ELEM
MACEDONIAN POWER PLANTS

WINDPARK BOGDANCI
PILOT PROJECT

Prepared by: Development and Investments Department

Skopje, 2015

Project Background

The decision for including the wind energy as part of ELEM's portfolio has been determined in June 2004, when the Development and Investment Department has announced Public invitation for developing a **"Wind Energy Resource Atlas and Site Screening of the Republic of Macedonia".**

An overall three-phase plan was prepared:

1. An overall wind resource atlas for Macedonia
2. High quality wind data from a number of promising locations
3. Preparation of feasibility studies for the best locations

Phase 1 was implemented in 2005 and in June 2005, AWS Truewind prepared "**Wind Energy Resource Atlas and Site Screening of the Republic of Macedonia"**. A MesoMap system, numerical model is used for weather forecast. The basic aim of applied technology and Atlas is to identify, select and choose regions and locations which own sufficient energy potential and where there must be continued with further measurements if wind parameters with setting of measuring stations.

Phase 2 was started in April 2006 under an agreement between ELEM, FEIT and NTE (Nordrondelag Electricitetsverk in Norway). This phase is sponsored by Norwegian Ministry of Foreign Affairs and the implementing company is Kjeller Vindteknikk. The project includes installation of four high quality wind measurement stations, which were installed in June/July 2006 at four identified high potential sites.

Phase 3 - The following step was preparation of Feasibility Study Environmental and Social Impact Assessment Study. Since the end of 2008 ELEM's wind energy activities have been supported by the Western Balkan Infrastructure Projects Facility (IPF), a component of the European Union programme CARDS. The Feasibility Study, completed in 2010, provided information about the physical characteristics, economic and financial viability, possibilities of financing and environmental, social, or other impacts of the project, such that the proponent can come to a decision about whether or not to proceed with the project. The strategic objective is to establish the first wind park in the Republic of Macedonia for the purpose of demonstrating the generation of electricity from wind energy and evaluating its potential in the country.

For its first wind project, ELEM has targeted a minimum **annual net production of 100 GWh from wind energy** or approx. 2 % of its current annual electricity generation. Calculating on the basis of widely-used utility turbines with installed capacities between 2 and 2.5 MW, a wind park size of 50 MW has been established to meet this target. A detailed site evaluation showed that this wind park size optimises the use of the available space and wind resources.

After accepting the Draft Feasibility Study ELEM organized a project conference in March 2010 and published the results of the study. During this conference also the first **contacts with potential financing institutions** were established. KfW Entwicklungsbank from Germany voiced their interest to provide financing for the Wind Park Bogdanci.

Project Realization

For the realization of the Project First Phase, out of the planned project cost of **55.500.000,00 Euro** for the period 2011 - 2014, the Government of the Republic of Macedonia approved from the KfW Bank a loan **of 32,9 million euro** and the remaining value to be provided from own financing resources of JSC ELEM and new loan from KfW Bank.

On 09.04.2011 Loan Agreement and Guarantee Agreement were signed in amount of 32,9 million Euros. Due to faster and more efficient project realization as well as successful accomplishment, Government of Federal Republic of Germany through KfW Bank, within bilateral financial cooperation for 2012 provided 15 million euro loan for the Projects for Energy Efficiency and Renewable Energies Phase III. Bilateral Agreement, Loan Agreement, Guarantee Agreement and Project implementation Agreement were concluded on 25.07.2013 where total loan amount is **47,9 million euro** and ELEM equity is **7,9 million euro**.

Providing incentive for new investments for use of the available wind energy, as renewable energy source, the Energy Regulatory Commission of the Republic of Macedonia, has enacted the Decision for Determination of a **Feed-In-Tariff** for the sale of electricity produced and delivered from windmills, determined to be 8,9 €cents/kWh. The privileged generator is obligated to use the privileged tariff in the period of 20 years.

One of the main goals of this project, as Pilot project, was to go through the entire legal procedure for construction of wind parks and to represent positive signal for all interested investors. Due to this reasons, and in accordance with existing legal regulative, JSC ELEM prepared and/or provided all necessary documents, such as: Analysis of impact of WP Bogdanci at the grid of Macedonian TSO MEPSO, completed by MEPSO in February 2010, Study for Geological and geotechnical survey of the terrain, Preliminary Design for Wind Park – Bogdanci, as well as ESIA-Environmental and Social Impact Assessment Study.

