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Management of End of life of Wind Farms

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Management of End of life of Wind Farms

- Introduction End of life of Wind Farms
- Choices at end of technical life time
- Decommissioning Policy Review
- Turbine disposal
 - Metal Prices
 - Blade Disposal
- Decommissioning costs
 - Security bonds
 - Restoration grade



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Management of End of life of Wind Farms

Guiding factors in terms of sustainability

- Life time extension
- Repowering
- Circular economy



Management of End of life of Wind Farms

Managing the asset of a Wind Farm

- Many different factors are involved
 - Technical conditions of the wind farm
 - Operation and maintenance strategy
 - Wind resource
 - Permit
 - Policy regarding planning, environmental impact, financial support etc.
 - Lcoe/Financial potential



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Choices at end of life

- Repowering
- Life time extension
- Decommisioning



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What do we mean?

- **Repowering**
 - Use the site
 - New turbines, new foundations, grid?
 - Increase energy production
- **Life time extension**
 - Keep using foundations, tower, grid
 - New nacell, new blades
- **Decommissioning**
 - Take down turbines
 - Restore the site



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What are the choices?

- **Repowering**

- Is there potential to use the wind resource more effectively?
- Is there potential according to planning and permitting?
- Is there potential for technology and infrastructure?

- **Life time extension**

- How long is the permit valid?
- Any financial support?
- Technical condition
- O&M

- **Decommissioning**

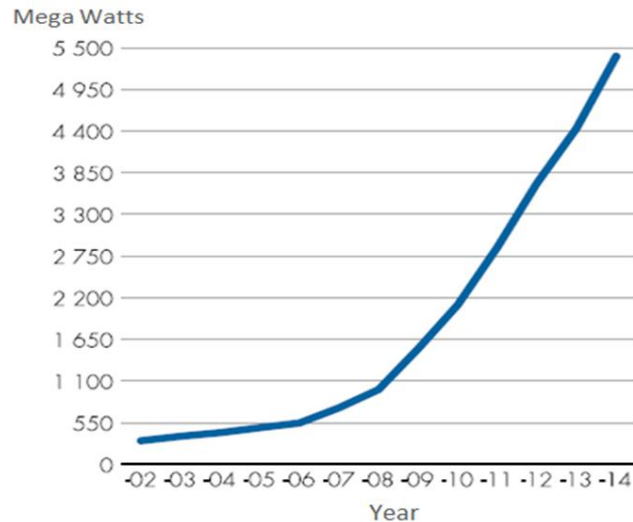
- If the two above doesn't work out



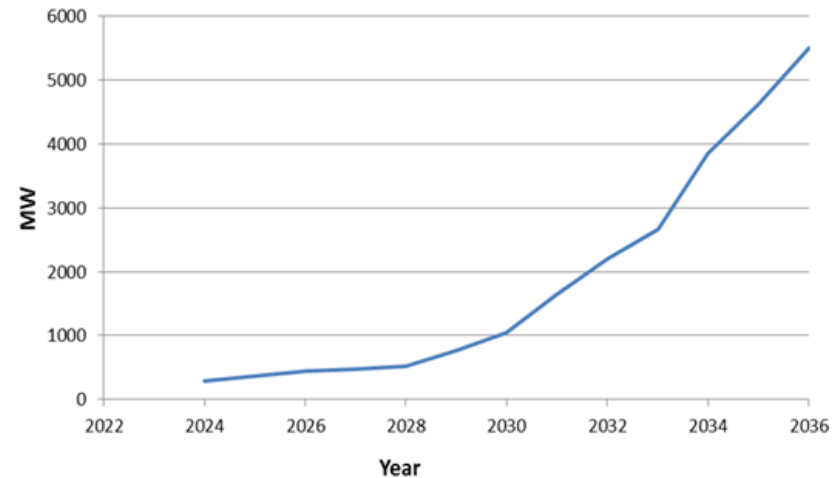
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Installed Capacity of Wind Power and Decommissioning

