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UKRAINE SUSTAINABLE ENERGY LENDING FACILITY (USELF)

Renewable Energy in Ukraine Technical Report: Wind

One of five technical reports on Renewable Energy for the USELF Strategic

USELF RENEWABLE ENERGY IN UKRAINE PROJECT SCENARIOS: WIND

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USELF RENEWABLE ENERGY IN UKRAINE PROJECT SCENARIOS: WIND

1. INTRODUCTION

The purpose of this technical report is to provide the USELF Strategic Environmental (SER) team with a representative scenario for wind development in Ukraine as the team develops the SER report. The analysis examines potential locations, technologies and operating conditions for the wind scenario. It focuses on the technical constraints associated with the availability of the resource and the technologies that employ the resource, but does not address environmental and socioeconomic constraints that will be discussed in the SER separately. This is not intended to preclude or limit the future development of other technologies that have not been identified here for review.

The report is organized into two sections:

- Resource and Potential
- Technology Characteristics

Section 2 (Resource and Potential) of the report provides the SER process with country-specific background of the availability and quantity of the wind resource, as well as potential locations or higher concentrations in Ukraine.

Section 3 (Technology Characterstics) describes the technologies that employ the resource for electricity production and details the performance characteristics, interconnection and operations and maintenance needs of the technology, as well as the availability of the technology components in Ukraine. The section also examines typical site considerations and construction activities associated with wind projects as inputs to the SER report.

2. RESOURCE AREAS AND POTENTIAL

The wind resources in Ukraine, coupled with the existing transmission infrastructure and load requirements, are sufficient to allow development of significant wind power facilities in Ukraine. This section identifies and discusses areas with good wind resources and transmission capabilities where the development of wind projects is more technically and economically feasible.

2.1 Proposed Projects

According to Ukrenergo, Ukraine's national grid operator, over 14,000 MW of wind projects have been proposed, 1,150 MW of which having received technical requirements from Ukrenergo. Table 2-1 shows the oblasts where interconnection to the national grid has been requested for wind projects. Realistically, not all of these proposed projects would reach completion. Projects may face interconnection or transmission constraints, as well as other siting, permitting, and development issues.

Table 2-1. Total Wind Project Interconnection Requests by Oblast

Regional Electrical System	Oblast	MW
Crimea	Crimea	5,279
Dnipro	Zaporizhia	3,045

South	Kherson	400
	Odessa	900
	Mykolaiv	2,500
Donbass	Donetsk	1,620
	Luhansk	250
Central	Kyiv	100
	Total	14,094
Source: Ukrenergo, Black Sea Regional Transmission Planning Project, 2010.		

2.2 Resource Areas and Transmission

This section summarizes areas with good wind resources (average wind power density) and associated transmission constraints that may limit overall development of projects in each region. In addition, mountainous terrain areas with steep slopes of greater than 20 degrees are considered technically challenging for development of wind and are shown in dark grey. These areas are found primarily in the Carpathian Mountains in western Ukraine and Crimean Mountains in southern Crimea. From the map, it is noted that the best wind resources in Ukraine are in the Carpathians, Crimea and southern coast of Ukraine, Donbass region, and windy areas along the Dniper river in Central Ukraine.

In determining the best wind resources for development in Ukraine, the estimates by oblast include areas with wind power density of greater than 300 W per m^2 at 80 meters. This would result in projects that can be sustained with current green tariff prices. The capacity potential by oblast was further discounted based on the class of wind. Wind areas that are rated 300-350 (W/m^2) are assumed to be 25% developable and wind areas that are rated >350 (W/m2) are assumed to be 50% developable. Thus, wind development could be much higher than shown in Table 2-2, but constraints were applied to limit the wind development in each region for purposes of SER review.

For the purposes of this evaluation, transmission system components operating at voltages of 220 kV or higher were available. Inclusion of transmission system components operating at lower voltages in this assessment may indicate additional limitations or capabilities to deliver power to local load centers, but would not necessarily change the transmission of power from one region to another. depicts the wind resources and transmission infrastructure in Ukraine. Refer to Appendix B for more detailed analysis of the individual regions.

The regional development scenario represents the maximum development of wind in each region for SER assessment purposes. This assumes that no new major transmission lines are developed. In total, this potential is similar to the level of proposed wind in the country. The regional development scenario is typically lower than the total development potential by oblast as shown in Table 2-2 due to additional transmission or load constraints of the region. Most oblasts in Ukraine have excess generation capacity to export and tremendous transfer capability with neighboring oblasts. For oblasts with robust wind resources and transfer capability, the primary constraint is the lack of demand within regional markets. The limitation for wind development in other regions would be constrained by the availability of good wind resource sites for development or transmission constraints.

Table 2-2. Estimated Maximum Wind Development

Regional Electric Power Systems	Oblast	Wind Development Potential in Oblast (MW)	Regional Wind-Only Development Scenario (MW)	Regional Wind Development in Combined Wind and Solar Development Scenario (MW)
Central	Cherkasy Chernihiv Kyiv Zhytomyr	813 0 333 83	1,229	922
Crimea	Crimea	2,839	2,839	2,129
Dnipro	Dnipropetrovsk Kirovohrad Zaporizhia	229 646 2,104	2,979	2,234
Donbass	Donetsk Luhansk	1,521 2,292	3,526	3,526
Northern	Kharkiv Poltava Sumy	0 229 0	229	229
Southern	Kherson Mykolaiv Odessa	1,979 63 833	1,281	961
Southwestern	Chernivtsi Khmelnytskyi Ternopil Vinnytsia	396 250 3,149 0	894	894
Western	Ivano-Frankivsk L'viv Rivne Volyn Zakarpattia	3,878 12,083 2,438 0 0	1,408	1,408
Total			14,386	12,303

Source: Black & Veatch analysis.

Since wind development in certain regions will be competing with solar development, Table 2-2 also shows the level of wind development if there is combined development of solar and wind. It is assumed there would be less development in each region as the two resources compete for transmission and load to serve.

Crimea has the most constrained transmission system due to the remote aspect of its electrical transmission grid. With approximately only 2,500 MW of export and import capacity, Crimea is limited, not by resource, but by transmission. The coastal region of Mykolaiv and Kherson is also transmission constrained, , but due to existing substation interconnection locations rather than existing transfer capability. If the power could be delivered along large distances at lower voltages to major substations, there would be adequate transmission to deliver the resources. This method, however, would incur heavy distribution losses.

The western, central, and eastern regions of Ukraine have a strong transmission backbone running through them, with multiple opportunities for interconnection of wind resources, where these resources are available. The major constraint would be the regional load that can absorb the output for the region or the availability of resources. It is anticipated that there would be very little development in the northern region of Ukraine.

3. TECHNOLOGY CHARACTERISTICS

The scoping report identified three wind project types for consideration in the SER. The three project types are anticipated to utilize modern wind turbines in the 2 – 3 MW capacity range, and consist of the following three project types: small wind farms with less than 20 MW of capacity, medium size wind farms with capacities ranging from 20 MW to 100 MW, and large wind farms with greater than 100 MW of capacity.

This section of the report discusses the major components required for each of the three wind farm sizes identified, the configuration of those components, performance, operation and maintenance, typical dimensions and project costs, the availability of major components in Ukraine, and interconnection requirements.