Taking into account available financial resources, it was agreed to install the wind park in **two phases**: the first phase with 36.8 MW and an annual net production of 100 GWh and a second phase with the remaining 13.8 MW and an additional net production of 37 GWh.

The layout of the wind farm consists of a total of 22 WECs which are oriented in one line, following the highest parts of the ridge. In the first phase 16 Wind turbines with 93 m rotor diameter each is installed. The layout is shown in the following:

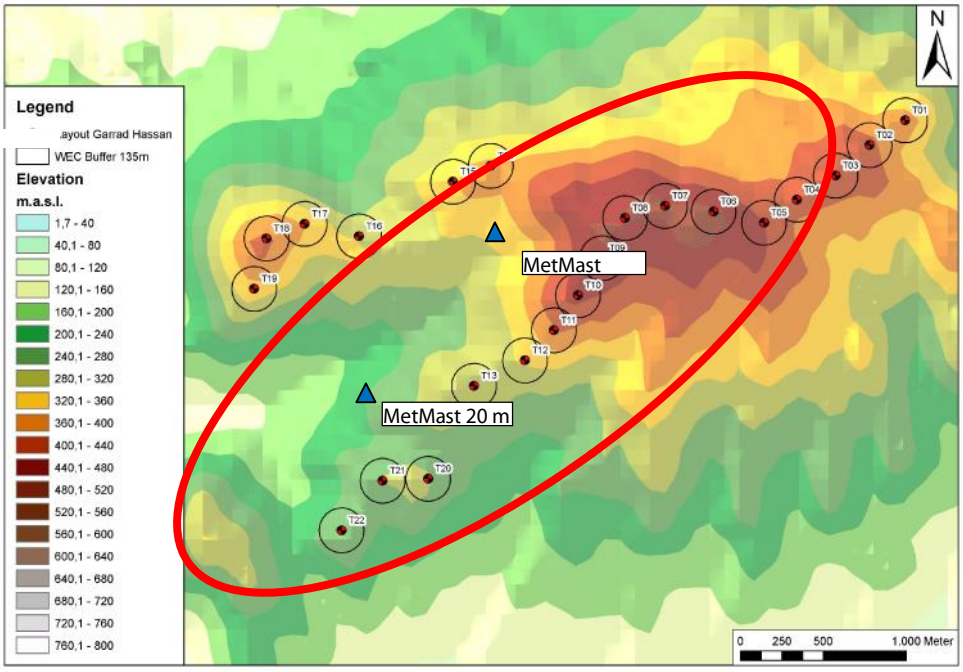


Figure: Layout for 16 turbines (marked in red)

Fichtner GmbH &Co. KG was assigned by ELEM AD the tasks of implementation consultant during engineering, tendering and contract awarding period (Phase I) and to assist throughout project execution, including site supervision (Phase II).

The scope of works of the Bogdanci Wind Park Project is subdivided into three lots:

LOT 1
Includes foundation construction, supply and assembly of wind turbines

LOT 2
Includes construction of access roads and crane platforms, substation, 110 kV transmission line Bogdanci- Valandovo.

LOT 3
Includes extension of the existing substation Valandovo with new transmission bay for grid connection.

The Project was realized during the period from 2012 – 2014.