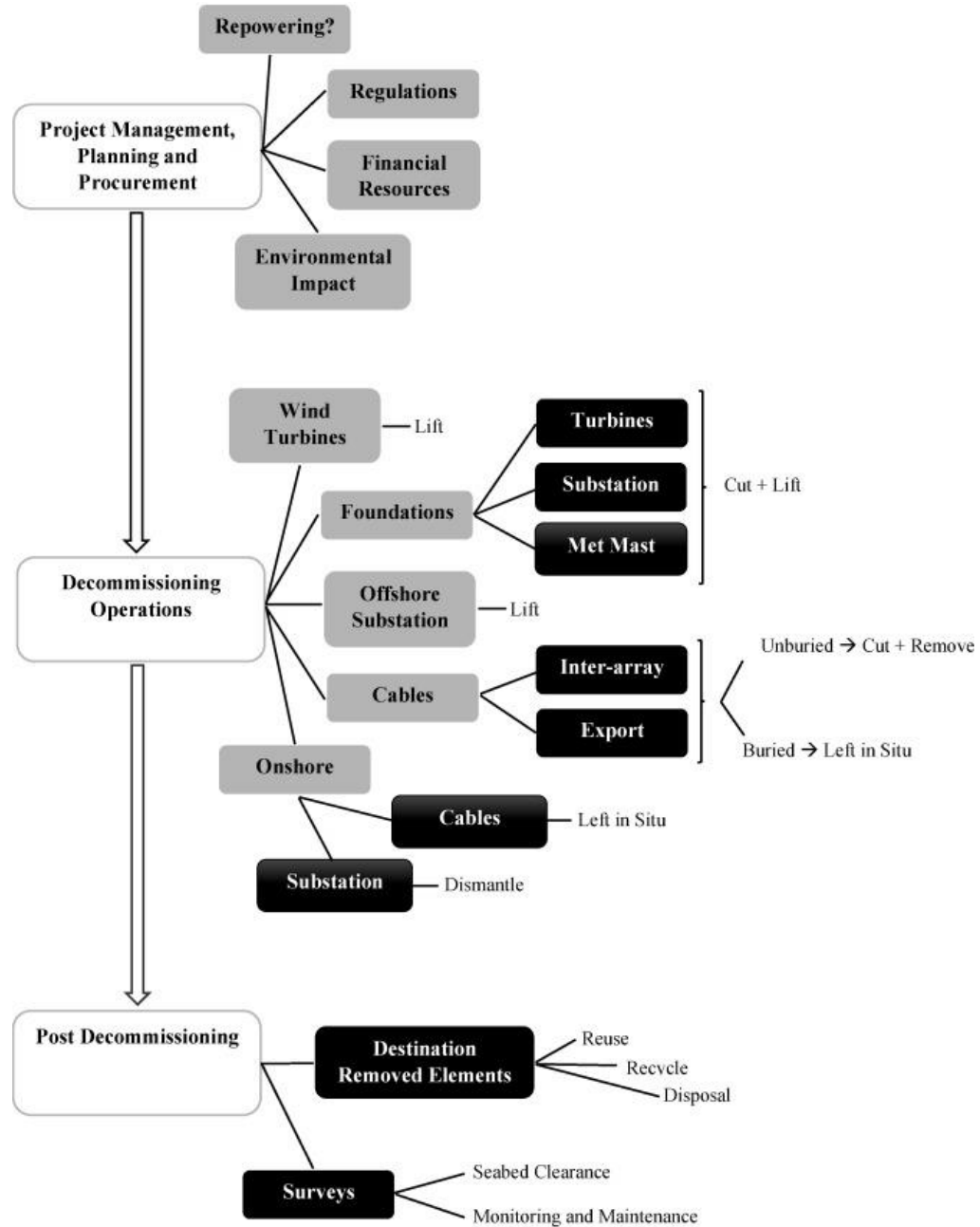
WIND POWER INSTALLED CAPACITY OVER THE LAST 13 YEARS IN SWEDEN



Expected Decommissioning in Sweden from 2024



Source: Svensk Energi, 2015

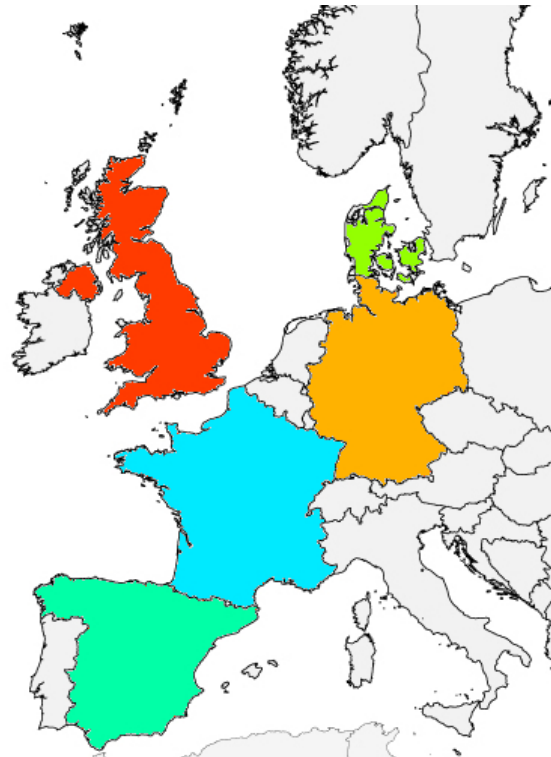




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Decommissioning Policy

- The policies in Denmark, France, Germany, Spain, the U.K. and the U.S. are reviewed as well as in Sweden





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Who decides the policy?

Onshore

Predominate National Level

Denmark (guidelines and over 150 meters)

France

U.K. (over 50MW)

Predominate Local Level

Germany

Spain

U.S.

U.K. (under 50MW)

Sweden



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Who decides the policy?

Offshore

Predominate National Level

Denmark

France

Germany

Spain

U.K.

U.S.

Sweden

Predominate Local Level

Germany (in territorial waters)

U.S. (in territorial waters up to 3 nautical miles)

U.K. (in territorial waters with installed capacity under 100MW)



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Security Bond

- Security bond is needed to guarantee restoration if the owner is unable
- In Sweden a security bond is set as a part of the environmental permit



Security Bonds

- Denmark- Can be required for onshore and offshore
- France- Required for onshore and offshore
- Germany- Can be required for onshore and offshore
- Spain- Can be required for onshore and always required for offshore
- U.K.- Can be required for onshore and offshore
- U.S.- Always required on federal land, can be required for other areas
- Sweden- Required for onshore and offshore



International standard

- Does not exist yet
- A significant share of Europe's wind turbine fleet will come to the end of its projected lifetime within the next 10 to 15 years