3.1 Components and Configuration

The configuration and individual components of typical wind projects are described herein. Since all wind farms generally consist of the same components and are configured similarly, these components are described in greater detail for small wind farms while the discussions related to medium and large wind farms is focused on additional items required beyond the baseline description.

Typical components of a wind project include: turbine, tower, collection system, interconnection facilities and access roads. Modern utility-scale wind turbines being installed today are anywhere from 1.6 MW to 3.0 MW per turbine. For purposes of the SER, more advanced turbines are evaluated, which are 2.0 MW to 3.0 MW.

Table 3-1. Configuration of Wind Power Facilities.

	Small Project	Medium Project	Large Project
System Size			
Capacity (MW)	< 20	20 – 100	> 100
No. of Turbines	7-10	7-50	50+

- **Temporary/Permanent Meteorological Towers:** Once a candidate site has been identified, temporary meteorological (met) towers are often installed to obtain site-specific meteorological data (wind speed and direction, wind shear, temperature, and humidity) to characterize the site appropriately for development. Data is typically collected over a period of 1 – 3 years prior to starting construction.

  The required number of met towers depends on the size of the project area and the complexity of the terrain, but generally can be characterized with 10 or less towers. Four-wheel-drive pickup trucks with trailers are usually sufficient to transport these towers to the site. Towers are usually a minimum of 50 meters high, and typically do not require below ground foundations, though guy wires are necessary. As wind tower heights increase, taller met towers requiring subsurface foundations may be necessary to capture wind at the higher elevation. Other types of met towers can estimate wind speeds at higher elevations, but these are often portable and can be rented rather than installed.

  Permanent towers are usually installed as monitoring towers for operating wind projects. These towers have instrumentation extending to at least the hub height of the project turbines, and typically require subsurface foundations. These permanent met towers help to rate the performance of the wind turbines.

In some cases rudimentary access roads must be developed to provide access for the installation of these facilities; in such cases the preliminary access road is later upgraded to provide permanent access during construction and operations and maintenance of the facilities.

- **Wind Turbines:** Most utility-scale wind turbines currently available from established turbine manufacturers utilize the Danish concept turbine configuration. This configuration uses a three-blade rotor, an upwind orientation (blades positioned upwind of the tower), and an active yaw system to keep the rotor oriented into the wind. However, some turbine manufacturers, such as Nordic, use two- blade designs. Two-blade designs may decrease costs, as fewer blades are used, but they have higher equipment loading and operational noise due to the design.

  The major components of a typical utility-scale wind turbine design are illustrated in Figure 3-1. The nacelle contains the drive train, which usually consists of a low-speed shaft connecting the rotor to the gearbox, a two- or three-stage speed increasing gearbox, and a high-speed shaft connecting the gearbox to the generator. Each turbine is equipped with a transformer to step up the generator voltage to the on-site collection system voltage. Depending on the wind turbine model, the transformer may be mounted within the nacelle or it may be installed on a foundation pad near the base of the tower.

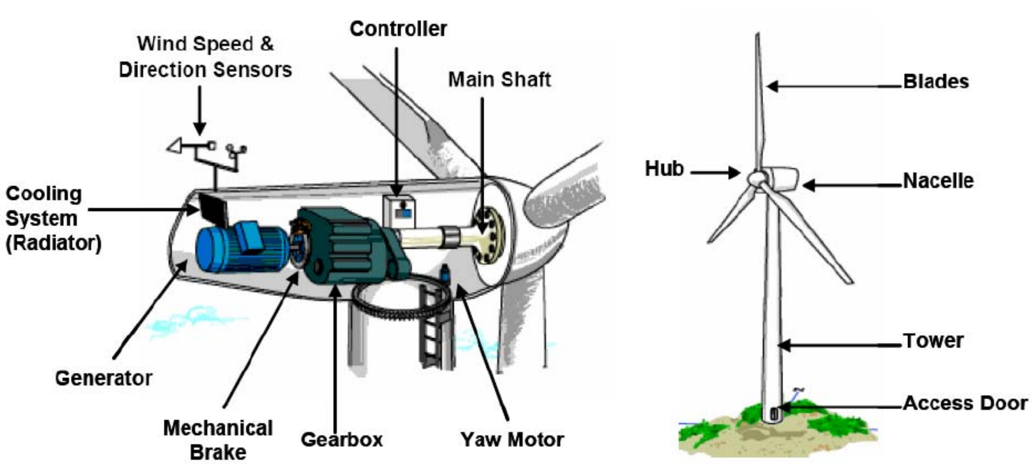


Figure 3-1. Typical Wind Turbine Schematic.

- **Tower:** Typical wind turbine towers installed today are prefabricated tubular towers. Tubular towers are preferred over steel lattice towers for aesthetic and practical reasons – access to the nacelle is safer and more convenient with a ladder mounted inside an enclosed tower, and the bottom of a tubular tower serves as an enclosed location for switchgear and controls. However, the maximum height of a tubular tower is limited by the diameter of the base section. Most modern wind turbines today are mounted on 80 to 100 m towers, though tower heights are increasing as turbine sizes increase.

- **Blades:** The purpose of the blades and rotor is to convert the kinetic energy of the wind to mechanical rotational energy that can then be converted into electricity. General design goals for the blade and rotor include maximizing aerodynamic efficiency (energy production) while minimizing loads on the blades and turbine structure. The rotor diameters measure about 100 m with a swept area of about 8,000 m^2. This translates to a maximum height of foundation to blade tip of 130 to 150 m. Overall operating height of the rotating blade is often constrained by aviation concerns.

- **Foundation:** The turbine foundation must support the weight of the turbine, and also prevent the turbine from overturning because of the high thrust loads from the rotor. The foundation design is always specific to the geological conditions at the site. The most common type of foundations for modern wind turbines is a reinforced concrete structure. A typical foundation may be 18 to 19 meters in diameter with a depth of 3 to 4 meters. The tower base section that is bolted onto the foundation is usually 4 to 6 meters in diameter. The spread-footing is shaped like an inverted "T" and uses a large-diameter pad that distributes the turbine over-turning loads over a large area (see Figure 3-2). In some cases, piles or pier foundations are required when suitable material is not present at the surface and the tower must therefore be on a foundation of competent material below grade.

Figure 3-2. Construction of Typical Spread Footing Foundation.

- **Collection System and Interconnection:** Typical utility scale turbines are equipped with a transformer to step up the voltage to the on-site collection system voltage or nearby distribution substation. The on-site collection system typically is operated at medium voltages of 25 to 35 kV. Collection systems for wind projects consist of strings of underground medium voltage cables that connect individual turbines to a substation located on or near the project site. These collection systems can be configured as loop, single string, or multiple string systems. For larger projects with project substations, overhead lines are then used to connect the project substation to the local distribution or transmission system. Figure 3-3 below shows a sample configuration of a typical wind turbine utilizing a combination of underground and overhead cables for the collection system:

  Large scale wind farms collect into a large collector substation with switchgear. The switchgear delivers the medium voltage feeders (approximately eight feeders per enclosed switchgear) to one or more step up transformers. This power is then delivered via overhead lines to the interconnection substation or an existing substation with space to build-out the bus work for future expansion. This process usually includes reconfiguration of the existing substation with a ring bus or breaker and a half scheme.

