ENVIRONMENTAL, HEALTH, AND SAFETY GUIDELINES FOR WIND ENERGY

INTRODUCTION

1. The Environmental, Health, and Safety (EHS) Guidelines are technical reference documents with general and industry-specific examples of Good International Industry Practice (GIIP).[1] When one or more members of the World Bank Group are involved in a project, these EHS Guidelines are applied as required by their respective policies and standards. These industry sector EHS Guidelines are designed to be used together with the **General EHS Guidelines** document, which provides guidance to users on common EHS issues potentially applicable to all industry sectors. For complex projects, use of multiple industry sector guidelines may be necessary. A complete list of industry sector guidelines can be found at www.ifc.org/ehsguidelines.

2. The EHS Guidelines contain the performance levels and measures that are generally considered to be achievable in new facilities by existing technology at reasonable costs. Application of the EHS Guidelines to existing facilities may involve the establishment of site-specific targets, with an appropriate timetable for achieving them.

3. The applicability of the EHS Guidelines should be tailored to the hazards and risks established for each project on the basis of the results of an environmental assessment in which site-specific variables, such as host country context, assimilative capacity of the environment, and other project factors, are taken into account. The applicability of specific technical recommendations should be based on the professional opinion of qualified and experienced persons.

4. When host country regulations differ from the levels and measures presented in the EHS Guidelines, projects are expected to achieve whichever are more stringent. If less stringent levels or measures than those provided in these EHS Guidelines are appropriate, in view of specific project circumstances, a full and detailed justification for any proposed alternatives is needed as part of the site-specific environmental assessment. This justification should demonstrate that the choice for any alternate performance levels is protective of human health and the environment.

APPLICABILITY

5. The EHS Guidelines for wind energy include information relevant to environmental, health, and safety aspects of onshore and offshore wind energy facilities. It should be applied to wind energy facilities from the earliest feasibility assessments, as well as from the time of the environmental impact assessment, and continue to be applied throughout the construction and operational phases. Annex A contains a full description of industry activities for this sector. EHS issues associated with the construction

[1] Defined as the exercise of professional skill, diligence, prudence, and foresight that would be reasonably expected from skilled and experienced professionals engaged in the same type of undertaking under the same or similar circumstances globally. The circumstances that skilled and experienced professionals may find when evaluating the range of pollution prevention and control techniques available to a project may include, but are not limited to, varying levels of environmental degradation and environmental assimilative capacity, as well as varying levels of financial and technical feasibility.