- Task Force on Dismantling and Decommissioning, including the whole wind energy supply chain
- First report on Decommissioning of onshore wind turbine
 - Includes examples of Decommissioning plan and Decommissioning communication plan



Onshore Comparison

<u>Onshore</u>	Sweden	Denmark	France	Germany	Spain	U.K.	U.S.
Decomm. Policy	Local	National	National	Local	Local	National/Local	National/Local
Level of restoration	Case by case locally determined	Nationally determined with local input	Nationally determined	Locally determined	Locally determined	Case by case locally/nationally determined	Nationally determined/locally determined
Decommissioning bonds	Required	Can be required locally	Required	Can be required locally	Can be required locally	Can be required locally/nationally	Required on federal/can be required locally



Offshore Comparison

<u>Offshore</u>	Sweden	Denmark	France	Germany	Spain	U.K.	U.S.
Decomm. Policy	National/ Local	National	National	Most National	National	National/Local	National/Local
Level of restoration	Locally determined case by case	Nationally determined case by case	Nationally determined	Nationally determined case by case	Nationally determined case by case	Case by case locally/nationally determined	Nationally determined/locally determined
Decommissioning bonds	Required	Can be required nationally	Required	Can be required nationally	Required	Can be required locally/nationally	Required on federal/can be required locally



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Resource management

- Oils
- Metals
- Rare Earth Metals
- Composites
- Concrete
- Cables



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Turbine Disposal

- What are the options?
 - Reselling
 - Remanufacturing
 - Recycling
- What are companies doing?



