Life Cycle Assessment of Wind Energy Converter

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1. Methodological Approach

Besides water, biomass, photovoltaic and wind energy are the most favourable renewable energy technologies globally. There is an enforced market introduction from onshore and also offshore wind facilities worldwide. The construction of wind parks is material-intensive; it needs a big amount of conventional energy, such as fossils, to produce it.

To examine the energy efficiency under these aspects, the international methodical approach of Life Cycle Assessment (LCA) was used. LCA is an instrument to quantify all impacts of the entire energy supply chain. To obtain the Cumulative Energy Demand (CED) for production, for instance of a wind converter, the whole facility has to be split up into components, sub-components and their respective materials. Using this material balance with specific data for energy and emissions, it is possible to calculate the CED.

For the final evaluation of the energy systems, the Energy Payback Time as a relationship of produced energy (valued as primary energy) to total CED has been used to decide if market introduction of wind energy is sustainable enough or not.

Within a survey (Mathur, Wagner, Bansal, 2007) this has been examined and discussed for wind energy converters with different nominal power output. For calculating the annual energy output, two locations of wind converters have been selected: near coastal and offshore. A large Wind Energy Converter (WEC) of 1.5 MW with 67 m hub height and 66 m rotor-blade diameter has been chosen for consideration. In addition, a park of multi-megawatt wind turbines in the ocean, 30 miles far away from the coast is considered. The reference unit for the offshore use is a prototype wind turbine of 5 MW with a 90 m hub high and 126 m rotor-blade diameter. For finding the material and energy balances, both wind turbines have been considered to be divided in four parts which are: rotor blades, machinery, tower and foundation. In addition, energy consumption for service and maintenance and also for transportation, mounting and dismantling has been taken into account.

2. Cumulated Energy Demand

The CED of the regarded onshore wind turbine sums up to about 13 500 GJ. The most important component group, due to a high content of energy-intensive materials (e.g. copper for the generator), is the machinery with a share of about 46 %. The tower has also a big share of about 28 %. The foundation holds 11 % and rotor blades hold about 8 %. For service and maintenance only 1 % of the total CED is needed while transportation, mounting and dismantling contribute about 6 %.

The CED of the offshore wind turbine sums up to about 85 000 GJ whereas the tripod foundation made of steel has the biggest share of about 31 %. In contrast to the 1.5 MW wind turbine the machinery only has a share of about 20 %. The tower contributes about 15 % while rotor blades hold a share of 7 %. Service and Maintenance during the lifetime of the wind turbine contributes about 22 % to the total CED. The major share of maintenance goes in replacement of components (e.g. gear box). For transportation, mounting and dismantling 5 % are needed.

3. Energy Payback Time

The net harvest of energy has to be appraised to calculate the Energy Payback Time (EPT). The net electrical power output can be found by the installed load of the wind turbines and the expected capacity factor. Using the German average primary energy conversion factor of electricity of 0.33 the net harvest has been converted to yearly energy output as equivalent primary energy (see Figure 1). The Energy Payback Time for the 1.5 MW coastal Wind Turbine is about four months while the Energy Payback Time for the 5 MW offshore design is approximately five months. The results show e. g. that - surveying the life cycle of a modern wind turbine, - much more primary energy can be harvested during the operational phase than is actually needed in the constructing phase.

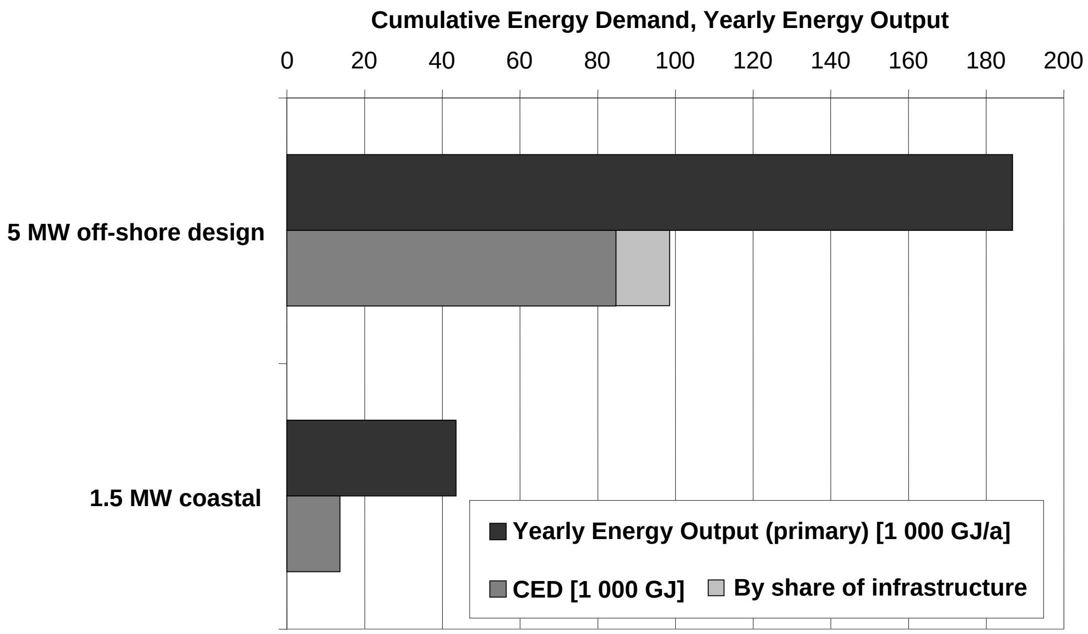

Figure 1: Comparison of CED and Yearly Primary Energy Output

4. Wind energy in India

The above described studies have considered the situation in Germany. Another important country using wind energy is India. Therefore also the energy analysis for Indian conditions is highly important. A very detailed and excellent analysis, also in respect to the possible maximum growth rates due to the needed CED, has been done by Mathur (Mathur et al., 2004). The results show that the offshore use of wind energy in different regions of India is also well-appropriated in respect of the yearly energy yield. To advise politics in term of market introduction of renewable energies, it is absolutely necessary to do such kind of investigations.

5. References:

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