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Decommissioning of Wind Farms – Ensuring Low Environmental Impact

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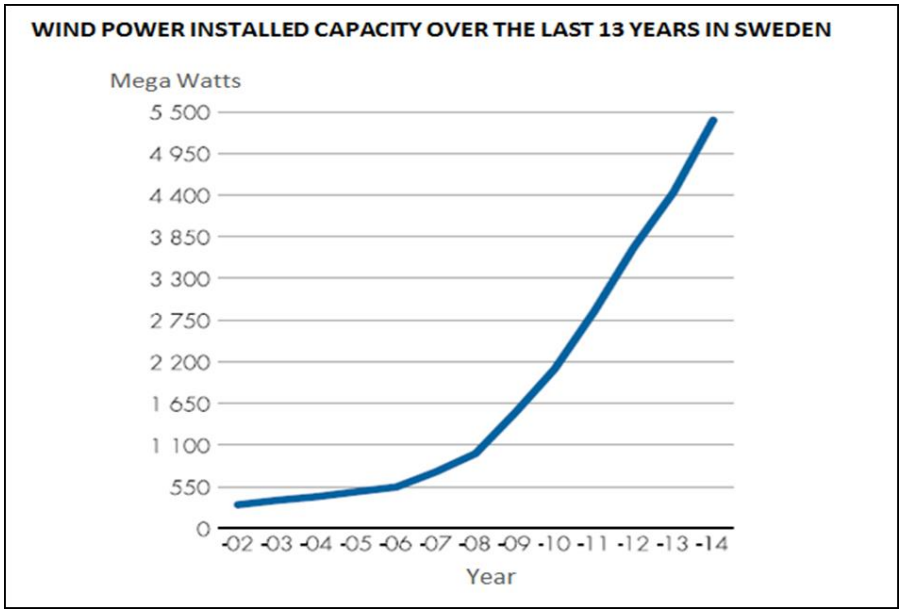
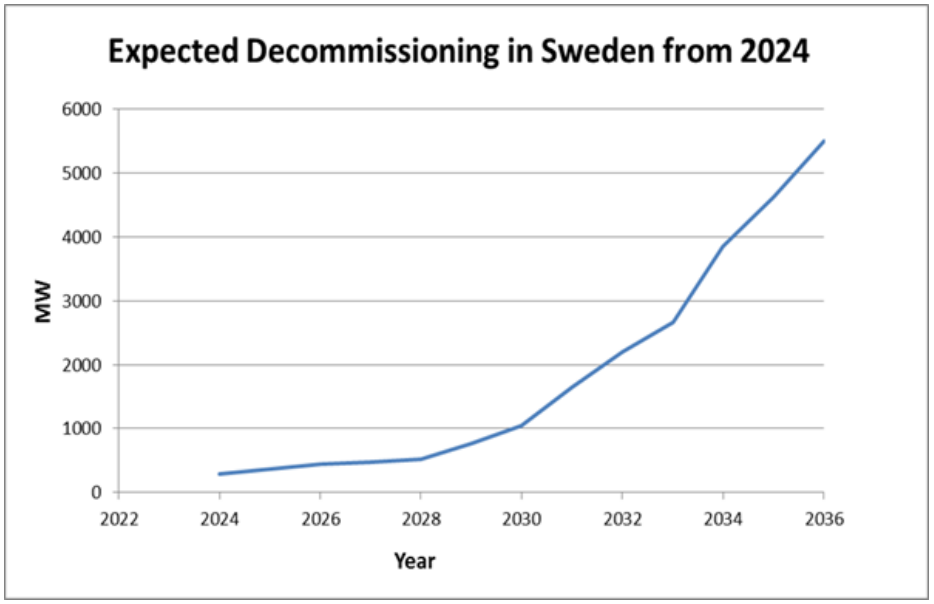
Installed Capacity of Wind Power and Decommissioning