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Reselling

- Turbine may be resold as is
 - The buyer pays for the turbine and to move the turbine
 - The owner takes down the turbine and finds a buyer
 - The owner sales to a third party who would then remove and resale the turbine



Products

- Wind turbine
- Used wind turbine
- Refurbished wind turbine
- Remanufactured Wind Turbines
- Domestic wind turbine
- Hybrid System

Focus areas

- Engineering
- Promoters wind farm
- Climate Change
- Energy projects

Our services

- Purchase wind turbine
- Sales wind turbine
- Dismantling wind farm
- Inspection & Quality
- Repowering
- Engineering
- EPC Energy Projects
- Turnkey Energy Plants
- Installation
- Transport & Logistic

Resources

- Financing Wind projects
- Marketplace

More on REPOWERING

- Careers
- Company profile
- References
- Partnerships
- Research & innovation

Used wind turbine for sale

REPOWERING sells used and new wind turbines and spare parts. In case you want to receive more information about one or more wind turbine models or parts, please you can download list of used/refurbished wind turbines, also you send contact form with your request info. You will receive the information by e-mail.



Planning, financing and operational management of wind farms worldwide

Second hand wind turbines

Repowering Solutions is a supplier of wind turbines second hand, new and refurbished wind turbine.

Our goal is working with reconditioned turbines where we can provide a competitive solution. Those turbines sometimes are not older than 5 or 10 years and the technology is reliable and compliant with all legislation. As reconditioned we can provide full warranty and the cost usually drops to a half or less than new turbines. This advantage makes a cash flow turn to positive

Contact us

If you need more information about our services or you are ready to request a quote.

E-mail

Support & Download

Support and Downloads



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Remanufacturing/Refurbishing

- Renovation of parts
 - Gearbox, pitch and yaw systems, etc.
- Half as expensive as new parts
 - Decreased life expectation
 - Quality and quantity concerns