FIGURE A-1: TYPICAL COMPONENTS OF AN ONSHORE WIND ENERGY FACILITY

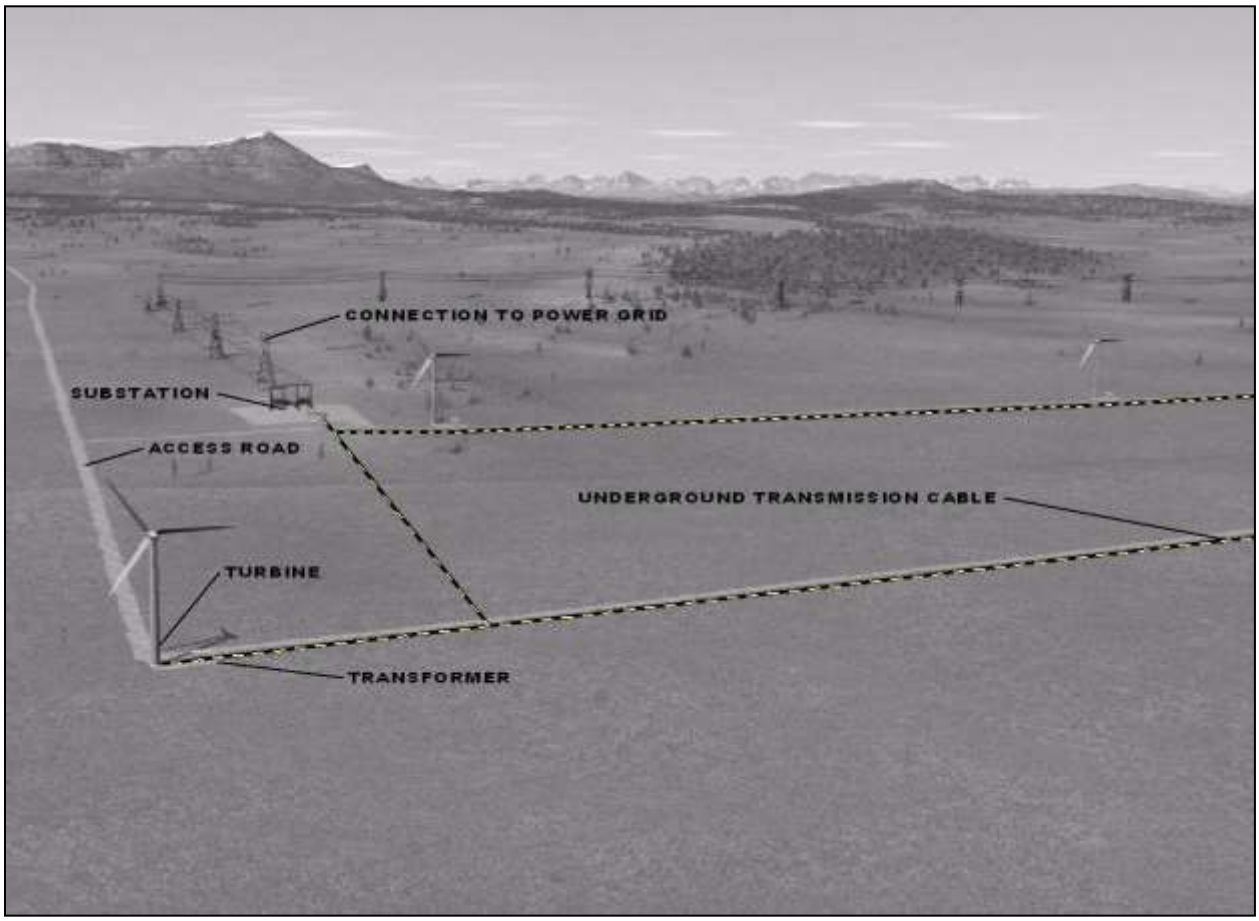
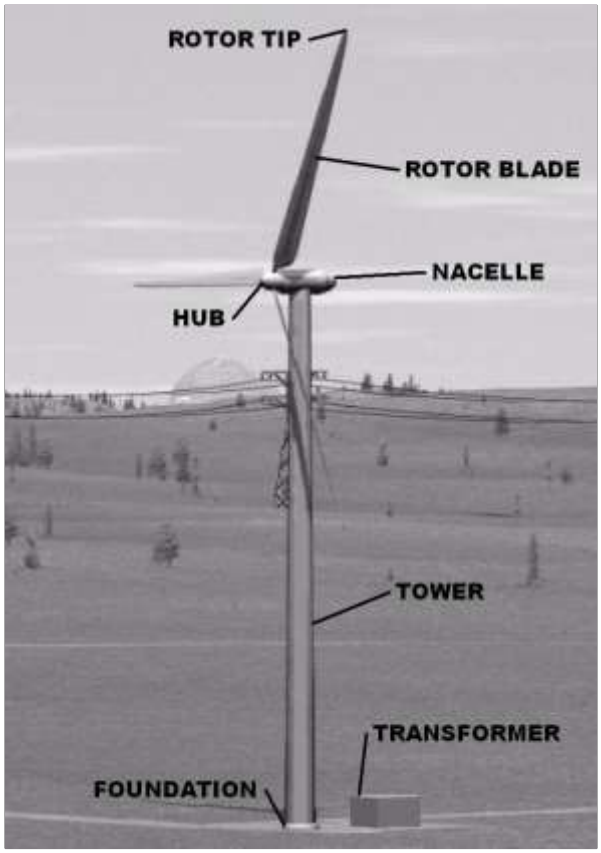


