Status Overview

Decommissioning offshore wind farms, recycling, reusing and selling of components/materials

About Me

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Contents

Background: Decommissioning

- Limited practical experience
  - 5 offshore wind farms decommissioned
- Till 2023 around 225 offshore wind turbines predicted to be decommissioned[1]
- Problem rising and need to make Wind Turbines fully 'green' alternative
- Post decommissioning material handling needs improvement
- Opportunity to make the process Circular

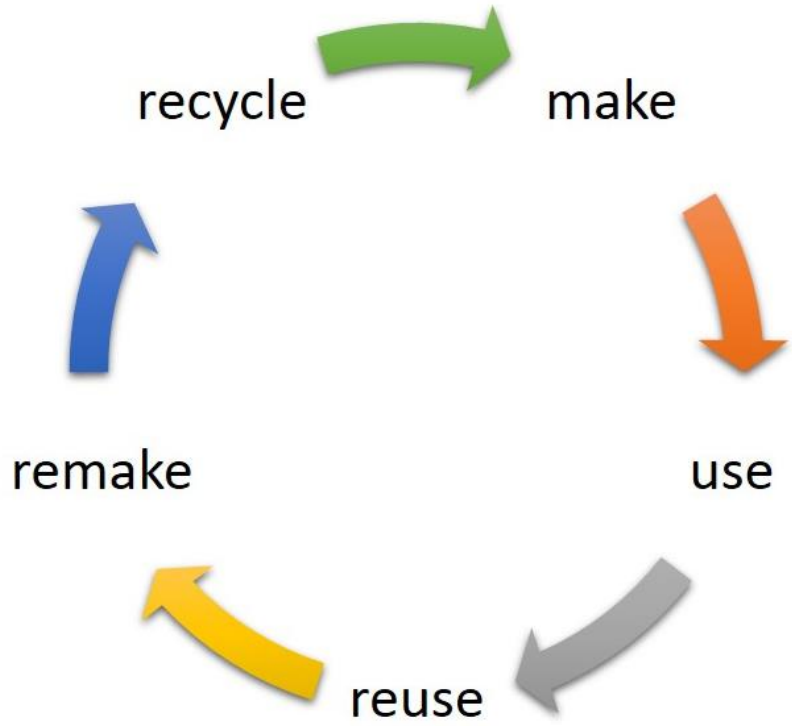
Source- 1: Market Analysis Report, DECOM Tools project

Background: Circular Economy

- Closed-Loop system

- Main goal - responsible resource consumption
  - Maintain highest value through cyclical loops
  - Increase product lifetime, process efficiencies

- Prefer processes with minimal effort to maintain the functionality



Circular economy representation[1]

Source- 1: Catherine Weetman

Data gathering and assumptions

- Material data gathered from 32 published LCA studies
  - 15 Vestas studies

- **Power form** of equation $M = a X^b$ used for curve fitting of Materials in a turbine
- Copper, Aluminium, Magnets, Cast Iron ~ Capacity (MW)
- Steel ~ Hub Height (m)
- Fibre Glass, Epoxy ~ Rotor Diameter (m)
- Foundation (Steel) ~ Capacity (MW)

Offshore turbine material = Onshore turbine material

Case Study: Utgrunden Offshore Wind Farm

Location: Sweden

Operational Years: 18

Decommissioned Year: 2018

Wind Farm Owner: Vattenfall

Wind Turbine: Enron Wind 70/1500

Hub Height: 65 m

Wind Turbine Capacity: 1.5 MW

Number of Turbines: 7

Capacity Factor: 34%

Foundation: Monopile

Distance from shore: 5 km

Screen shot of location of Utgrunden OWF[1]

Source- 1: 4C Offshore

Results: Material Ranking

Materials	Mass (%)	Rank
Foundation	51.1%	1
Steel	33.9%	1
Cast Iron	6.0%	2
Cables	3.4%	3
Fibre glass	3.3%	3
Epoxy	1.3%	4
Copper	0.4%	5
Aluminium	0.3%	5
Magnet	0.2%	5