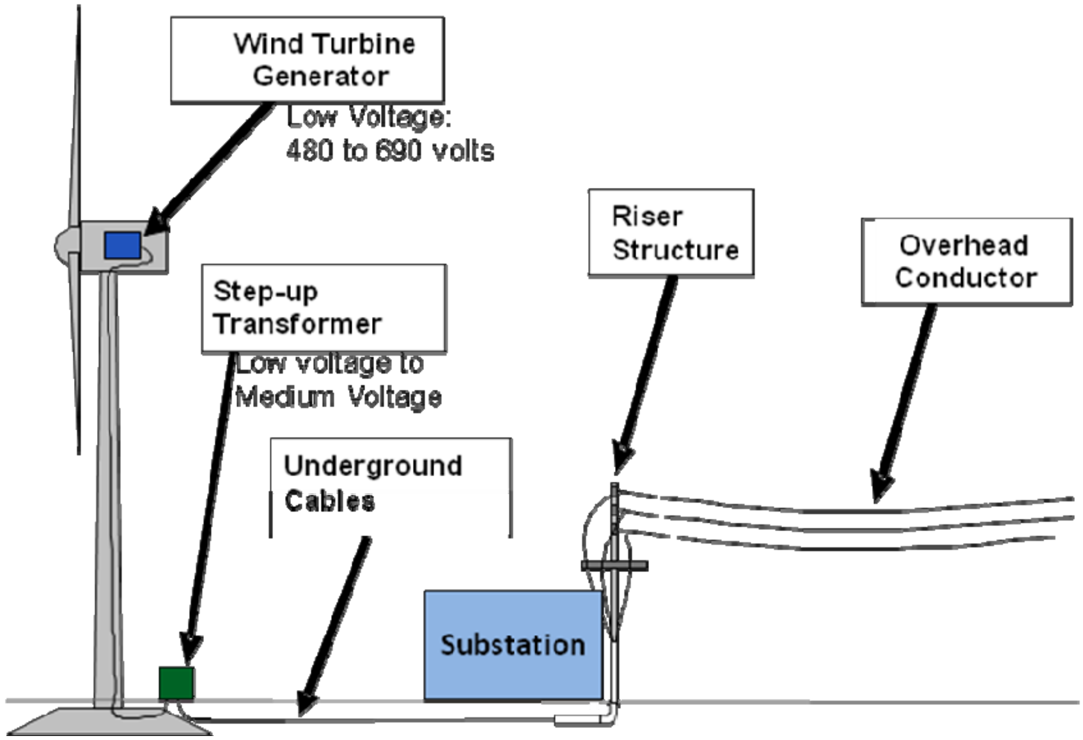


Figure 3-3. Typical Wind Collection System Arrangement.

- **Turbine Configuration and Project Area:** The total land area a project may occupy can vary greatly depending on site specific considerations, though turbines are usually spaced 3 to 10 diameters apart. According to an analysis by the National Renewable Energy Laboratory (NREL) of U.S. installations, the total land requirements for wind farms average about 18 to 48 hectares per MW.[1] The lower end of the range is associated with forested areas, while the higher end of the range is associated with row crops. Table 3-2 presents typical land requirements for wind power facilities.

Table 3-2. Average Land Usage Requirements for Wind Farms.

	Total Land Usage	Permanently Impacted Land		Temporarily Impacted Land	
	(ha/MW)	(ha/MW)	(%)	(ha/MW)	(%)
Forest	18.3 ± 12.6	0.36 ± 0.22	2%	1.11 ± 1.14	**6%**
Small Grains	24.5 ± 7.7	0.31 ± 0.52	1%	0.50 ± 0.17	2%
Shrubland	26.3 ± 12.8	0.22 ± 0.12	1%	0.63 ± 0.50	2%
Pasture / Hay	27.4 ± 15.4	0.24 ± 0.15	1%	0.59 ± 0.66	2%
Grasslands/ Herbaceous Growth	35.7 ± 16.7	0.41 ± 0.22	1%	0.37 ± 0.11	1%
Row Crops	47.6 ± 25.1	0.24 ± 0.28	1%	0.87 ± 0.65	2%

Source: National Renewable Energy Laboratory (2009).

[1] Denholm, P. et al, "Land-Use Requirements of Modern Wind Power Plants in the United States." National Renewable Energy Lab NREL/TP-6A2-45834, August 2009.

Much of this land is required to space the turbines and remains unimpacted by physical development; only two to eight percent of the required land is impacted by development. NREL goes further to distinguish between permanent impacted areas and temporary impacted areas. Permanent impacted areas include land occupied by wind turbine pads, access roads, substations, service buildings, and other infrastructure which physically occupy land area, or create impermeable surfaces. Additional direct impacts are associated with development in forested areas, where additional land must be cleared around each turbine. Total permanent direct impact of land is about one or two percent. Temporarily impacted areas are associated with temporary construction-access roads, storage, and lay-down, which account for 1 to 6 percent. It is noted that installations in forested areas, which are often along ridgelines, require the least amount of total area, but do have higher direct impact area per MW than most of the other land areas, with the exception of grassland. Likewise, temporary impacts on land can be higher for forested areas and ridgeland, due to the constraints of siting turbines and access roads in steep topography. The remaining unimpacted areas can have additional uses, such as for cropland or pasture.

Various landforms have differing exposures to prevailing wind conditions. For example, only the tops of ridges in hilly areas are practical sites for wind turbines due to superior wind exposure, while flat land areas can experience similar wind conditions across a broad area. Accordingly, typical layouts of wind farms for different sizes and for two landforms--flat and ridgeline are shown in the figures below.

Figure 3-4 Flatland Installation in Spain

Figure 3-5. Ridgeline Installation in Spain

For purposes of the SER, the lower end of the range of land coverage (18 hectares per MW for forestland) reflects ridgeline construction, while the average coverage of all the different types of areas (30 hectares per MW) reflects flat land construction.

- **Additional Components:** Some additional facilities may be found at medium or large wind farms that would be uneconomical for a small facility. Depending on the scale of operations, the wind energy project may include a central control building, hot/cold weather packages, parts storage area and maintenance shop facility or these could be combined into one building on site.