Measurement Campaign

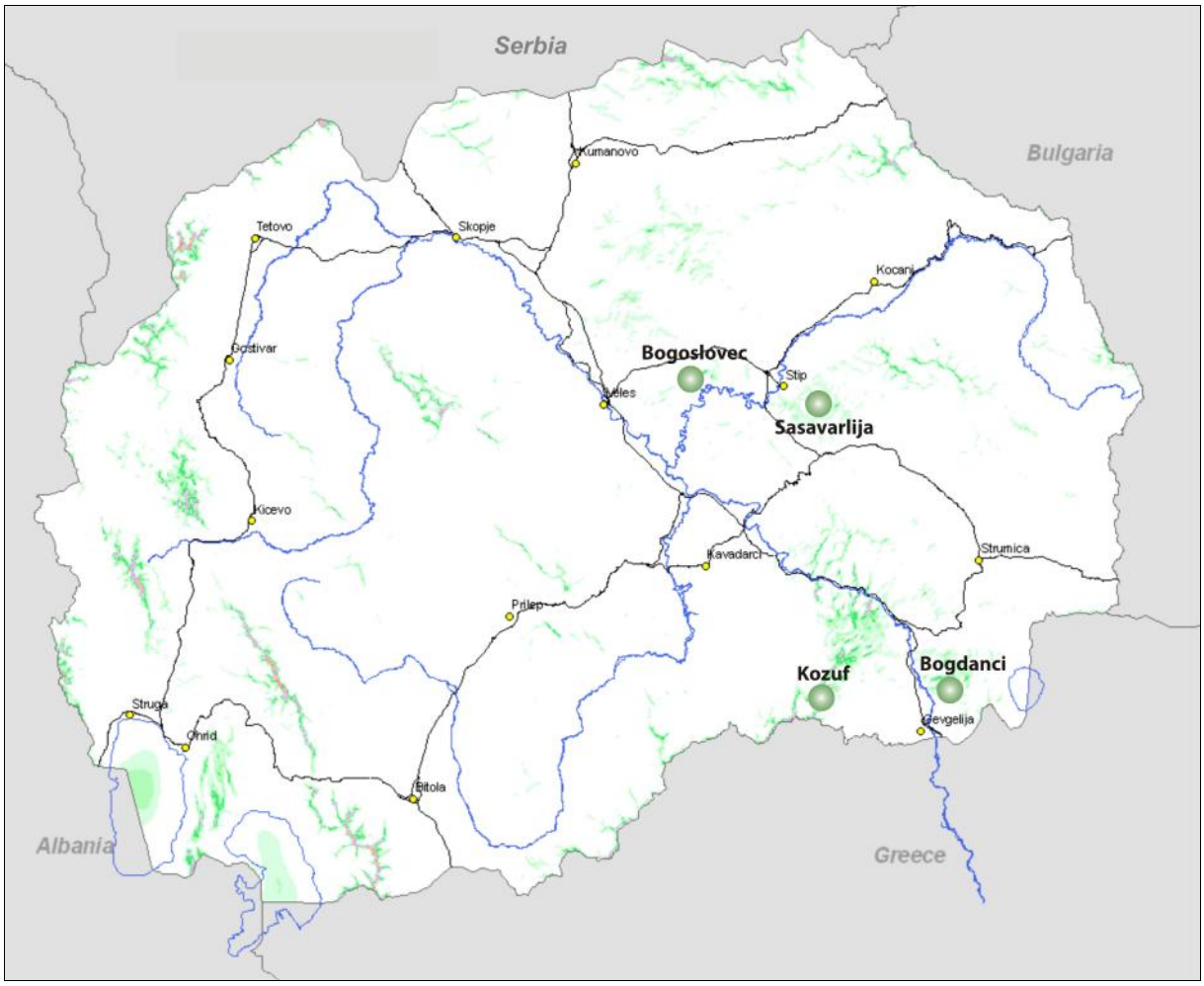


Figure 1: Map showing the locations of the four "Phase 2" sites.

The four sites where measuring stations with height 30 – 50 m were installed are:

1. Bogoslovec (Sveti Nikole) – 733 m above sea level
2. Sasavarilja (Stip) - 857 m above sea level
3. Ravanec (Bogdanci) – 472 m above sea level
4. Flora (Kozuf) - 1730 m above sea level

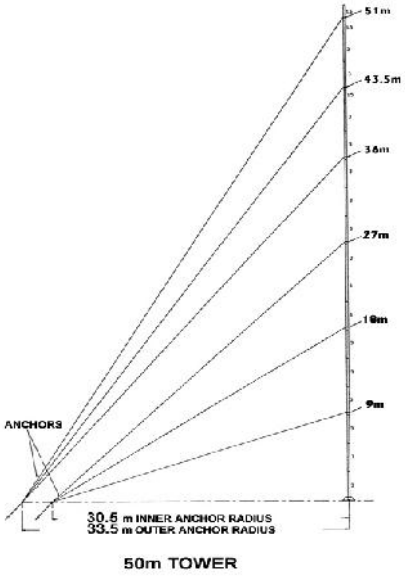
Measuring Equipment

For the measuring campaign in Republic of Macedonia a **NRG Symphonie Logger System** was used. The Symphonie logger is a 12 channel data logger optimized for the needs of the wind energy assessment user.

Installed instruments:

The NRG #40 Anemometers
The P2546A Cup Anemometers
The NRG #200P Wind direction vanes
The NRG #110S Temperature sensors

Measuring Towers



As it was above mentioned, during the measuring campaign in Republic of Macedonia, the instruments were installed at 50 m and 30 m towers. The tower is tubular type, with the following dimensions of the segments:

- length - 3 m
- diameter - 200 mm.