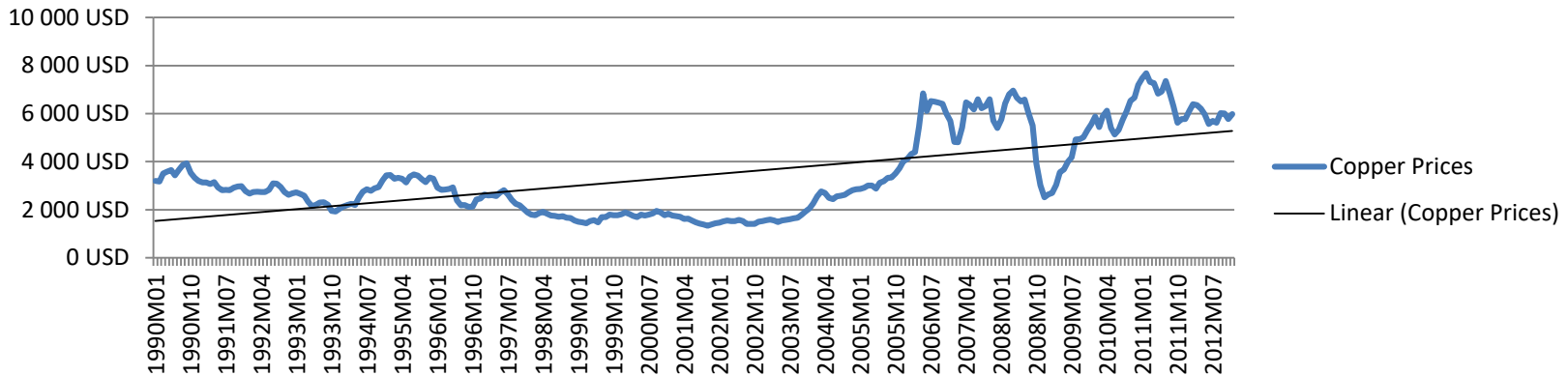
Recycling

- Approximately 80% of a wind turbine's weight comes from its tower, gearbox and blades.
 - Primary metal components
 - Steel (nickel and iron)
 - Copper
 - Aluminum
 - Non-metal components
 - Foundation
 - Blades
 - Quality is important