Source: Svensk Energi, 2014

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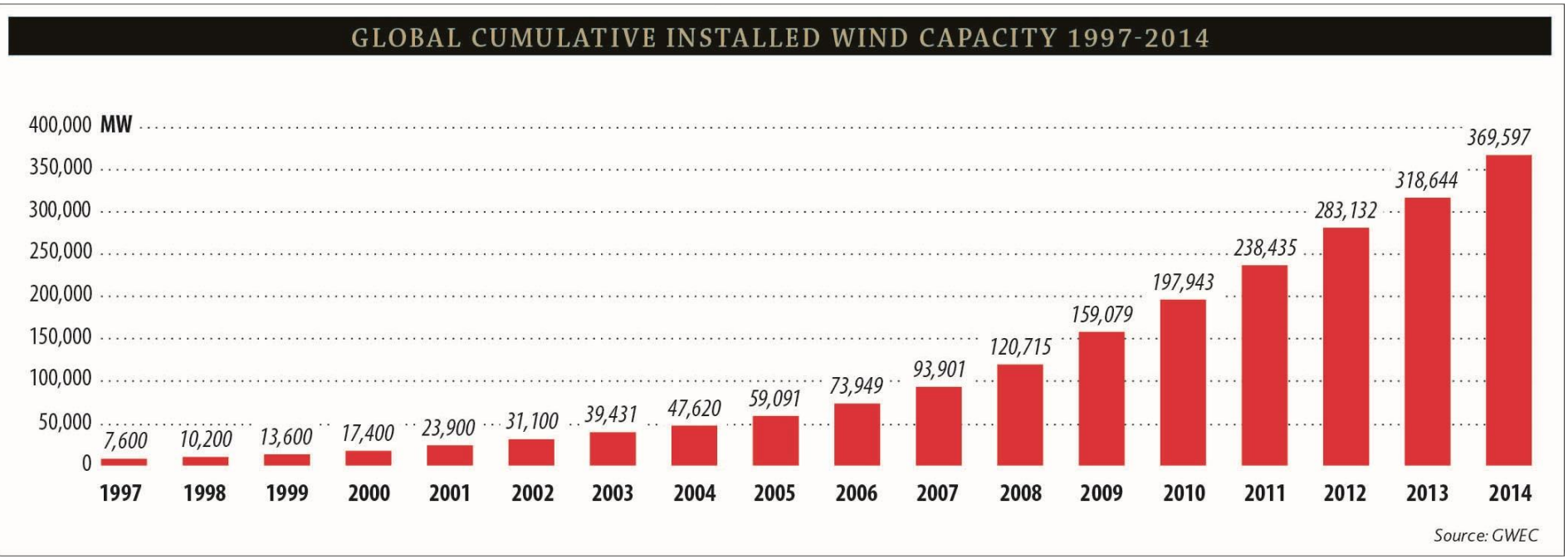
Installed Capacity of Wind Power and 20 years later decommissioning



Source: GWEC, 2015

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Decommissioning process

Dismantling of turbine

- Transport of crane
- Set up of crane
- Dissasembly of turbine

Treatment of blades

- Severing of blades
- Transport of blades
- Disposal of blades

Treatment of tower and nacelle

- Severing of tower & nacelle
- Transport of waste material
- Disposal of concrete
- Disposal of organic material
- Disposal of electronic components

Treatment of foundation

- Demolishment of foundation
- Severing of foundation
- Transport of waste material
- Disposal of concrete
- Disposal of metal
- Restoration of foundation site

Treatment of cables

- Excavation of cables
- Transport of cables
- Disposal of cables
- Restoration of cable site

Source: Perez O., Rickardsson E - 2008

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Disposal options by component

Component	Reef	Landfill	Scrap	Leave in place
Turbine Blades	N	Y	N	N
Turbine Nacelle	N	Y	Y	N
Turbine Tower	N	U	Y	N
Monopile-transition piece assembly	Y	Y	Y	N
Monopile	Y	U	Y	N
Cables	N	Y	N	Y
Scour protection	N	U	Y	Y
Substation foundation	Y	U	Y	N
Substation topsides	N	Y	N	N

(U = unlikely)

Source: Kaiser, M.J. & Snyder, B. - 2012

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Restoration grade onshore

	Denmark	France	Germany	Spain	UK	US
Foundation Removal Required	Partial, 1 meter	Partial, ,3-2 meters	Partial, varies by location	Partial, varies by location	Situation dependent	Partial, varies by location
Tower Removal Required	Yes	Yes	Yes	Yes	Most likely, situation dependent	Yes
Cable Removal Required	Can be required	Yes, Within 10 meters of the turbine and transfer station.	Can be required	Maybe, varies by location	Situation dependent	Maybe, varies by location
Crane Pad Removal Required	Can be required	Yes	Yes	Maybe, varies by location	Situation dependent	Yes, varies by location
Road Removal Required	Can be required	Yes	Yes	Maybe, varies by location	Situation dependent	Maybe, varies by location

Source: Aldén et al., 2014

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Decommissioning costs

	Denmark			Sweden				USA		
Size (MW)	0,2	0,6	1,65	0,225	0,5	2	2	1,5	2	2,4
Cost (ThSEK)	53	130	427	40	270	1 125	465	349	749	729
Cost SEK/kW	267	217	258	181	539	563	232	240	386	313