Towers were installed respecting all the regulations related to such type of towers:

- to be able to withstand wind and ice loading extremes expected for the location;
- to be structurally stable to minimize wind-induced vibration;
- have guy wires secured with the proper anchor type;
- to be equipped with lightning protection measures including lightning rod, cable and grounding rod;
- to be secured against vandalism and unauthorized tower climbing;
- to be protected from cattle or other grazing animals.

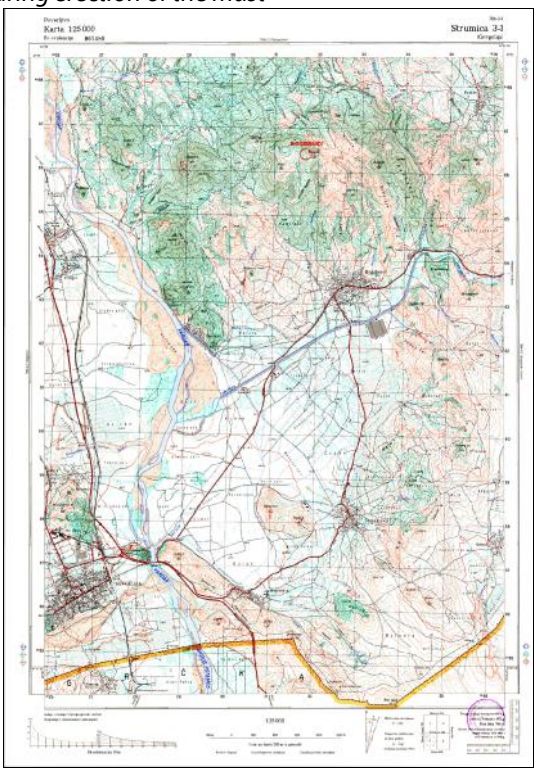
Bogdanci Site

Position

Map Projection	Datum	Zone	Elevation at Tower Base	Northing	Easting
EUREF89	UTM	34	472	4565376	630825
	GEO	34	472	41°13'45.1"	22°33'39.4"

Picture 1 – Bogdanci Site – During erection of the mast

Picture 2 – Bogdanci Site – Measurement Mast



Picture 3 – Bogdanci Site - Map

Additional Measuring Sites

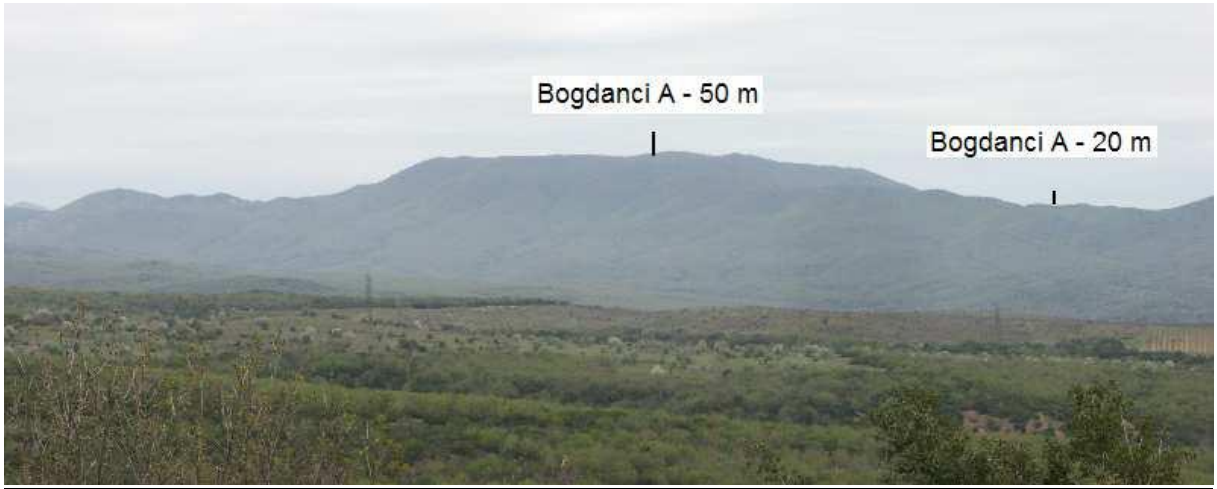
Bogdanci A Site

Position

Map Projection	Datum	Zone	Elevation at Tower Base	Northing	Easting
	GEO	34	329	41°13.263′	22° 32.980′

This is the original site, selected with support of experts from the American company AWS Truewind. It is site which had a sufficiently large wind resource and enough space to install a wind park with an annual generation potential of 100 GWh. A measuring station with a 50 m tower was installed at the highest elevation of the area at nearly 500 m above sea level. In order to use the complete potential of this site, apart from the central plateau, neighbouring ridges had to be assigned as wind park area which had partly only half the elevation of the central plateau and were up to 2 km away from the wind measuring station.