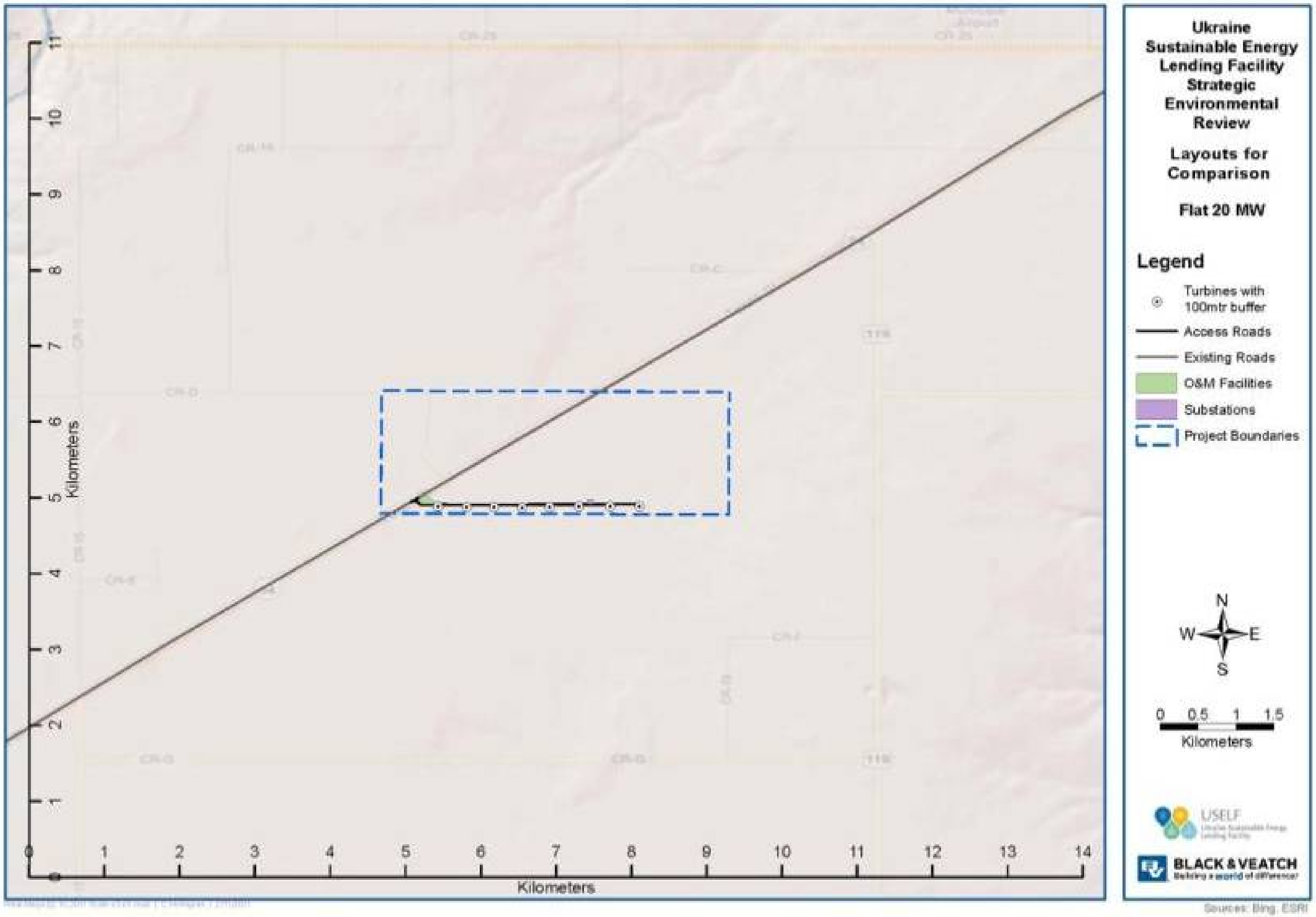


Figure 3-6. Representative Project Configuration (20 MW) on Flat Land.

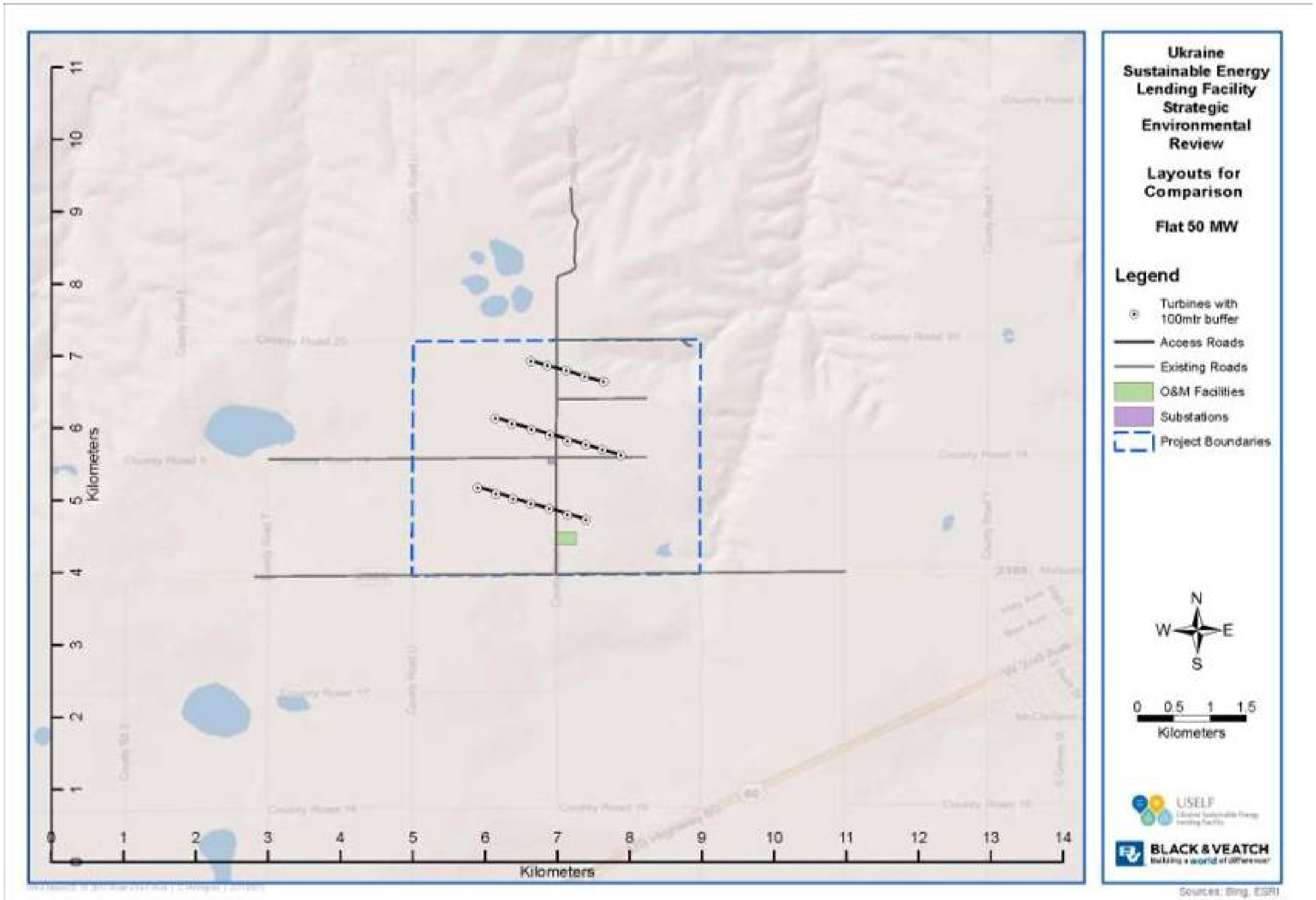


Figure 3-7. Representative Project Configuration (50 MW) on Flat Land.

