**Technology Fact Sheet for Mitigation**

## Wind (on-shore) utility-scale [i]

| **Technology: Wind (on-shore) utility-scale** | |
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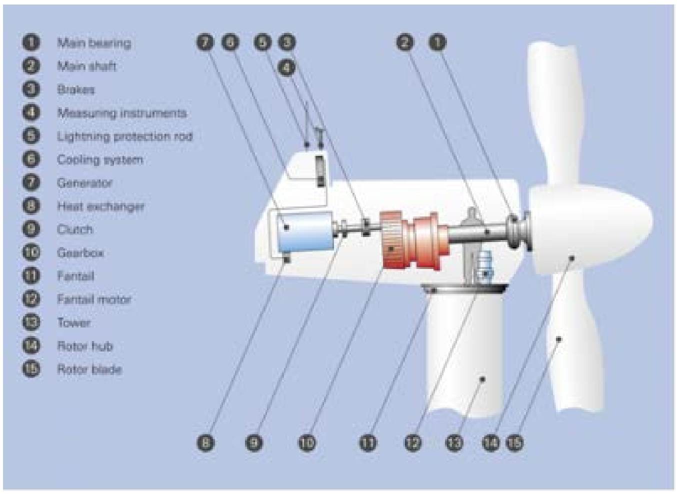
| **Sector : Energy** | |
| **Subsector :** | |
| Technology characteristics | |
| Introduction | Besides conventional hydropower, onshore large-scale wind energy is presently the cheapest form of renewable energy. At locations with a good level of wind resource, it can be cost competitive with some forms of traditional/thermal power production. Global wind energy capacity has been growing very rapidly over the past decade. In 2009, newly installed capacity was more than 34GW (GWEC, 2010) representing more than 25% of total new generation capacity globally. In 2009 wind energy contributed approximately 1.8% of worldwide electricity demand, a percentage that has doubled since 2006 (Wiser and Bolinger, 2010). |
| Technology characteristics/highlights | A large wind turbine primarily consists of a main supporting tower upon which sits a nacelle (the structure containing the mechanical to electrical conversion equipment). Extending from the nacelle is the large rotor (three blades attached to a central hub) that acts to turn a main shaft, which in turn drives a gearbox and subsequently an electrical generator (Fig 1). In addition to this there will be a control system, an emergency brake (to shut down the turbine in the event of a major fault) and various other ancillary systems that act to maintain or monitor the wind turbine.<br><br><br>Figure 1: Cut-away view of a typical wind turbine (source ZF, 2010)<br><br>Modern turbines reach a conversion efficiency of approximately 50 percent, close to the theoretical limit (59%) and very close to the practical limit that is imposed by the drag of the blades. Nevertheless there is a significant body of ongoing global R&D into construction methods/materials for larger turbines, conversion efficiency refinements, lower cost components and improved reliability. |
| Institutional and organizational requirements | There is extensive experience in many countries with permitting and planning frameworks for wind parks including in many developing countries. Generally, the following are necessary:<br>• A lease/payment-scheme for the area of interest for deployment of the wind park. This land may be government owned which makes |

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| | negotiations potentially straightforward, but in many instances wind parks are deployed on agricultural land and can coexist with the existing agricultural practices. In areas where the land is owned by a small number of stakeholders direct payments to these parties are often arranged. In a country where a larger number of small-scale land users might own an area of interest, this may present problems and should be considered in the development of a wind park; payments to communities may assist in overcoming this issue.<br>• Appropriate environmental permits based on an environmental impact assessment (EIA) that can take between 1-2 years depending on the level of baseline data demanded by the permitting authority and the sensitivity of the area.<br>• Permits from local/district planning officials that control the use of land within a region. These have been known to cause problems/delays/cancellations in instances where local communities/councils are not in favour of erecting wind turbines.<br>• Grid connection agreement / power purchase agreement with the relevant body to ensure distribution and a market for the resulting electricity. |
| Operation and maintenance | Negligible as it relates to maintaining electronics and interfaces (software). |
| Endorsement by experts | It can generally be said that the level of acceptance of wind parks onshore is high if appropriate measures are taken to ensure the limited noise and shadow effects do not affect local communities. It is endorsed by experts |
| Adequacy for current climate | Fits well, both for the current and future climate. |
| Scale/Size of beneficiaries group | Utility-scale wind farm requires private investment (could be in form of public private partnerships). The beneficiaries will be the entire population. |
| Disadvantages | Can be perceived as threatening to birds, making noise, and visually not desirable. |
| Capital costs | |
| Cost to implement mitigation technology | "Though the cost of wind energy has declined significantly since the 1980s, in most regions of the world, policy measures are required to make wind energy economically attractive" (IPCC, 2010). However in areas where prices of conventional electricity supply are high due to imported fuels or other factors but which have a good wind resource, wind power can be economically competitive without subsidies. For modern turbines the levelised cost of electricity in 2009 (accounting for capital costs, lifetime O&M and typical financing costs) ranges between US$50 to 100/MWh at good to excellent sites (IPCC, 2010). The site specific costs are influenced by the nature of the local wind resource, local capital costs (for example wind power capital costs are lower in China) and the financing arrangements for the specific project. Figure 4 presents a slightly different set of cost estimates for onshore wind energy from the IEA (2010) and compares this to conventional sources of electricity across a number of regions.<br>Onshore a large majority of the costs are associated with the turbine and tower which should be considered when studying the socio-economic impact a project might have on a local community. Without localisation of manufacture, the economic benefits may prove to be limited. |