Source: Aldén et al - 2014

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Costs of Decommissioning

- Installed capacity
- Geografical location
- Restoration grade

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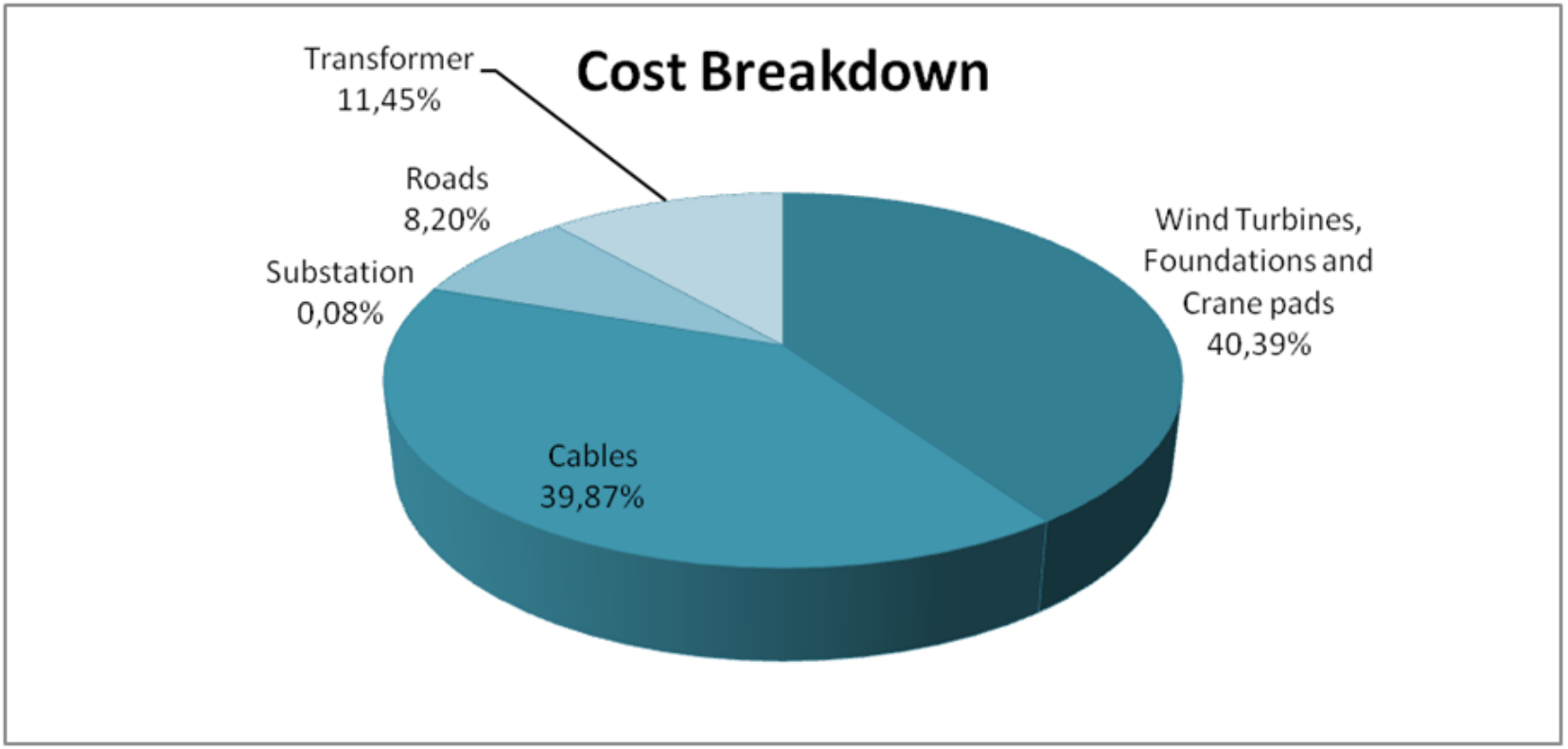
Decommissioning costs in Italy



Source: Falco M. – 2014

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Decommissioning costs

Restoration Level	Sweden Model example	Sweden Gotland	Sweden Västerbotten	Italy Unknown	Sweden Falkenberg	Sweden Gotland
	1.65 MW	2 MW	2 MW	2 MW	0,225 MW	0,5 MW
	Estimated case	Estimated case	Estimated case	Estimated case	Actual case	Actual case
Foundations	✓	✓	✓	✓		✓
Cables	✓			✓		
Crane pads		✓		✓		✓
Roads		✓		✓		✓
Total Cost	1.482.000	1.125.000	465.000	4.000.000	41.643	269.600
Total cost per MW	898.000	562.000	232.000	2.000.000	181.000	539.000

