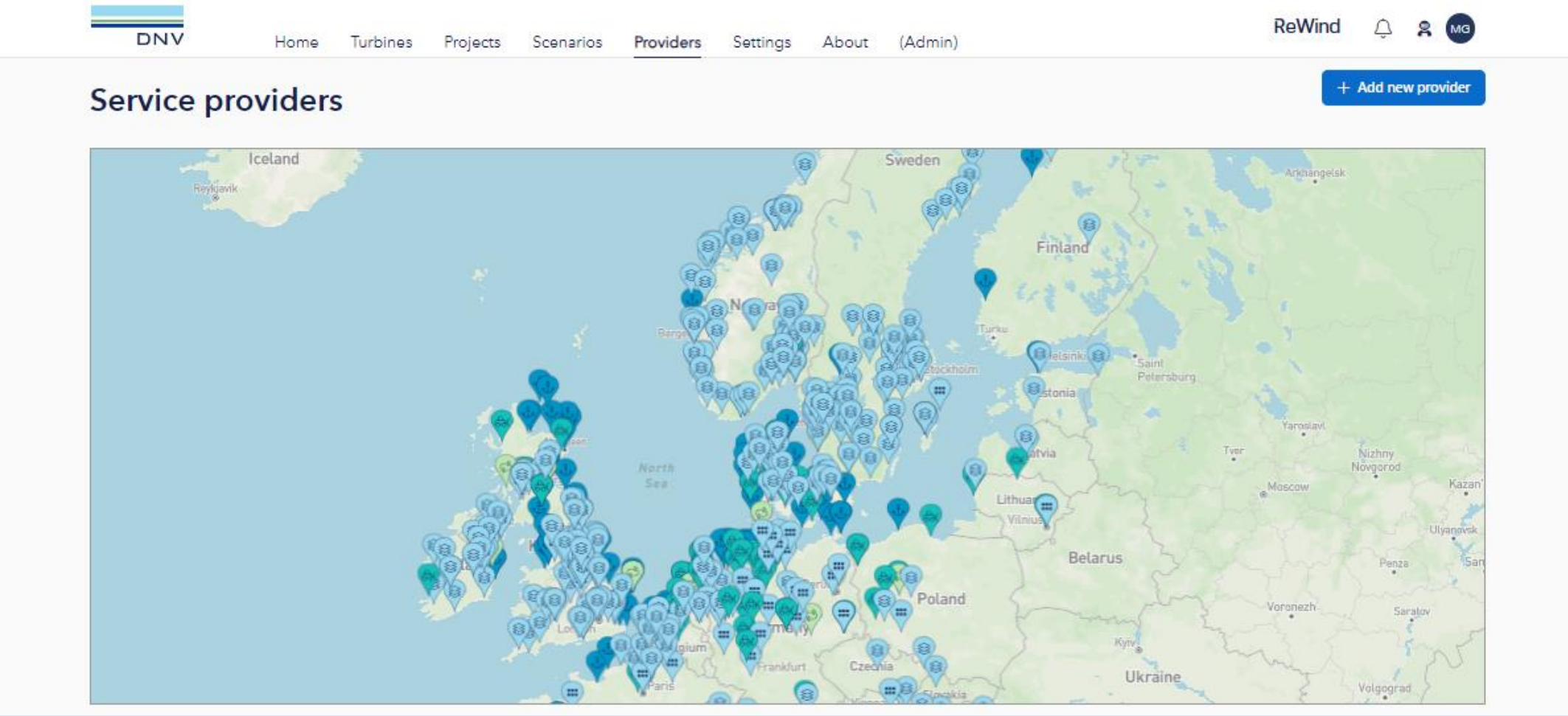
Steel	7667.4 tonnes
Cast Iron	1961.0 tonnes
Copper	1874 tonnes
Concrete	2215.0 tonnes
Aluminium	129.3 tonnes
Rare Earths	0 tonnes
Glass Fibre	618.2 tonnes
Epoxy Resin	298.5 tonnes
PUR/PVC Foam	26.6 tonnes
Balsa Wood	37.3 tonnes
Epoxy Gelcoat	21.3 tonnes
Silicon	20.4 tonnes
Other	656.1 tonnes
Total	**13838.5 tonnes**

