WWF Climate & Energy

HARNESSING THE POWER OF THE WIND

WWF supports both onshore and offshore wind power as a major solution to the various problems the world faces with its present energy supply

WWF advocates for 100% clean and sustainable renewable energy for all by 2050. By early 2013, all renewable energy sources (RES) contributed almost one fifth of all primary energy use. About half of this is traditional, unsustainable biomass used mainly for cooking in developing countries. Yet renewables are growing rapidly, particularly in the power sector.

More than 5% of all global electricity supply is now coming from wind, solar and geothermal power. If we include hydro power, the share grows to about 18%. Recently more money was invested worldwide in new renewable power than in fossil and nuclear power.[1]

By early 2013, wind energy provided almost 3% of all electricity generated gobally. Its present power capacity is about 300 GW.

1 REN 21, 2013: PEW/BNEF, 2013

Starting from less than $US 20 billion in 2004, global investments in wind power grew to $US 80 billion in 2012.[2]

Leading countries with regard to installed wind power capacity are China (75 GW), US (60 GW), Germany (30 GW), Spain (22 GW) and India (18 GW), followed by UK, Italy, France, Canada, Portugal with just below 10 GW wind power capacity.[3]

However, in terms of per capita instalment of wind power (in Watts/person), things look slightly different. [4]

World	41 W/cap.
Denmark	745
Spain	500
Portugal	450
Sweden	400
Germany	390
Ireland	390
US	190
Canada	180
Greece	160
China	60
India	16

The EU consumed about 7% of its power needs from wind in 2012 with Denmark, Portugal and Spain leading with about 30%, 20% and 16% respectively.

Presently, onshore wind dominates the wind technology option with more than 90% of wind power generators terrestrially situated. However, offshore wind is expected to take a growing share in the future. Its comparably high capacity factors[5] and potential scale and size will attract many conventional energy investors to also look for new options in the classical 'base load' electricity supply scheme.

Wind power already provides about 750,000 jobs globally, with China and the EU each creating around 40% of that total. Since 2008, wind turbine prices overall fell by 25% (Organisation for Economic Co-operation and Development - OECD) and 35% (China).[6]

Together with continuously growing capacity factors, which are important for less variable [7] power supply, this brought the overall costs of electricity of wind power down in all regions. Capacity factors for wind power grew from 25% to 35% since 1999 in the US, for instance. Coupled with more efficient technology, the development of larger wind turbines contributed to increased capacity as they take advantage of more continuous wind at higher altitudes. Depending on good locations and technology choice, capacity factors may reach 50% in Latin America, EU and Africa.[8]

Presently, the LCOE [9] of new onshore wind is between $US 0.06 and 0.14/kWh worldwide depending on national/regional circumstances. This is comparable to OECD fossil fuel LCOE. Overall lowest wind power costs are seen in some parts of China, US and EU. The majority of all wind power costs – between 65% and 85% - are spent during the initial installation. Grid costs can be kept well below 10% but may increase if grid connections are not part of the overall system development of a wind park.

By 2020, offshore wind parks, which still are up to twice as costly than onshore, are expected to reduce by about 25%. The cost decline for onshore wind is expected to be less.[10] However, it is projected that by 2030 wind LCOE in OECD and China with capacity factors of only 25 – 35% will be cheaper than LCOE for coal and gas even without any carbon price.[11]

2 REN 21
3 REN 21
4 GWEC 2013a, IEA 2012
5 Capacity factor refers to percent of total time of year when full power is being produced. For instance a capacity factor of 80% tells us that plant runs 80% of the year.
6 REN 21
7 Variable power supply refers to weather depended electricity generation mainly by wind and solar.
8 IRENA, 2013
9 LCOE – Levelised Cost of Electricty. Calculates the production cost of a certain power technology over expected lifetime and is expressed in manu facturing cost per kWh. LCOE includes all initial installations costs, maitenenace and operations as well as fuel costs and in some cases decommission ing. LCOE does not include any externalities such as CO2 or general air and water pollution, solid and nuclear waste generation, as well as overall land and biodiversity impacts.
10 IRENA, 2013
11 Bloomberg New Energy Finance, 2013
12 BNEF, 2013
13 GWEC, 2013b