FIGURE A-2: TYPICAL STRUCTURAL COMPONENTS OF A WIND TURBINE



100. As the wind speed increases, the rotor blades begin to rotate. This rotation turns the generator LQVLGH WKH QDFHOOH WKHUHE\ Energy to electricity. Most wind turbines start ZLQG ¶V generating electricity at approximate wind speeds of 3 to 4 meters/second (m/s) (10.8 to 14.4 kilometers/hour (km/h)), generate maximum power at wind speeds of around 12 m/sec (43 km/h), and shut down to prevent damage at around 25 m/s (90 km/h).[84] The maximum blade tip speed can be approximately 90 m/s or 320 km/h. At high wind speeds, rotor power can be limited in one of three ways: stall control, variable pitch control, and active stall control. In stall control, the aerodynamic design of the rotor blade regulates the power of the rotor. At high wind speeds, a stall-controlled blade will begin to go into stall above a pre-determined power limit, according to the aerodynamic design of the rotor blade. In pitch control, the pitch of the rotor blades can be altered up to 90º to maximize wind capture. Once the power limit is reached, the pitch is changed to begin spilling energy from the rotor. Active stall control is a combination of stall and pitch control whereby the blades are similarly designed to stall control blades but can still be turned to adjust the pitch. Until the 1990s, passive stall regulation was the preferred strategy, however pitch regulation is now the favored means of limiting rotor power for large turbines.

[84] BWEA 2005b.

101. The amount of energy in the wind is proportional to the cube of the wind speed. In other words, doubling the wind speed results in eight times the energy contained in the wind. A turbine will typically generate electricity 70 to 85 percent of the time.[85] The turbine's energy production does not change in the same proportion, however, but roughly with the square of the wind speed. The electricity generated by a wind turbine is generally at 700 volts, which is not suitable for power transmission.[86] Therefore, each WXUELQH ZLOO XVH D WUDQVIRUPHU WR ³VWHS XS´ WKH YROWDJH WR system (e.g., 11 kilovolts (kV)). The collector system is connected to a transformer that increases the voltage to a level suitable for connection to a utility substation. The connection between a turbine transformer and the substation, on one hand, and the substation and the electrical grid on the other can be made using underground or aboveground transmission cables. Depending on the project layout, the turbine transformers can be connected independently to the substation, or the turbines can be connected to one another and then connected to a substation.

102. The design lifetime of a wind turbine is approximately 20 years, but in practice turbines may last longer with proper maintenance.

103. Routine maintenance will be conducted throughout the lifetime of the wind turbine. Maintenance activities may include turbine and rotor maintenance, lubrication of parts, full generator overhaul, and maintenance of electrical components, as necessary.

104. The operation and maintenance of wind energy facilities does not typically involve air emissions or effluent discharges. Fluids and other waste materials associated with typical maintenance activities are not normally stored onsite and are disposed of according to appropriate regional or national regulations and/or best management practices.

A.2 Facilities Unique to Offshore Wind Energy Facilities

105. The structural elements and operation of an offshore wind energy facility are similar to those of an onshore wind energy facility. The main differences between offshore and onshore turbines are the size of the turbines, the height of the turbine towers, and the diameter of the rotor blades. Another difference is that offshore wind energy facilities typically use subsurface (marine and terrestrial) cables to transmit electricity from the turbines to the transformer and from the transformer to a substation located on land (Figure A-3).

106. The structural component materials (e.g., towers) will be similar to their onshore counterparts, however some different methods are used to adapt the structure to the marine environment, including coating the metal parts to protect them from corrosion; using sealed nacelles; designing different foundations/towers to cope with wind, wave, current, tide, and seabed interactions (Figure A-1); and providing special access platforms for maintenance.

107. Typical activities for the construction of offshore wind turbines include establishment of the turbine foundation, marine transport of the turbine components, tower assembly, lifting of the nacelle and rotors onto the wind tower, and rotor/nacelle assembly.

[85] BWEA 2005d.
[86] BWEA 2005b.

108. The types of foundations and associated applications that can be used for offshore wind turbines include:

- Monopile: Most conditions, preferably in shallow water and not in deep, soft material.
- Tripod: Most conditions, preferably not in deep, soft material; suits water depths greater than 30 meters (m).
- Concrete gravity base: Virtually all sediment conditions.
- Steel gravity base: Virtually all sediment conditions, and deeper water than concrete.
- Monosuction caisson: Sands, soft clay conditions.
- Multiple suction caisson: Sands, soft clay conditions; deeper water than monosuction.
- Floating: Deep waters to 100 meters.