Total wind farm mass : 2969 tons

Materials	Monetary Value(%)	Rank
Cables	32.1%	1
Steel	30.6%	1
Foundations	25.1%	1
Copper	8.5%	2
Cast iron	4.4%	3
Aluminium	1.7%	4
Magnet	0.5%	4
Epoxy	-0.8%	5
Fibre glass	-2.1%	5

Total WF monetary potential : 704714 EUR

Results: Material Ranks

Materials	Recycling rate	Rank
Copper	98%	1
Cast Iron	98%	1
Aluminium	95%	1
Steel	92%	2
Cables	90%	2
Foundations	50%	3
Fibre glass	15%	4
Epoxy	15%	4
Magnet	5%	5

CO_2 emissions after recycling

Materials	GHG emissions (ton CO2-eq / ton)	Rank
Magnet	12.51	1
Fibre glass	5.82	2
Epoxy	2.80	3
Aluminium	2.77	3
Copper	2.27	3
Cables	1.68	4
Foundations	1.42	4
Steel	0.67	5
Cast Iron	0.37	5

Results: Material Ranks

Materials	Complexity Rank
Magnet	1
Fibre glass	1
Epoxy	1
Cables	2
Foundations	3
Aluminium	4
Copper	4
Steel	5
Cast Iron	5

Complexity based on difficulty of recycling

Materials	Criticality Rank
Magnet	1
Steel	2
Cast Iron	2
Aluminium	3
Fibre glass	4
Epoxy	4
Cables	4
Copper	5

Criticality based on economic importance and supply risks

Conclusion

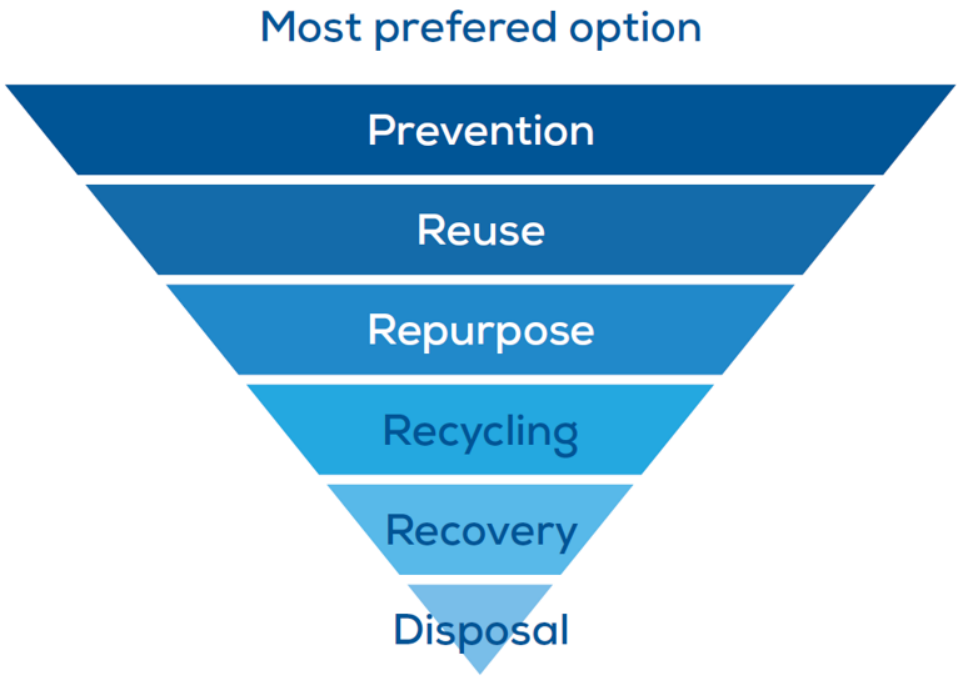
Ranked materials according to various parameters

- Steel : quantity
- Cable : environmental impacts, monetary potential
- Blades : complexity, image
- Magnets : criticality, environmental impacts
- Foundation (Steel) : regulations

- Increased focus on more effective disposal required

Recommendations

1. Improving lifetime extension
2. Increase focus on reuse, refurbish of components
3. Improve supply chain for cable, magnet, blade
4. Research effective foundation removal
5. Blades refurbishing, remanufacturing



Waste hierarchy according to CE principles[1]

Source- 1: Wind Europe, Accelerating Wind Turbine Blade Circularity

Thank you