Long-term implementation projection based on "normal" development for 2030 predicts that wind power (mainly onshore) may provide more than 1500 GW capacity, about five times as much as today.[12]

The wind industry foresees that wind power could supply up to 12% of global electricity by 2020, creating 1.4 million new jobs and reducing CO_2 emissions by more than 1.5 billion tons per year. This represents about 5% of all present CO_2 emissions. By 2030, wind power could even provide more than 20% of global electricity supply.[13]

Impacts of wind power

All energy projects have environmental impacts. This includes renewable energy projects and installations. Some renewable technologies can have both positive and negative environmental impacts, particularly if they are not properly planned and executed.

However, most renewables with the exception of bad-practice bioenergy, have no harmful greenhouse gas or other air or water polluting emissions (such as SO_2, NO_x, heavy metals, ashes etc) while in operation. They do not create any solid waste such as coal ashes and hence have a huge advantage over all fossil fuels.

Renewables also do not create any toxic waste which is one substantive benefit when compared to zero-carbon nuclear.

Compared to conventional fuels, solar PV, geothermal and windpower require negligible amounts of freshwater.[14] Economically and socially, renewables provide more jobs per unit energy than conventional fuels and become increasingly cost-competitive in many markets and regions. In 2012, wind and solar combined provided more than 3 million jobs worldwide, about 50% more than the 20 largest oil and gas companies put together.

Domestic renewable energy installation such as wind power substantially decreases the need for costly fuel imports for electricity from oil, gas and coal. This is particularly relevant in poor developing countries (LDC) where the net value of fossil fuel imports is about 10% of GDP on average but can be much higher in individual countries.[15]

According to The Energy Report[16] calculations "an additional 1 000 000 onshore and 100 000 offshore wind turbines would meet a quarter of the world's electricity needs by 2050".

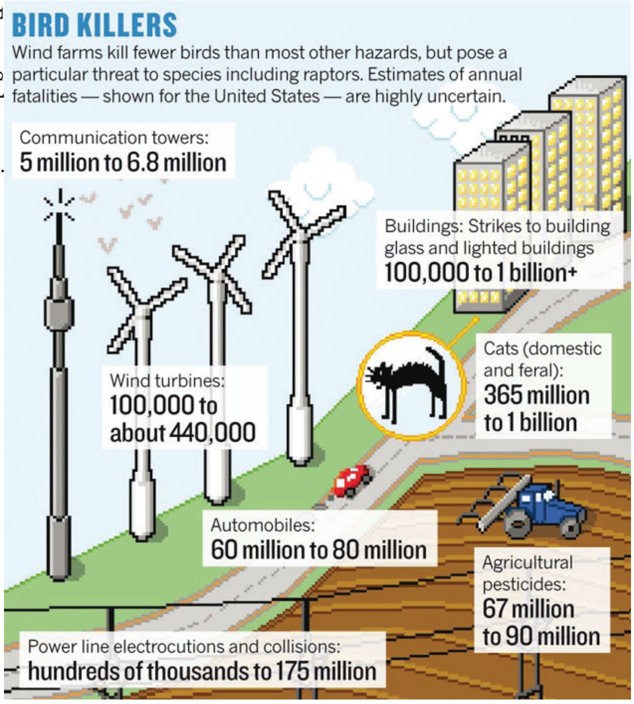
Onshore and offshore wind turbines would produce almost 30% of our global electricity needs. This would mean that wind technologies would expand massively. Presently wind power provides more than 5% of all global electric capacity and due to lower load factor than conventional power stations almost 3% of all electricity in mid 2013.