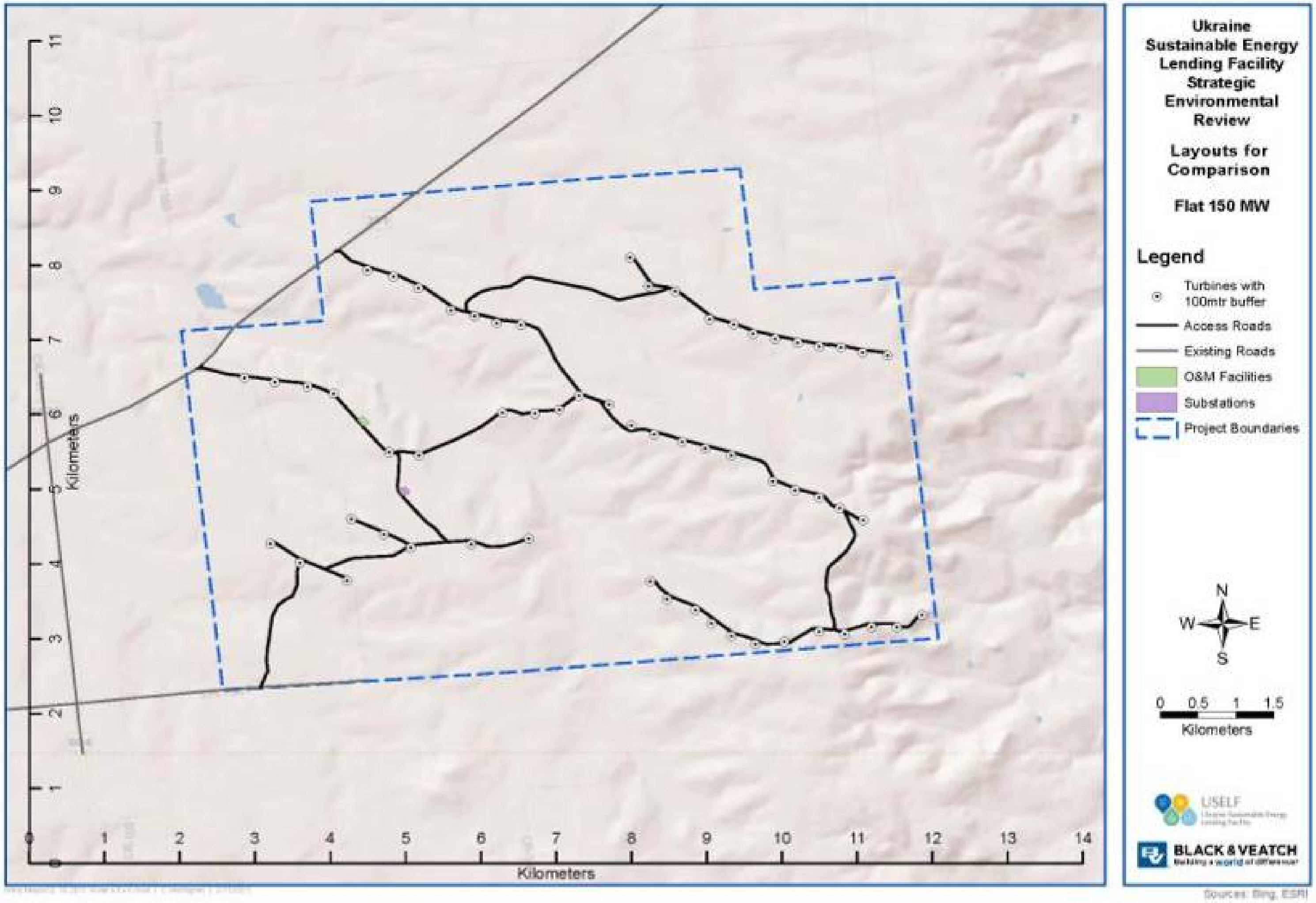


Figure 3-8. Representative Project Configuration (150 MW) on Flat Land.

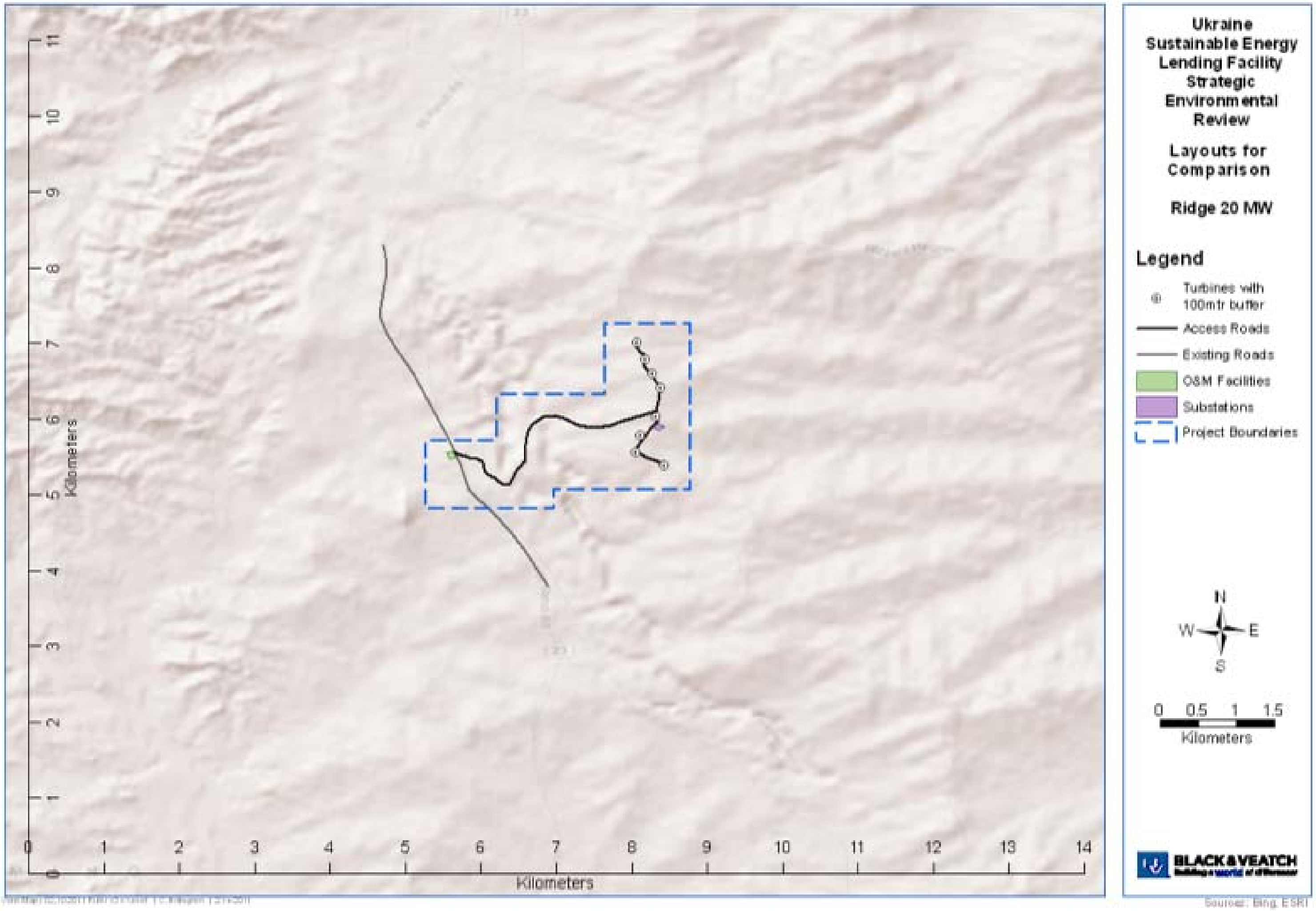


Figure 3-9. Representative Project Configuration (20 MW) on Ridgeline.