€250k

cost savings to date

Challenges

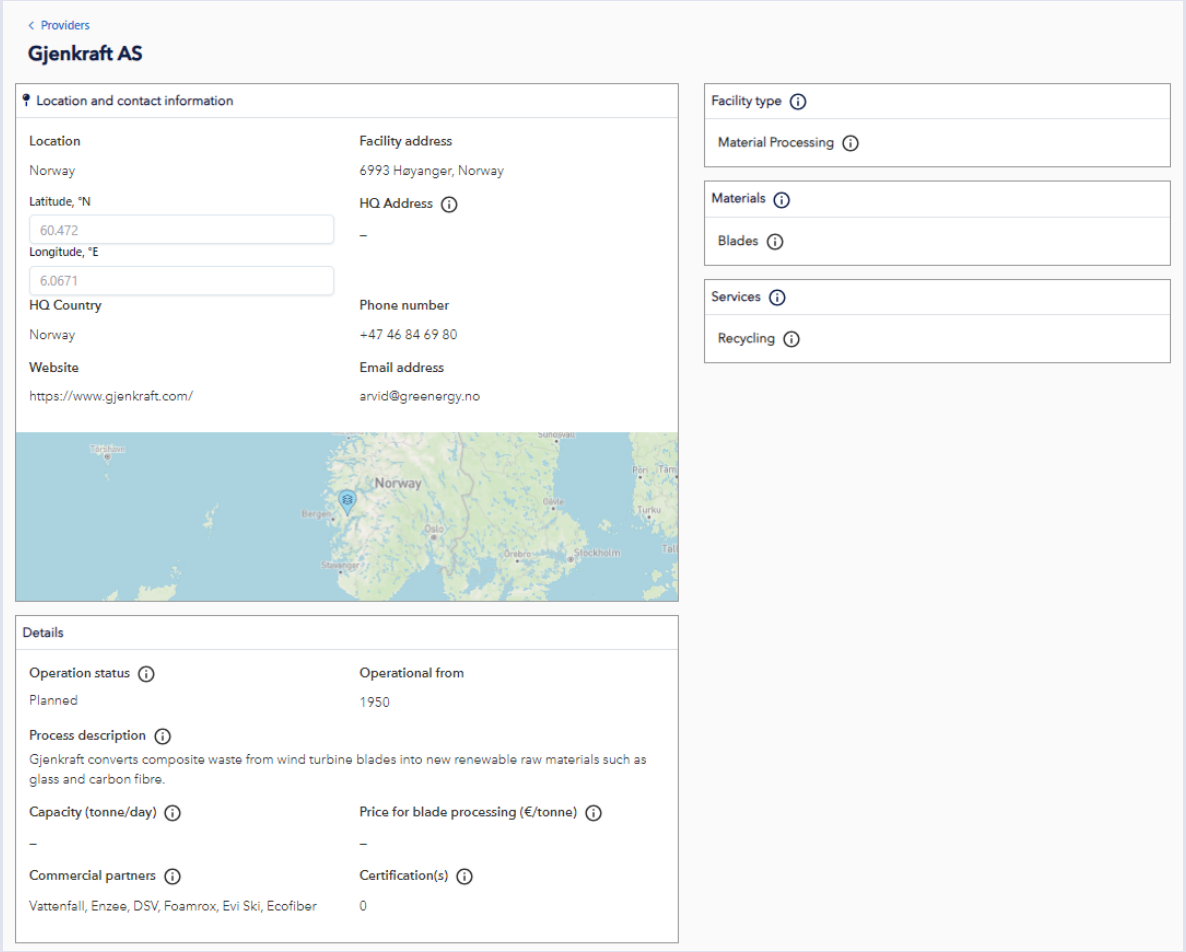
2. Identifying and filling gaps in the downstream supply chain



2. Identifying and filling gaps in the downstream supply chain

The supply chain is developing:

- Blade recycling and processing facilities are growing in number and TRL is increasing
- Rare earth recycling is expanding with the push from the EU
- We are seeing an influx of new providers from North American trying to establish themselves in Europe
- Certainty in supply chain availability is a big question in offshore tenders



2. Identifying and filling gaps in the downstream supply chain

Operators considerations:

Costs and carbon savings are weighted equally;

- Not only interested in the gate fee per tonne for blade material
- Operators wish to understand the true cost per tonne of offset carbon, tCO2e/€, to inform opportunities for sustainable end of life planning
- Understanding a benchmark range for the cost of reducing carbon emissions allows an operator to fully cost the plan of sustainably decommissioning windfarms and provides value in:

3. Optimising the cost of decommissioning and maximising end of life value

End of life value can be optimised

- The majority of decommissioning costs are related to vessel costs and time at sea
- The scope of decommissioning has a huge impact on the overall cost

The EOL value of the asset depends on:

- The material composition of the asset
- The EOL strategy: can I sell the turbines?
- The way in which the materials are handled

Supporting offshore wind auctions

Eurus Energy

Pain points:

- Japanese offshore wind tenders require that developers submit both circularity and decommissioning cost plans as part of the qualification process
- Estimating the project decommissioning costs and material breakdown for early-stage projects where designs are not finalised
- Understanding the technologies that will be available in the future for recycling and decommissioning wind projects.

“We knew that ReWind can calculate removal costs, schedules, recycling, etc., so I tried the trial version.

ReWind is very straightforward to operate, and even as a beginner in marine construction, was able to use it easily.

There are plans to allow calculation of the cost and schedule of floating foundations in the future, which I would definitely consider using.”

Get in touch and try out ReWind

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https://www.rewind.software/