Technology Fact Sheet

Technology Name	**On-shore wind plant connected to the network.[i]**
Subsector GHG emission	2005 year: Category 1A1-Energy Industry (Stationary fuel burning for electricity and heat production). CO2 emission: $2986{,}6 \cdot 10^3$ t [*Comunicarea Naţională Doi a Republicii Moldova elaborată în cadrul Convenţiei-cadru a Organizaţiei Naţiunilor Unite privind schimbarea climei.*/ Ministerul Ecologiei şi Resurselor Naturale / Programul Naţiunilor Unite pentru Mediu; Coord.: Violeta Ivanov, Georgr Manful; Grupul de sinteză: V. Scorpan, M. Ţăranu,, P. Todos, I. Boian.-Ch.: „Bons Offices" SRL, 2009-323 p. ISBN 978-9975-80-313-7, tab. 2.11, pag. 105]
Background/Notes, Short description of the technology option	The conversion of the kinetic energy in the wind into electrical power is known as wind energy. There are a number of ways in which this conversion can be done. However after a period of experimentation and development one design has come to dominate the market. This is known as the horizontal axis wind turbine (HAWT) with its archetypal three-bladed rotor. 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. 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. Modern multi megawatt wind turbines have main towers that are typically 70 to 120 metres high supporting rotors with a similar range of diameters. Inside the tower there is a mechanism that ensures that the nacelle/rotor faces into the wind (i.e. is yawed correctly) to give maximum generation and maintain symmetric loads on the three blades and drive shaft. Generally the three blades are constructed from composites which provide a relatively high strength (required due to the large bending moments they experience) whilst maintaining a low weight and size given their length. Modern designs have a relatively low rotational speed in the order of 10 revolutions per minute (partly due to the desire to keep noise levels low) and thus typically require a gearbox to increase the speed of the drive shaft to match the rated generator speed. While most wind turbines use gearboxes (or indirect drive systems) there also exist direct drive configurations whereby the generator is coupled directly to the slow moving rotor. These types of designs do not require gearboxes and thus avoid the reliability issues that have been known to trouble certain gearbox designs. However the larger generator size that is required in order to obtain the correct generation frequency faces its own challenges in regards to construction and cost. Even for indirect systems, differences exist in the type of generator that can be used. Older designs tend to be classed as 'fixed speed' meaning that the rotor always rotates at the same speed under all wind conditions. For a number of reasons many modern turbines use generators that allow for variable speed generation whereby the rotational speed is optimised to the incoming wind speed and the generator provides output at a range of frequencies. The resulting fluctuations in voltage and frequency are corrected by power electronics in order to provide electricity suitable for export to the grid. The advantages of this approach include reduced harmful torque fluctuations into the gearbox, increased conversion efficiency, the ability to continue operation during a grid disturbance and the ability to provide reactive power. These last two are increasingly being demanded of wind parks by transmission system operators. Further improvements to the level of energy capture are obtained by most modern turbines by changing the angle of the blades. This 'variable pitch' system rotates the blades about their own axes so that for changing wind conditions the optimum efficiency is achieved. The system also acts to control the turbine, angling the blades 'out of the wind' during periods of high wind speed to prevent damage and providing the primary method for disabling the device. In spite of continuing advances in turbine technology, there is an inherent physical limit as to the amount of energy in the wind that can be extracted. A theoretically