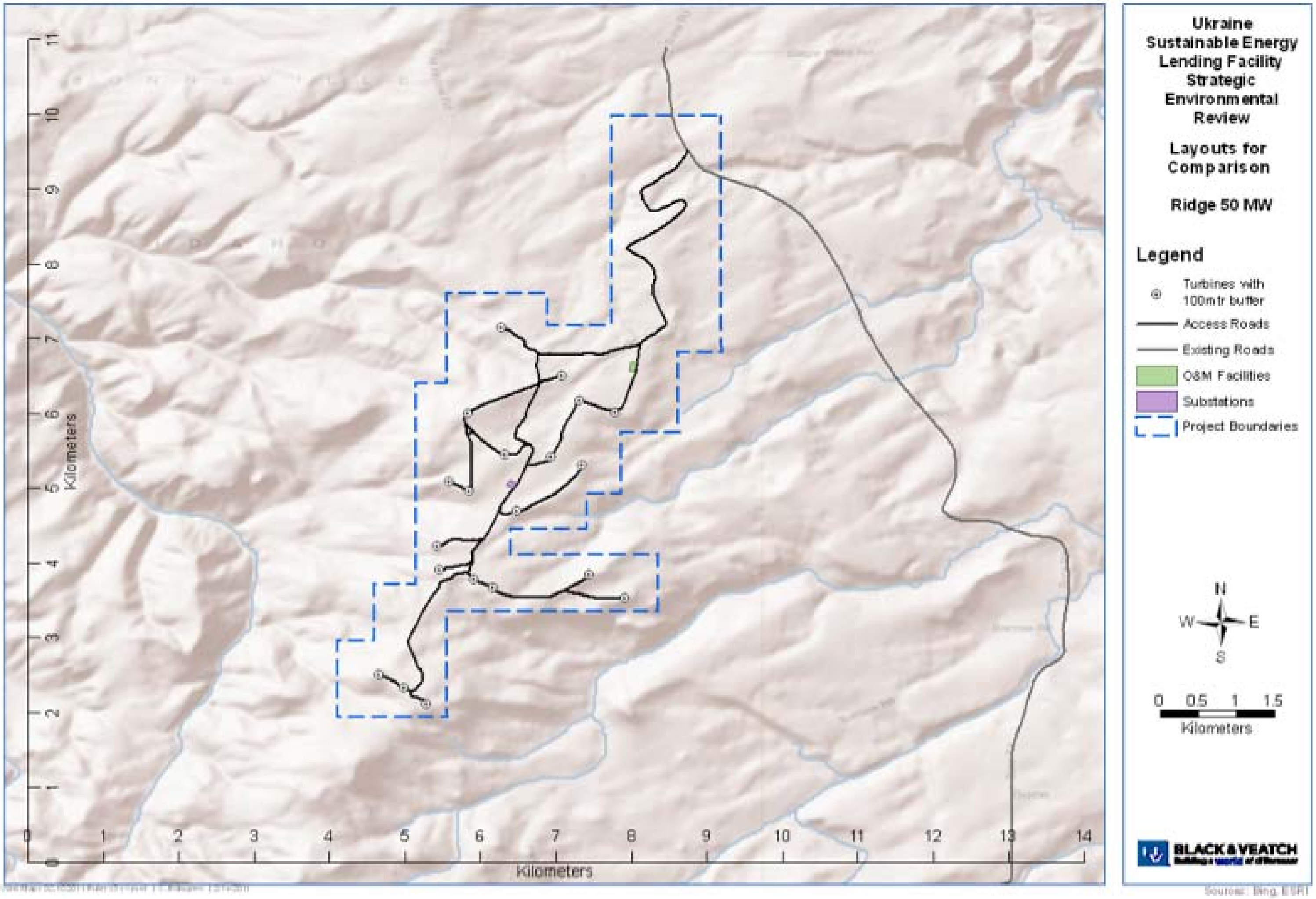


Figure 3-10. Representative Project Configuration (50 MW) on Ridgeline.

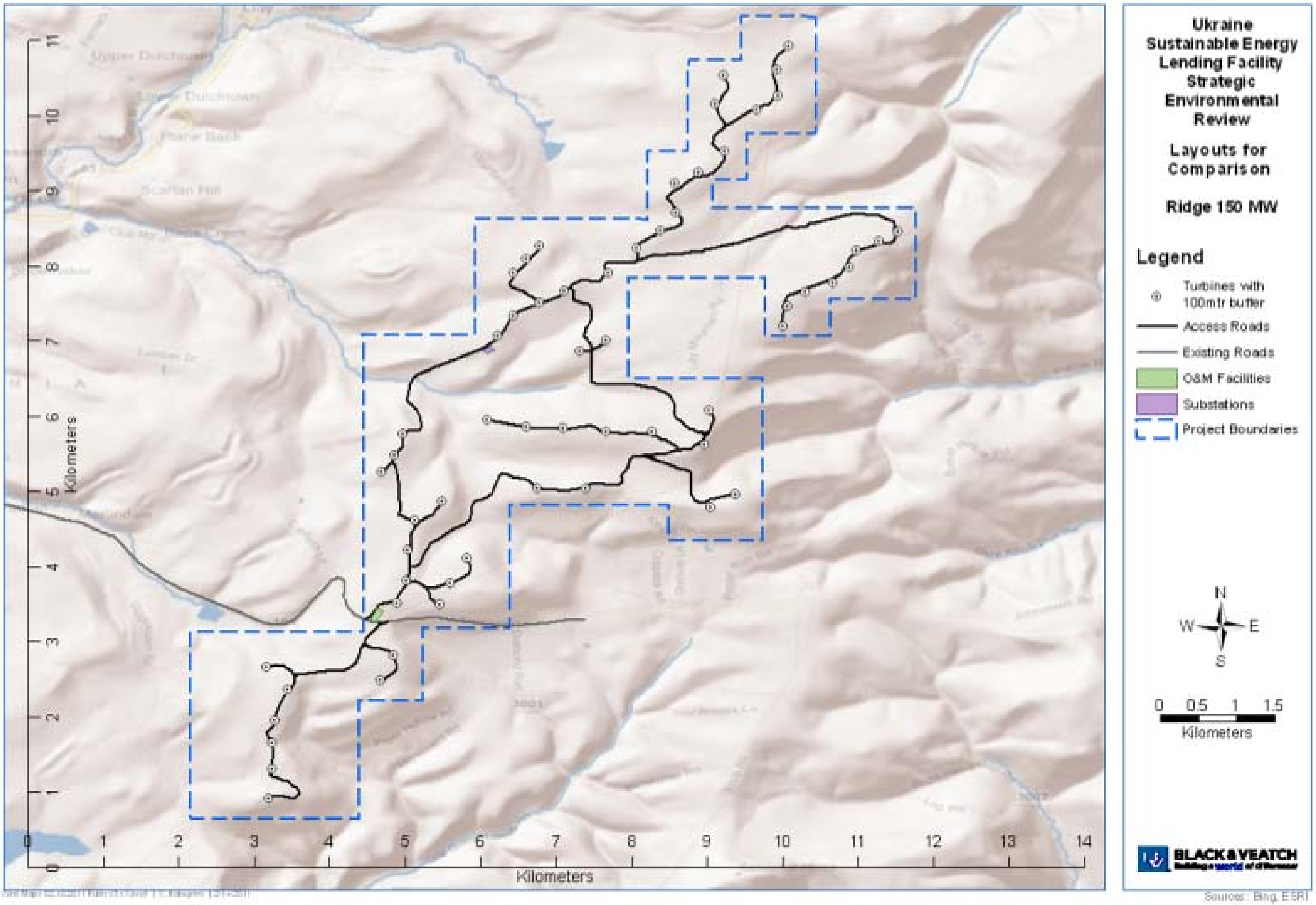


Figure 3-11. Representative Project Configuration (150 MW) on Ridgeline.