Compared to all conventional fossil and nuclear technologies, WWF strongly supports both onshore and offshore wind power as a major solution to the various problems the world faces with its present energy supply.

However, local and regional impacts may occur.

14 IPCC, 2011
15 IEA, 2011
16 WWF, 2011

From: Subramanian, 2012



What kind of environmental impacts could result from such an expansion of wind energy? Such a question is not entirely theoretical, since Denmark already sources nearly 30% of its electricity from wind and aims for 50% by 2020.

First and foremost, good participatory planning and the implementation of an Environmental Impact Assessment is crucial. This should encompass the responsible siting of wind parks, avoiding locations particularly important for bird and bats migration, feeding and resting.

Wind parks will require dedicated land and sea areas, but would not limit this land/sea use to power production only. Land between turbines can still be used for agriculture, grazing or nature protection. Water between offshore turbines can still be used by marine life.

Finally, like all other technologies, wind power will require raw materials at the manufacturing and construction stage.

Generally, land and sea use and their consequences for biodiversity and materials use by wind power are by far the most important topics to be discussed.

Specific land and sea use and impacts on biodiversity

Manufacturing, transport, installation, operation and decommissioning of wind turbines induces some negative effects on land-based habitats and ecosystems. These include bird and bat collision, avoidance of or displacement from an area, habitat disturbances and, in the worst case, destruction and reduced species reproduction.[17]

Available literature shows mortality estimates of all species of birds combined ranging from 0.95 to 11.67/MW/yr.[18] Bat fatalities range from 0.8 to 41.1 bats/MW/yr.

The magnitude and population-level consequences of these bird and bat collision fatalities are not negligible but “still appear to be orders of magnitude lower than other anthropogenic causes of bird deaths (e.g. vehicles, buildings and windows, transmission lines, communications towers, house cats, pollution and other contaminants”.[19]

The vast majority of bird kills in the US are not as a result of windmills. Another recent study found much lower bird fatalities of no more 20,000 in US per year and a much lower casualty rate per kWh generated than fossil fuels or nuclear.[20]

Responsible siting for largely enhanced wind power development will further reduce and avoid the fatalities, particularly for bats and birds of prey.

For offshore wind energy, implications for benthic resources, fisheries and marine life must also be considered. The limited research to date does not suggest that offshore plants pose a disproportionately large risk to birds compared to onshore wind energy.[21] They find, for example, that seabirds tend to detect and avoid large offshore wind power plants. Potential other negative impacts include underwater sounds and vibrations important for

17 Drewitt and Langston, 2006; NRC, 2007; Stewart et al., 2007
18 NRC, 2007
19 Erickson et al., 2005; NRC, 2007
20 Sovacool, 2013
21 Dong Energy et al., 2006; Desholm & Kahlert, 2005
22 Wilhelmsson et al., 2006
23 IPCC, 2011

sensitive sea mammals especially during construction, electromagnetic fields, physical disruption and the establishment of invasive species.

The physical structures may, however, create new breeding grounds or shelters and act as artificial reefs or fish aggregation devices.[22] Additional research is still necessary but the impacts do not appear to be disproportionately large.[23]