Copper

Copper Prices per Ton 1990-2012



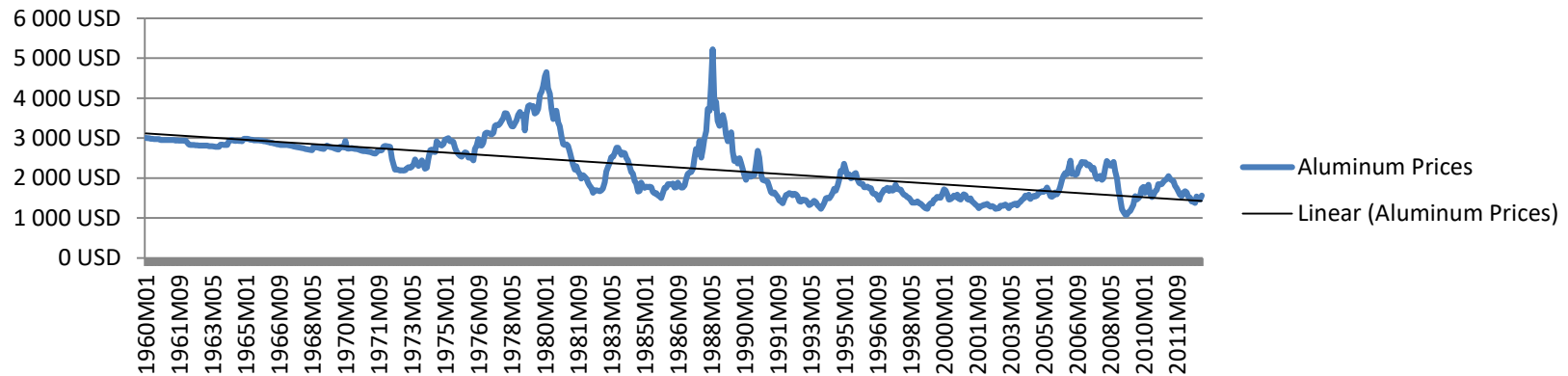
Copper Prices per Ton 1960-2012



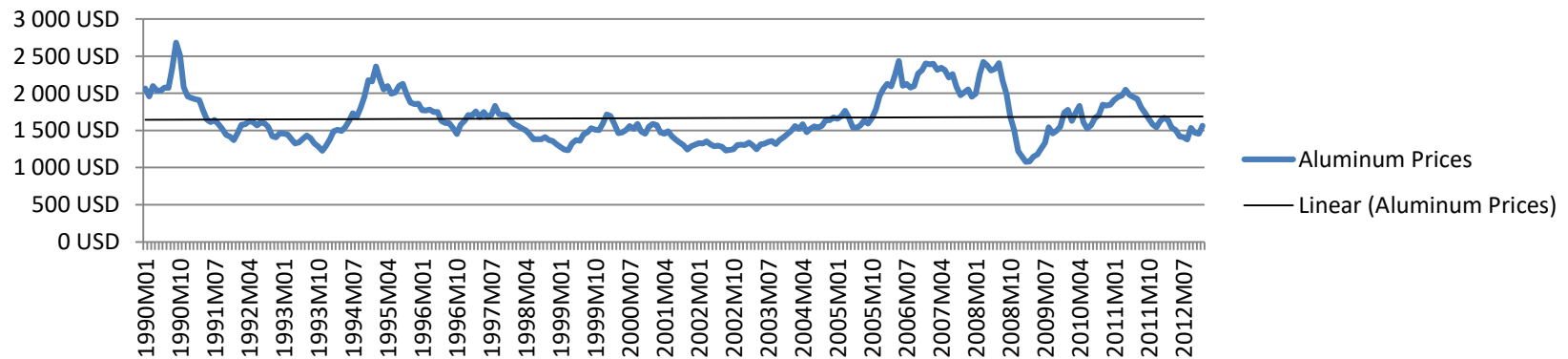


Aluminum

Aluminium Prices per Ton 1960-2012



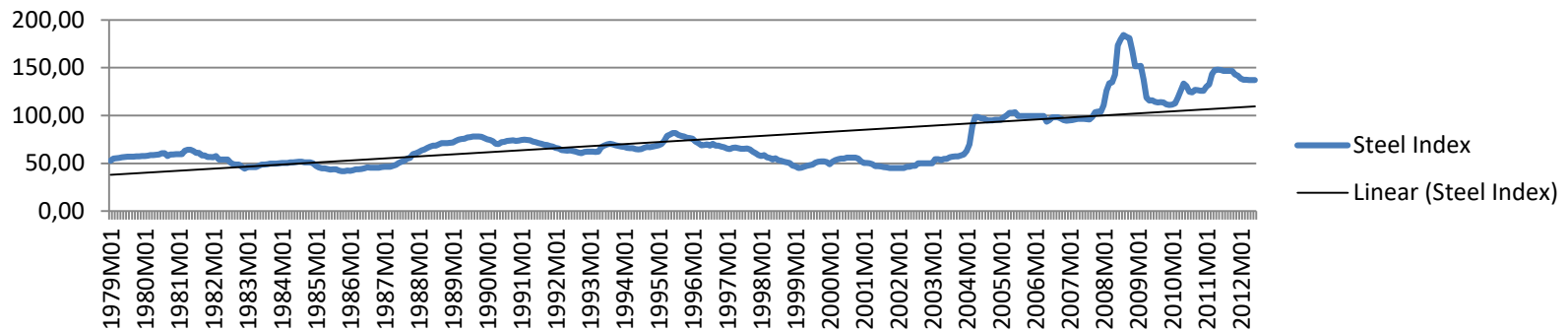
Aluminium Prices per Ton 1990-2012



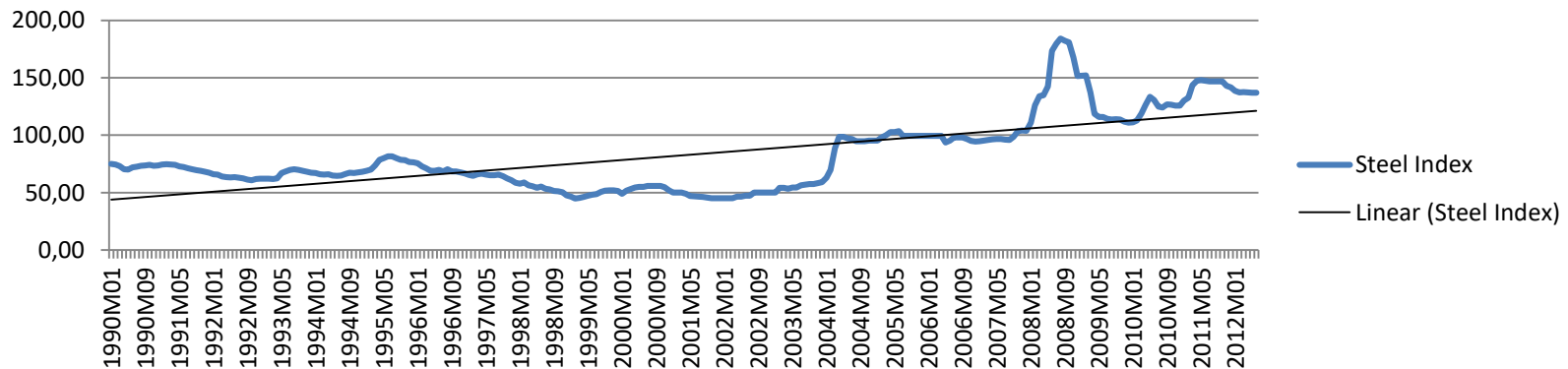


Steel

Steel Index Price 1979- June 2012



Steel Index Prices 1990- June 2012





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Blades

- Limited disposal options
 - Landfill
 - Mechanical
 - Pyrolysis
 - Oxidation in fluidized bed
 - Chemical
 - Energy recovery
 - Non-conventional





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Resource management

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Decommissioning costs

- Crane costs
- Labour costs
- Transport of materials
- Landfill cost
- Working to suitable size metals
- Removal of foundations
- Restoration of crane pads
- Restoration of roads
- Removal of cables
- Income
 - Reselling
 - Recycling





Decommissioning costs

	Danmark			Sverige				USA		
Size (MW)	0,2	0,6	1,65	0,225	0,5	2	2	1,5	2	2,4
Cost (Thousands of SEK)	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



Costs of Decommissioning

- Installed capacity - wind turbine size and amount
- Geographical location
- Grade of restoration



Reuse, recycle and restoration grade

- Re-sell wind turbine
- Recycle metals, but wind turbine blades are challenge
- Removal of foundations, crane pads, roads and electrical cables



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



Decommissioning costs

Wind turbine	Blade diameter (m)	Hub height (m)	Decommissioning cost high (ThEuros per WTG)	Decommissioning cost low (ThEuros per WTG)	Actual WTGs	Resold/recycle income low (ThEuros per WTG)	Resold/recycle income high (ThEuros per WTG)
Vestas V27	27	30	8,5	6,5	20	35	59