To reduce the error in output forecasting of this large site with inhomogeneous topography, therefore, an additional measuring station at 280 m above sea level was installed. **This tower is just 20 m high**, as a correlation with the three years of measurements from the 50 m tower (with an anemometer at 20 m above ground) will be accurate enough.



Bogdanci A as seen from the Bogdanci B Wind Park Area

Project status

In January 2012 a Contract with the Consortium TERNA - SIEMENS Greece was signed for **LOT 2** - construction of access roads and crane platforms, middle-voltage cables, SS 20/110 kV Bogdanci and 110 kV OHTL Bogdanci - Valandovo.

In August 2012 a Contract with SIEMENS Denmark was signed for **LOT 1** – construction of foundations for wind turbines as well as supply, transport and installation of 16 x 2,3 MW wind turbines.

In December 2012 a Contract with DASS Ingenering Macedonia was signed for **LOT 3** - extension of the existing SS 110/35 kV Valandovo with new transmission bay and command control facility for grid connection of WP Bogdanci to Energy power System of Republic of Macedonia.

The Project was registered as a CDM Project at UNFCC in November 2012.

Project Realization was completed in 2014.

TECHNICAL DESCRIPTION OF THE PROJECT

Technical parameters - WP Bogdanci First Phase.

Основни карактеристики на ПВЕ Богданци	
• Average wind speed	7,1 m/sec
• Number of turbines	16
• Installed capacity	36.8 MW (16 x 2,3 MW)
• Rotor Diameter	93 m
• Average Annual Production	100 GWh
• Voltage Level	110 kV

Wind Park Description

The entire system relating to such energetic connection comprises 20kV cable line network, 20kV power plant, 2x25/40MVA ONAN/ONAF power transformers located at SS 110/20kV "Bogdanci", 110kV transmission line "SS Bogdanci - SS Valandovo" for transmission of the electric power to the existing SS 110/35/10kV "Valandovo", the latter actually being the point of connection to the National electric power transmission system operator (MEPSO), as well as access roads and platforms for installation of the wind turbines.

SS TC 110/20kV; 2x25/40MVA Bogdanci enables transformation and transmission of the generated electricity from the WP Bogdanci to the electric power system of Macedonia, through 11 km long 110 kV OHTL SS Bogdanci - SS Valandovo.

For this reason, in addition to the construction of a substation, the proposed design further envisages construction of a 110kV transmission line "TS Bogdanci - TS Valandovo", which implies broadening the TS Valandovo by one 110kV transmission line bay, extending the

existing 110kV bus-bar systems and providing room for one additional transmission line bay.

According the technical requirements for the disposition of the wind turbines, positioned applying the minimal required distances in between, wind turbines are connected internally on 20 kV voltage level.

Description of the Wind Turbines

The project consists of 16 Siemens wind turbines Type SWT - 2.3 - 93.

Short description of the main components of the SWT - 2.3 - 93 turbine is presented below:

Rotor
The SWT-2.3-93 turbine has a three-bladed rotor with pitch regulation for power output optimization and control. The rotor speed is variable in order to maximize the aero-dynamic efficiency, and speed compliance during power regulation minimizes the dynamic loads on the transmission system.

Blades
The blades are made of fiberglass - reinforced epoxy. In this process, the blades are cast in one piece, leaving no weak points at glue joints and providing optimum quality. Blades are mounted on pitch bearing and their pitch may pounce for 80° due to switching off.
Each blade has own safety independent pitch mechanism available for blade pouncing under different conditions.
The blade pitch arrangement is used to optimize and regulate power output through the operating range. The blades are feathered to minimize wind loads during standstill under extreme wind conditions.

Rotor hub
The rotor hub is cast in nodular cast iron and is fitted to the main shaft with a flange connection. The hub is large enough to provide a comfortable working environment inside the structure for two service technicians during maintenance of bolt connections and pitch bearings.