Planning and siting

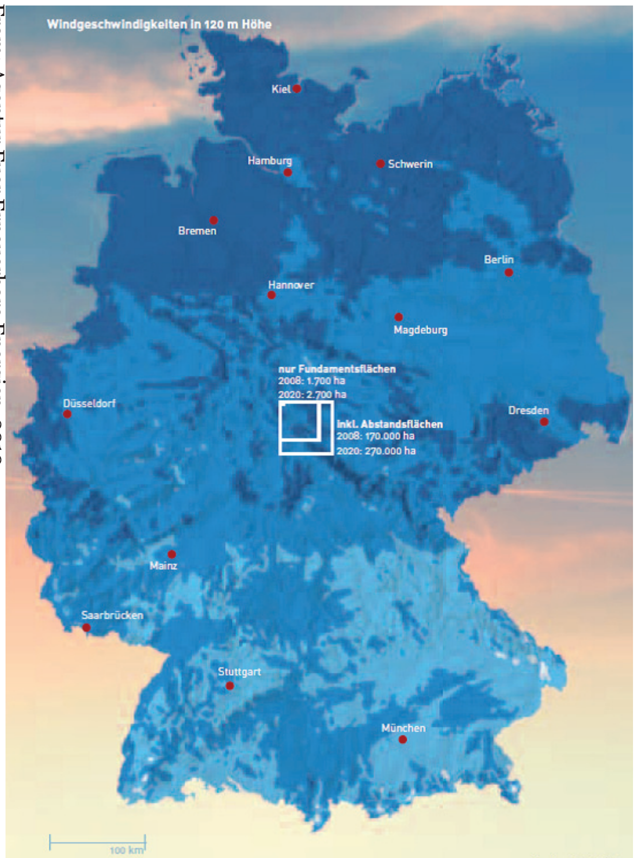
Appropriate planning and siting procedures can reduce the impact of wind energy development on ecosystems and local communities, and techniques for assessing, minimizing and mitigating the remaining concerns could be further improved. Wind energy projects should be subject to independent Environmental Impact Assessment (EIA) before consent is given.

This is law now in many countries. EIA should provide a comprehensive analysis of the potential impacts and benefits of the proposal upon the community, fauna, and flora and the atmosphere and must contain a comparison with energy was to be created by another energy source.

The EIA process should be transparent, involving full consultation with all interested parties early in the process.

Proposals for wind farm developments within IUCN category I-II protected areas and/or national parks should not be allowed, unless a comprehensive EIA clearly indicates that the proposed development will not cause adverse effects on the integrity or conservation objectives of the statutory protected area.

More research is needed on the precise impacts of large-scale offshore wind developments in marine environments, noting the data from existing offshore wind projects in Europe. However, available evidence suggests that the positive environmental and social effects of wind energy generally outweigh the negative impacts that remain after careful planning and siting procedures are followed.[24]



From: Agentur Fuer Erneuerbare Energien, 2010

Although community and scientific concerns should be addressed, more proactive planning, siting and permitting procedures may be required to enable more rapid growth in wind energy utilisation.[25]

Land requirements

Unlike several other energy industries, such as coal power plants or coal mines, wind parks allow for multiple uses of the land or sea. For reasons of aerodynamics, windparks need to leave substantial space between the individual towers. New windmill technologies with higher capacities of up to 5 MW will decrease the land area needed.

Agricultural activities can be combined with wind electricity production. Nevertheless, wind farms require space.

This German example (above) shows how much land would be required in this highly industrialised

24 Jacobson, 2009
25 IPCC, 2011
26 Willburn, 2011, WED, 2011
27 USGS, 2009

and comparably densely populated country to satisfy about 20% of projected electricity consumption by wind in 2020 (270 000 ha, represented by the largest square) and including the distance between the windmills. The very small white spot on the top left of the square indicates the space taken up by the wind turbines which amounts to a negligible 1% of the space required.

Materials use

The primary materials needed for wind turbines include steel for towers, nacelles and rotors; pre-stressed concrete for towers; magnetic materials for gearboxes; aluminium and copper for nacelles; wood epoxy and glassfibre reinforced plastic (GRP) for rotor blades; and carbon-filament reinforced plastic (CFRP) also for rotor blades. In the future, there is likely to be greater use of composites of CFRP, GRP, and steel.[26]

The earth does have somewhat limited reserves of presently economically recoverable iron ore (in the order of 100 to 200 years at current production rates),[27] but the steel used to make towers, nacelles, and rotors for wind turbines should be 100% recyclable. For example, in the US, 98% of steel construction beams and plates were recycled.[28]

Wind turbines also use Rare Earths, for example for permanent magnets, such as neodymium, dysprosium, praseodymium, terbium, chromium, nickel, molybdenum and manganese. However, even if the availability of such materials seems limited, alternative turbine designs are being developed and implemented.[29]

By using lifecycle analysis, alternatives assessment, and other tools, the wind industry can and does move away from the its very few but most toxic and hazardous inputs and makes sure some of these substances do not end up in the environment throughout the supply chain.