	perfect (yet infeasible to construct) wind turbine could only ever extract 59 percent of the available energy, also known as the Betz limit. Modern turbines reach a conversion efficiency of approximately 50 percent, close to this theoretical limit and very close to the practical limit that is imposed by the drag of the blades. Source: Tony Burton et all. *Wind Energy Handbook,* John Wiley & Sons, Ltd, 2001-617 p. ISBN 0-471-48997-2
Implementation assumptions, How the technology will be implemented and diffused across the subsector? Explain if the technology could have some improvements in the country environment.	The first requirement when considering the possibility for wind energy is the identification of a suitable site that has a high level of resource, i.e. it is windy. More specifically it should be windy at the height above the ground at which the rotor will be situated. The surface friction of the earth's surface, local topology and surface cover means that wind speeds are lower near the ground than they are higher up. Even at good sites there will be many times when a wind turbine is operating below its rated power (its nominal capacity) or producing no power at all because of a lack of wind. This means that although a turbine may be rated at, for example, 2 MW it will produce a certain percentage of the theoretical power it could have produced had it operated continuously. This percentage is the capacity factor. For onshore wind turbines this capacity factor varies between sites depending on the amount and consistency of the wind. In Europe capacity factors are in the order of 20 to 30 percent, in China on average approximately 23 percent, in India around 20 percent while in the US roughly 30 percent [6]. Based on measurements made in different locations were calculated annual average wind speeds at 90 m height above the ground. Annual average wind speed varies between 6,17 and 7,78 m/s. When using wind turbines designed for Wind Class IEC IIIA we get a capacity factor of 0,3. **Grid integration** The primary perceived problem with wind energy is related to the intermittency of supply. The variability of wind on any given day, week or month means that the amount of power that is produced can change accordingly. In the short term wind levels and thus power generation can be estimated from meteorological reports with a reasonable degree of accuracy. However this does not solve the issue those on days when there is little or no wind, an alternate form of generation is required, requiring additional backup capacity that would not be needed for traditional base-load power stations. To date there have been a large number of studies of the integration of wind energy into electricity networks. IPCC study [6] provides a good summary of the related literature which broadly concludes that at levels of penetration of up to 20 percent of supply the effects of variability and associated costs are relatively low. Thus, for Moldova in the next 5 years installed wind power capacity will be limited to about **250 MW.**
Implementation barriers	Lack of investments. The legal framework is ambiguous and is not completed.
Reduction in GHG emissions	Assuming that the next 20 years will be installed 550 MW wind power, by 2030 CO2 emissions will be reduced by $834{,}8 \cdot 10^3$ t annually.
Impact Statements - How this option impacts the country development priorities	
Country social development priorities	**Reduce unemployment.** Will be created about 220 new jobs [7] (Operations & maintenance & other direct employment).
Country economic development priorities – economic benefits	**Increased energy security.** Lack of own natural fossil fuel reserves is obliging the country to import 95 % of energy resources needed. 70 % of electricity demand is covered by import. All natural gas is coming from GAZPROM
Country environmental development priorities	Wind energy has a net positive impact on climate change mitigation (see Reduction in GHG emissions above). 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 limit their impact on local habitats or ecosystems.

	There are, nonetheless, ecological impacts that need to be taken into account when assessing wind energy. Potential ecological impacts of concern for onshore wind power plants include the population-level consequences of bird and bat collision fatalities and more indirect habitat and ecosystem modifications.
Other considerations and priorities such as market potential	-
Costs	
Capital costs	Investment costs are the most significant costs of wind generation. The upfront investment costs, such as the cost of the turbine, foundation, electrical equipment, grid connection, etc, typically make up around three-quarters of the levelised cost of wind generation. In the absence of any Moldova-specific data, we refer to publicly available data to estimate investment costs. There is some variation between the investment costs reported in our different data sources. We recommend using an investment cost of $2100 per kW of installed capacity. This cost is *Capacity-Weighted Average Investment Cost* from IPCC Special Report that was published in June 2011. We use this source because it is a recent estimate of investment costs and is also a reasonable average of different data sources. The EWEA estimate is significantly lower, however this is explained by the fact that it dates back to 2006.
Operational and Maintenance costs	O & M costs are related to a limited number of cost components, and include: Insurance, Regular maintenance, Repair, Spare parts, Administration. Based on experiences in Germany, Spain, the UK and Denmark, O&M costs are generally estimated to be around 1,7 to 2,1 c$ per kWh of wind power produced over the total lifetime of a turbine . We recommend for Moldova to use 1,7 c$/kWh.
Cost of GHG reduction	Cost of GHG reduction is 69,2 USD /tCO2
Lifetime	20 years
Other	-

[i] This fact sheet has been extracted from TNA Report - Technology Needs Assessment for climate change mitigation - Republic of Moldova. You can access the complete report from the TNA project website **http://tech-action.org/**