3.2 Operations and Maintenance

All major components of the wind turbines are expected to undergo routine maintenance. This would involve the use of small amounts of greases, lubricants, paints, and/or coatings for corrosion control. Wastes resulting from component maintenance typically include small amounts of gear oil and lubricating oils from yaw motors or of transmission and glycol-based coolants from transmissions equipped with forced-flow radiator cooling loops.

Most turbine manufacturers design their turbines in modular fashion, which allows a single turbine to be down, while remaining turbines can continue to operate. Thus, it is likely that most major overhauls or repairs of turbine components would involve removing the component from the site to a designated off-site repair facility. Typically, if a generator or gearbox fails (sometimes, even if smaller components like yaw drives fail) a crane needs to be called to the site. Most turbines are not able to lift/lower those components on their own.

The operation of a wind energy development project can be monitored and controlled from a remote location. For smaller sites, maintenance personnel may monitor the wind farm remotely and be on call for repairs. Larger sites may be attended during business hours by a small maintenance crew of up to six individuals.

The life of wind turbines are expected to be 20-25 years with proper maintenance. As new technologies are developed over time, operators may choose to "repower" all or part of the site by replacing existing turbines with ones incorporating state-of-the-art technologies, or with larger and more cost-efficient turbines. Repowering may also involve replacing some electrical power management and conditioning equipment.

3.3 Project Summary

Table 3-3 summarizes performance and typical cost for the three wind project sizes discussed in this report.

Table 3-3. Performance and Cost Characteristics of Wind Power Facilities.

	Small Project	**Medium Project**	**Large Project**
System Size			
Capacity (MW)	< 20	20 – 100	> 100
No. of Turbines	7-10	7-50	50+
Flat			
Required Area (hectares)	<600	600-3000	>3,000
Permanent Impacted Area (hectares)*	<6	6-30	>30
Ridgeline			
Required Area (hectares)	<360	360-1,800	>1,800
Permanent Impacted Area (hectares)*	<7.2	7.2-36	>36
Typical Hub Height (m)	80-100	80-100	80-100
Typical Rotor Diameter (m)	100	100	100
Performance			
Capacity Factor (%)	25 – 40	25 – 40	25 - 40
Emissions**			
NO_x (g/MMBTU)	0	0	0
SO_x	0	0	0
PM	0	0	0
CO_2	0	0	0
Typical Costs			
Installed Cost ($/kW)	2,300 – 2,700	2,000 – 2,500	1,900 – 2,300
Maintenance Costs ($/kW)	50 - 60	40-50	40 - 50

Notes:
*Permanent impacted area is assumed to be 1% for flat areas and 2% for ridgeline.
**Excludes emissions associated with construction and maintenance activities.

(a) Interconnection and Transmission

Wind turbines are induction generators that require reactive power, depending on the output power and power factor correction, which can cause self-excitation, thus increasing harmonic content. Increasing harmonic content can create stability concerns for an interconnection, especially within weaker power systems (e.g. radial distribution lines). Different padmount transformer configurations can also increase or decrease the amount of fault current onto the system, so it is important to design the system to keep the zero sequence impedance to a minimum, but still have a ground reference (so no overvoltage scenarios occur). Series neutral reactors or resistors can be added to the neutral connections of the collection system to increase the zero sequence impedance, thus decreasing the fault current. Wind projects of different sizes have different interconnection concerns as discussed below.

Smaller interconnections (< 20 MW) are typically more feasible to interconnect at lower voltages due to the equipment necessary to build out an interconnection substation for the wind farm. These interconnections would be best suited at the lower transmission voltage and distribution levels. The other reason for this is that smaller wind farms will typically serve local load instead of delivering power across long high-voltage transmission lines. The only caveat is that intermittent resources should not be interconnected to radial distribution systems due to stability concerns at the local distribution level.

Smaller scale wind farms can typically deliver the power through one medium voltage underground feeder which may tap directly into the distribution system at an interconnection substation. Each individual wind turbine will require a low voltage to medium voltage step-up transformer, although some newer models have built-in transformers inside the nacelle. A stepup transformer from the medium voltage side of the wind turbine pad mount transformers may not be necessary if the feeder voltage is the same as the distribution voltage. Distribution interconnection codes vary and should be used to determine requirements.

Medium scale interconnections (20-100 MW) are more feasible to interconnect at the medium transmission voltages, such as 220 kV and 330 kV. These project substations require larger equipment, but are acceptable for medium scale wind farms. These wind farms may serve local load, but can also be delivered into key transmission substations which step up to higher voltages. It is also optimal to locate these at substations with multiple outlets to avoid curtailment and ensure delivery of power.

Medium scale interconnections typically require two to four medium-voltage feeders that collect into enclosed switchgear within a new collector substation at the project site which then is connected via overhead transmission to an interconnection substation. The switchgear may also be located within an existing substation and interconnected to a built-out bus within the fence. Large scale interconnections (> 100 MW) are injected at higher voltage substations that have multiple outlets. The reason for this is to allow for delivery dispersed between multiple transmission lines and to avoid curtailment.

(b) Availability of Components in Ukraine

In order to qualify for the Green Tariff from 2012 onwards, qualifying renewable energy facilities must contain at least 30% of raw materials, supplies, fixed assets, works and services (including engineering, construction) of Ukrainian origin (or "Ukraine content provision") in the cost of construction. The content requirement increases to 50% by 2014.

As reported by the International Energy Agency, Windenergo, a joint venture created in 1994with the American company Wind Power, has produced (under a Wind Power license) approximately 750 turbines with a 107 kW capacity.[2] These turbines cost much less per kW compared to foreign makers due to lower labour and material costs in Ukraine. However, this particular type of turbine has very low efficiency and, thus, is not very cost-effective per unit of energy generated. According to the Ukrainian Wind Energy Association, twenty three former military industrial plants are now involved in component manufacturing for this turbine while assembly is carried out at the Yuzhnyi Machinery plant in Dnipropetrovsk, the former rocket-building plant.[3]

In 2003, the Dnipropetrovsk plant Yuzhmash bought another license from a Belgium company (Turbowinds) and started producing 600 kW turbines. The enterprise produces the lower and upper sections for windmills towers of two types WM-100 and WM-600. Towers for the wind turbine installation are made of roll stock steel.