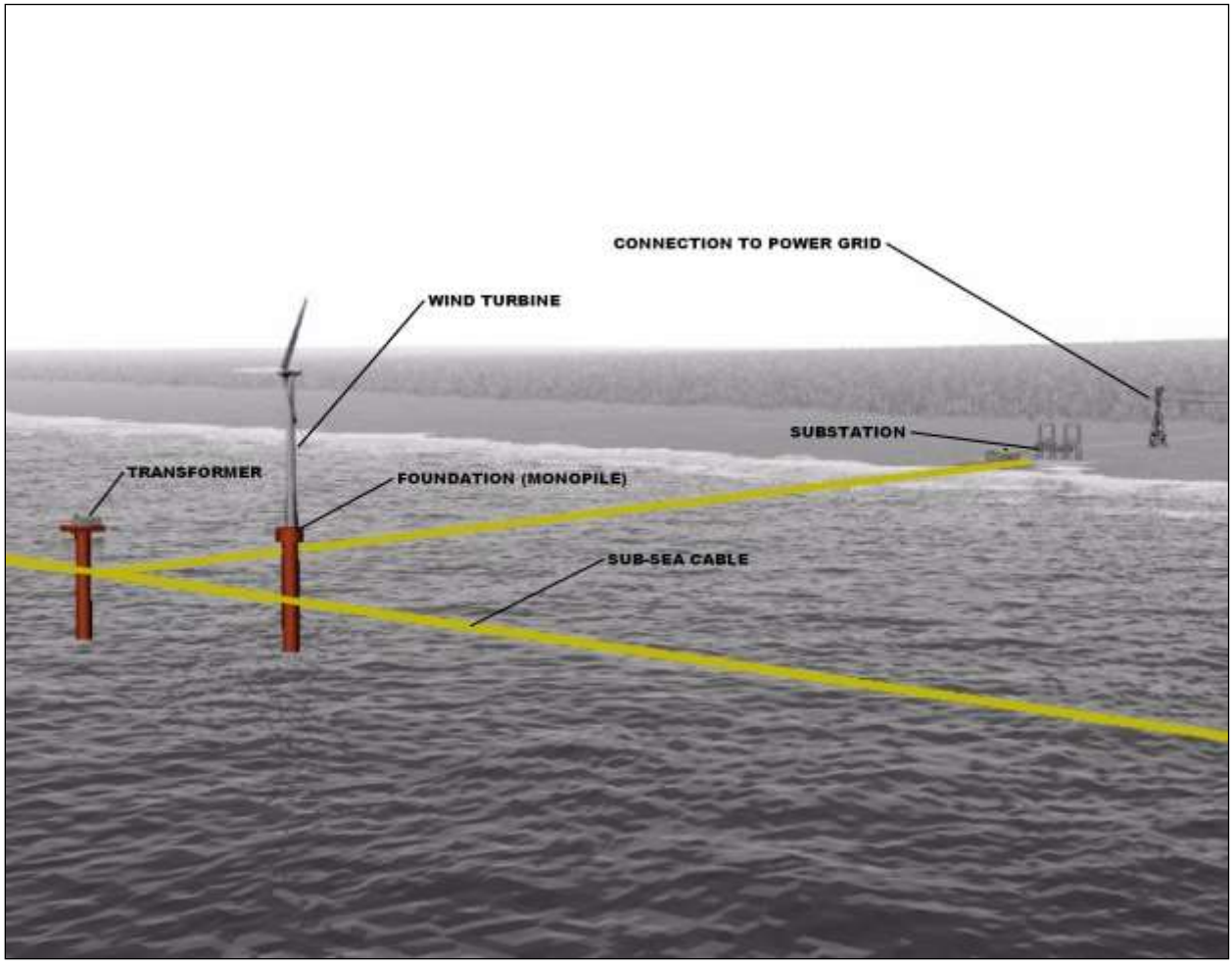



FIGURE A-3: TYPICAL COMPONENTS OF AN OFFSHORE WIND ENERGY FACILITY