The wind industry is making progress in also ensuring a clean supply chain of other raw materials.

References

Agentur für Erneuerbare Energien e.V., 2010; Erneubare Energien 2020 – Potenzialatlas Deutschland

BNEF, 2013 (Bloomberg New Energy Finance); Global Renewable Energy Market Outlook 2013 – Fact Pack April 23, 2013

Desholm, M. and Kahlert, J.; 2005; Avian collision risk at an offshore wind farm. Biology Letters, 1 (3), p.296–298.

DONG Energy, Sweden & Vattenfall, Denmark, Skov- og naturstyrelsen, Denmark and Energistyrelsen, 2006; Danish offshore wind: key environmental issues.

Drewitt, A. L. and Langston, R. H. W., 2006; Assessing the impacts of wind farms on birds. Ibis, 148, pp 29–42.

Erickson, W. P., Johnson, G. D. and Young, D. P. J., 2005; A summary and comparison of bird mortality from anthropogenic causes with an emphasis on collisions. http://www.treesearch.fs.fed.us/pubs/32103

EWEA, 2012 (European Wind Energy Association); Personal Communication

GWEC, 2013a (Global Wind Energy Council); Global Wind Report – Annual Market Update 2012

GWEC, 2013b (Global Wind Energy Council); Global Wind Energy Outlook 2012

IEA, 2011 (International Energy Agency); World Energy Outlook 2011

IEA, 2012 (International Energy Agency); World Energy Outlook 2012

IRENA, 2013 (International Renewable Energy Agency); Renewable Energy Power Generation Costs in 2012

IPCC, 2011; IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation. In: Prepared by Working Group III of the Intergovernmental Panel on Climate Change [O. Eden-

28 USGS, 2009
29 EWEA, 2012

hofer, R. Pichs-Madruga, Y. Sokona, K. Seyboth, P. Matschoss, S. Kadner, T. Zwickel, P. Eickemeier, G. Hansen, S. Schlömer, C. von Stechow (eds)], United Kingdom and New York, NY, USA: Cambridge University Press, p.1075.

Jacobson, M. Z. and Delucchi, M. A., 2009; A Path to Sustainable Energy by 2030.

NRC, 2007 (National Research Council of the National Academies); Environmental Impacts of Wind-Energy Projects

PEW/BNEF, 2013 (Pew Centre Charitable Trusts/ Bloomberg New Energy Finance); 2012 – Who is winning the Clean Energy Race?

REN 21, 2013; Renewables 2013 – Global Status Report

Stewart, G. B., Pullin, A. S. and Coles, C. F., 2007; Poor evidence-base for assessment of windfarm impacts on birds. Environmental Conservation, 34 (01), pp.1–11.

Sovacool, B., 2013; The aviation benefits of wind energy; Renwable Energy, January 2013, Pages 19–24

Subramanian, M., 2012; The trouble with wind turbines; NATURE, Vol. 486, 20th June 2012

USGS, 2009 (United States Geological Service); Mineral Commodity Summaries, 2009.

WED, 2011; Windpower Engeneering & Development, http://www.windpowerengineering.com/design/materials/metals/

Willburn, D.R, 2011; Wind Energy in the United States and Materials Required for the Land-Based Wind Turbine Industry From 2010 Through 2030.

Wilhelmsson D, M. T., 2006; Influence of offshore windpower on demersal fish. ICES Journal of Marine Science, 63, pp.775–784.

WWF, 2011; The Energy Report, 100% Renewable Energy by 2050.

Contact

Stephan Singer
Director Global Energy Policy
WWF International
ssinger@wwf.eu