[2] "Ukraine Energy Policy Review 2006," International Energy Agency. 2006.
[3] http://www.uwea.com.ua/ukraine_wind.php (Accessed February 9, 2011)

According to IEA, there are plans to produce new generation turbines with capacities of 2.5 and 3 MW, though progress towards this goal has yet to be confirmed. The Ukrainian wind components industry will need to be expanded or modified considerably to accommodate the content provision of the Green Tariff and the demand for larger turbines of 2-3 MW that are not being produced in the country currently.

In addition, since towers, foundations and roads utilize basic construction materials and labor, these likely can be sourced domestically.

3.4 Site Considerations

There are many factors which need to be considered when assessing potential wind development sites. Key factors include:

- **Wind power density and availability of resource.** This is the primary factor used in screening potential sites for wind generation.
- **Site Access and Constructability.** Often areas with excellent wind resources are also remote and difficult to access due to steep terrain and lack of access roads. Most sites will require some development of access and maintenance roads, but locations requiring significant amounts of earthwork or clearing to make space for turbine and road construction will not be economical to develop. Unfavorable geotechnical conditions (e.g. rocks that require blasting), may significantly increase construction costs. For access, although each turbine manufacturer has their own specific access requirements a typical rule of thumb is that access roads should generally not be steeper than 10% grade or have sharp turns with less than a 45 m turning radius.
- **Proximity to Transmission and Load Centers.** Sites that are situated a great distance from load centers or major transmission lines face greater development costs and are generally less favorable than sites with better access to these facilities. Larger projects are able to locate farther away from transmission while smaller projects are located closer to transmission, due to economies of scale of larger projects to absorb higher transmission costs.
- **Proximity to Local Residents.** Wind turbines generate some noise during operation and because of their height also have visual impacts. Some communities therefore object to having wind farms located too close in proximity to residences.
- **Alternative Land Use.** Generally speaking, wind farm development does not require intensive use or development of land and therefore wind farms can often be utilized for dual purposes (for example agricultural purposes). Therefore this factor must be taken into consideration but is generally not as important of an issue as the other constraints identified.
- **Environmental Impact.** Environmental impacts also need to be considered. Turbines pose a risk to raptors and bats. Increased human presence may also impact land animals. These impacts need to be studied and mitigated for each project. Very tall turbines can create concerns regarding aviation, especially at night since the blade tips are not lit.

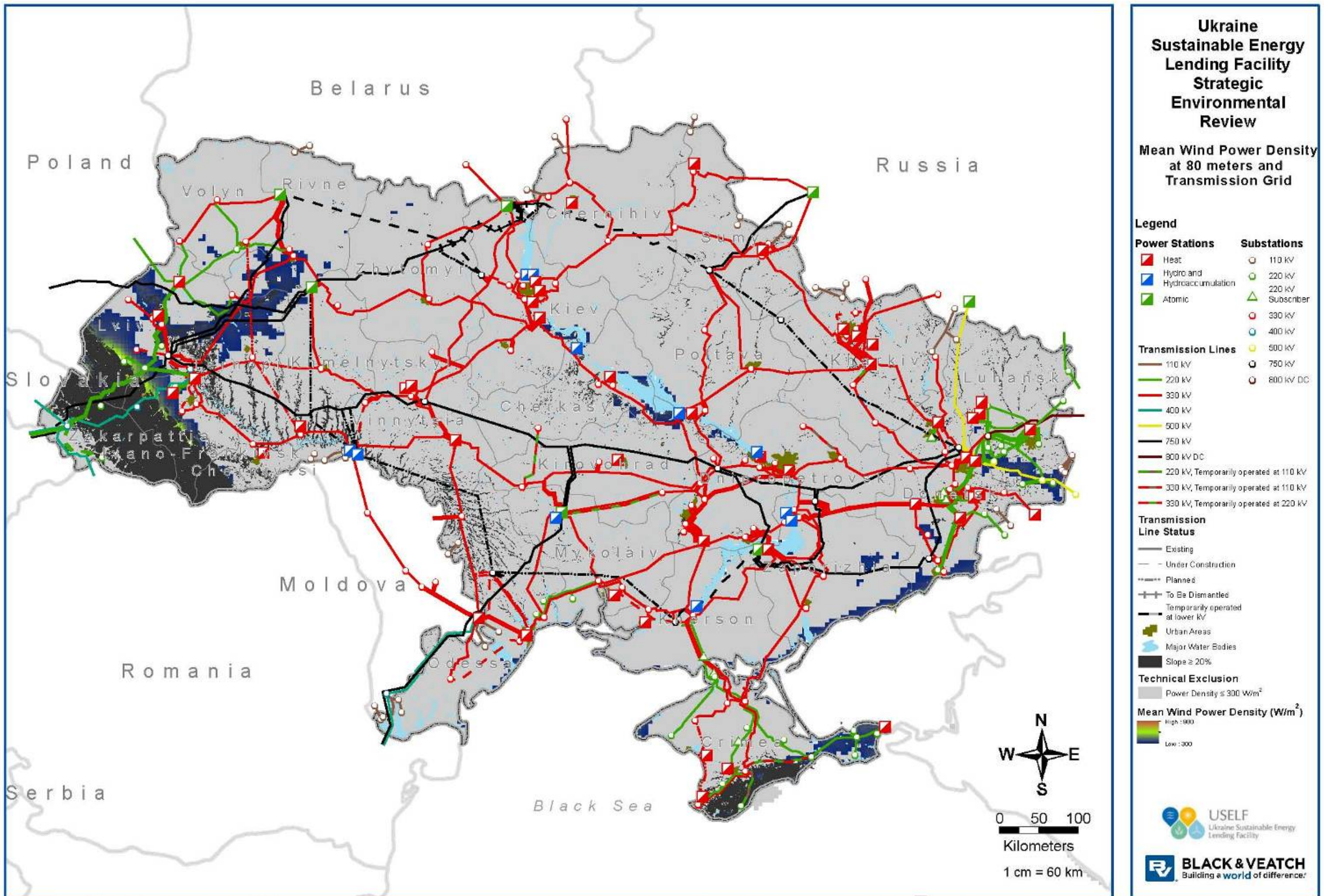
3.5 Construction Activities

The specific requirements of construction are very site dependent. The following discussion is intended to represent typical expected construction activities. However, some qualifiers to these construction activities are also introduced because of unique site conditions. Construction of a wind energy development project is likely to involve the following major actions - additional activities may also be necessary at very remote locations or for very large wind energy projects; they can include constructing temporary offices, sanitary facilities, or a concrete batching plant.

- erection of meteorological towers (to gather data)
- establishing site access
- performing site grading
- constructing lay-down areas and an on-site road system
- removing vegetation from construction and lay-down areas (primarily for fire safety)
- excavating for tower foundations
- installing tower foundations
- erecting towers with cranes
- installing nacelles and rotors
- installing permanent meteorological towers (as necessary)
- constructing the central control building and a weatherproof equipment and parts storage area (which may be separate or combined with the control building)
- constructing electrical substations
- interconnecting towers, the control building, meteorological towers, and substations with power-conducting cables and signal cables
- performing shake-down tests

FIGURES

Figure 2 1. Map of Wind Resources and Transmission Lines



Sources: UKREnergo; 3Tier, International Centre for Tropical Agriculture (CIAT), DeLorme, ArcWorld Supplement, ESRI.

Figure 2-3-12. Map of Wind Resources and Transmission Lines.