Vestas V29	29	30	8,5	6,5	5	48	78
Wind World 150 kW	20	24	8,5	6,5	3	9	13
Wind World 250 kW	25	30	8,5	6,5	2	16	27
Vestas V47	47	40 - 50	25	20	bid		
Vestas V52	52	65	50	40	bid	100	150*

*transport and deconstruction ~100 ThEuros



Security bond in Sweden 1

- Onshore security bond per wind turbine 300 000 to 400 000 SEK
- 15 % of entire decommissioning bond paid before construction
- 85 % of decommissioning bond paid in installments before and/or during operation
- Big variation 250 000 to 1 300 000 SEK per turbine
- Offshore was 1,5 million SEK per turbine



Security bond in Sweden 2

- The entire decommissioning bond paid before construction
- Most common 500 000 SEK per turbine
- Difference between concrete and steel towers.
- Example of 700 000 SEK steel tower and 1 million SEK concrete tower per turbine
- Recent example of 1,25 million SEK
- New insurance solution available



Guidance for restoration

- Swedish Environmental Protection Agency and Energy Agency
- Suggests that restoration grade and post treatment is set by the environmental permit
- Income from recycling of metals will not be considered when the security bond is set



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



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

Source: McCarthy, 2015



Decommissioning costs – scale factor

Wind turbine	Blade diameter (m)	Hub height (m)	Decommissioning cost bid (ThEuros per WTG)	Number of WTGs
Vestas V90	90	95	196	1
	90	95	147	2
	90	95	115	5
	90	95	105	10



Decommissioning of Wind Farms –

- In the planning phase you have the possibility to prepare for a limited environmental impact
- Decommission plan and costs needs to be considered/estimated in the planning phase
- Decommission costs are difficult to estimate
- Security bonds are often required
- Need to explore new ways to secure the bonds