| Cost Component | Onshore | Offshore |
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| Turbine | 71% - 76% | 37% - 49% |
| Grid connection | 10% - 12% | 21% - 23% |
| Civil works | 7% - 9% | 21% - 25% |
| Other capital costs | 5% - 8% | 9% - 15% |

Installed cost distribution for onshore and offshore wind power plants (IPCC, 2010).

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| Additional cost to implement mitigation technology, compared to "business as usual" | The above cost is additional since the reference scenario is 'doing nothing'. |
| Long term cost (i.e. 10, 30, or 50 years) without mitigation technology | Operation and maintenance of conventional power plants. |
| Long term cost (i.e. 10, 30, or 50 years) with mitigation technology | Negligible operating and maintenance costs over lifetime of systems (20 years). Need to change electronics (e.g. inverter) maybe once during lifetime. |
| Development impacts, direct and indirect benefits | |
| Direct benefits | • GHG emission reductions<br>• Savings on energy bill<br>• Job creation<br>• Enhanced environmental and health benefits |
| Reduction of vulnerability to climate change, indirect | The renewable nature of wind energy, the large available resource and the relatively advanced nature of the technology mean that it has the potential to make a significant contribution to climate change mitigation. By acting to displace generation from thermal power plants onshore wind energy can prevent the emission of roughly 2,000 tonnes of $CO_2$ per year per megawatt of installed wind capacity (assuming it replaces coal and is located at a reasonable wind energy site).<br>Although there is some amount of carbon used in the manufacture of the devices, studies have shown that the payback period (the time it takes for the wind energy to offset the emissions associated with its fabrication and installation) is relatively low, typically in the order of 6 months or less (IPCC, 2010). |
| Economic benefits, indirect<br>Employment<br><br>Growth & Investment | <br>Creation of jobs to:<br>• Install and commission systems (e.g. suppliers of hardward, interface electronics, switching and interconnections at sub-stations, installers; energy resources assessments etc ..)<br>Can create investment in developing and supplying consulting and training services. |
| Social benefits, | |

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| indirect<br>Income<br>Education<br><br>Health | <br>Income generation from the abovementioned employment and investment<br>Training in the technology may lead to more training and spread of technology application.<br>Improvement of health conditions through improved comfort. |
| Environmental benefits, indirect | Reduction in GHG emissions.<br>Although wind energy has a net positive impact on climate change mitigation (see below) local environmental impacts must also be considered. The most well publicised potential issue is the impact that wind turbines can have on bird and bat populations due to collisions. IPCC (2010) provides a good summary of the specific studies that have looked at the number of fatalities of these species. There is a strong argument that the number of recorded fatalities, while site specific, is relatively low compared to other anthropogenic causes of bird and bat deaths such as cars, collisions with buildings, feral cats and transmission lines.<br>In terms of other ecological effects related to the installation, the turbines have a relatively small environmental footprint and are often constructed on agricultural or brown-field sites, which limits their impact on local habitats or ecosystems. In instances where they are being installed in more pristine environments, a more rigorous environmental impact assessment may be required. |
| Local context | |
| Opportunities and Barriers | **Opportunities** / **Barriers**<br>Wind SIPP already implemented in Mauritius / Higher initial costs for design and installation<br>In line with government policy<br>Grid code exists in Mauritius / Need for a skilled installers (accreditation)<br>Good wind regime |
| Market potential | Long-term energy strategy 2011-2025 mentions the following large-scale wind projects.<br><br>(i) Construction of a 20-30 MW wind farm at Curepipe Point — **2013**<br>(ii) Construction of an 18 MW wind farm at Plaines des Roches — **2013-2014**<br>(iii) Construction of 20MW wind farms every three years, as from 2017 — **2017, 2020, 2023** |
| Status | Grid-tied SIPP systems are eligible in Mauritius. There are no utility-scale grid-connected systems in Mauritius. Mauritius does have experience with the operation of small wind turbines in Rodrigues. |
| Timeframe | Can be implemented immediately provided incentives like feed-in-tariff is provided. |
| Acceptability to local stakeholders | The technology is easily acceptable to all stakeholders once barriers are overcome. |

[i] **This fact sheet has been extracted from TNA Report – Technology Needs Assessment Reports For Climate Change Mitigation – Mauritius. You can access the complete report from the TNA project website http://tech-action.org/**