Source: Aldén et al - 2014 & Perez O., Rickardsson E. – 2008

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Security bond

Source: Aldén et al - 2014

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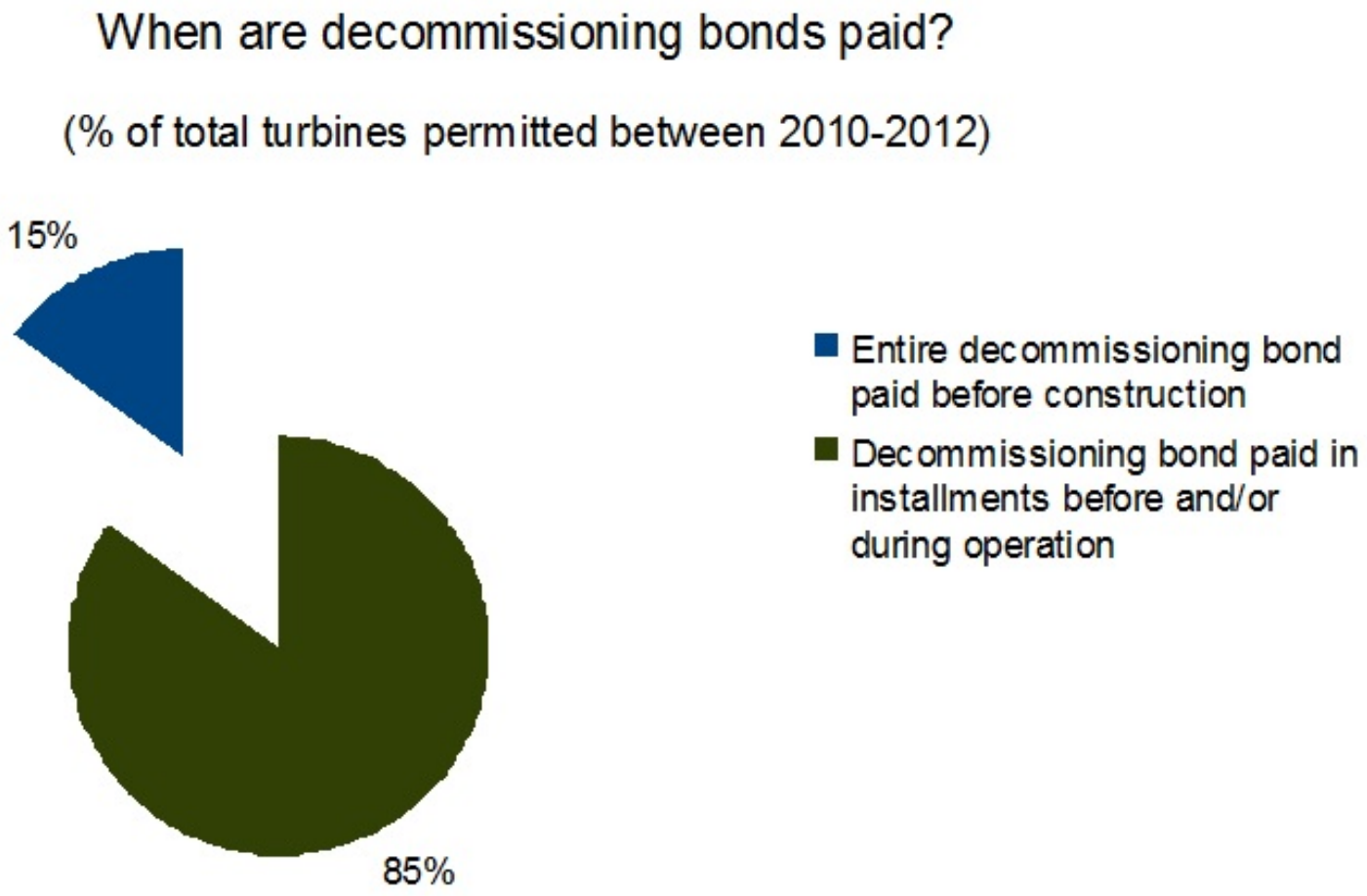

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Estimated decommissioning costs

Scenario	Turbine	Quantity	Cost of decommissioning per WT (SEK)	Residual value per WT (SEK)
1	Vestas V112 – 3MW	13	478 950	228 360
2	Nordex N117 – 2.4 MW	35	405 400	213 120
3	Siemens SWT 107 – 3.6 MW	8	445 460	205 030
4	Vestas V82 – 1.65 MW	20	351 260	100 735

Source: McCarthy, 2015

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Estimated decommissioning costs – scale factor

Scenario	Turbine	Quantity	Cost of decommissioning per WT (SEK)	Residual value per WT (SEK)
5	Vestas V112 - 3MW	8	501 450	218 348
1	Vestas V112 - 3MW	13	478 950	228 360
6	Vestas V112 - 3MW	20	446 380	222 330
7	Vestas V112 - 3MW	35	428 950	222 480

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Decommissioning of Wind Farms – Ensuring Low Environmental Impact

- Environmental impact of wind farms is relatively small and reversable
- Reuse or recycling of materials
- Foundations and cables often partly removed
- Security bonds neccessary to guarantee restoration
- New calculation methods and authorities approval need to incorporate residual value
- Need to explore new ways to secure the bonds