Generator
The generator is a fully-enclosed asynchronous machine with squirrel-cage rotor, which does not require slip rings of type "Siemens Loher" with nominal power of 2300kW, nominal revolutions 1550rpm; speed 600-1800 rpm, nominal voltage 750V, frequency 16,5-60Hz. The generator rotor construction and stator windings are specially designed for high efficiency at partial loads. Generator is protected with thermal breakers and analogue sensors for temperature measurement.

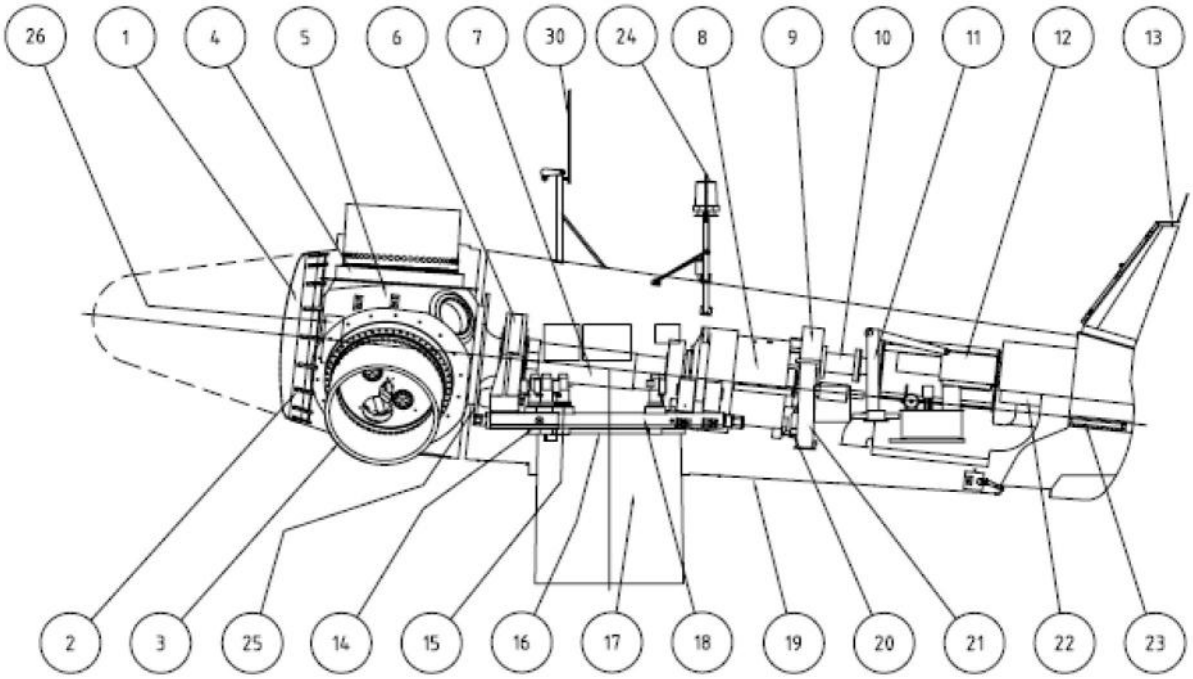
The generator is internally ventilated with thermostatic controlled system and cooled with an air-to-air heat exchanger which efficiently maintains internal generator temperature independently of environmental temperature.

Tower
The SWT-2.3-93 turbine is mounted on a tapered tubular steel tower with 80 m height. The tower is divided in three sections. The tower has internal ascent and direct access to the yaw system and nacelle. It is equipped with platforms and interior electric lighting.

Platforms are located just below the intermediate flange locations for suitable accesses to connection of cables and for tightening the flange connection bolts. Platforms are also located just below the upper controller box and above the main controller box. The upper platform is located just below the top flange for suitable access to the nacelle, for tightening bolts and servicing the yaw system.

SCADA (Supervisory Control and Data Acquisition)

The SWT-2.3-93 turbine is equipped with the unique WebWPS SCADA system. This system offers remote control and a variety of status views and useful reports from a standard Internet Web browser. The status views present electrical and mechanical data, operation and fault status, meteorological data and grid station data.



(1) Spinner
(2) Spinner bracket
(3) Blade
(4) Pitch bearing
(5) Rotor hub
(6) Main bearing
(7) Main shaft
(8) Gearbox
(9) Brake disc
(10) Coupling
(11) Service crane
(12) Generator
(13) Meteorological sensors
(14) Yaw bearing
(15) Yaw gear
(16) Yaw ring
(17) Tower
(18) Nacelle bedplate
(19) Canopy
(20) Oil filter
(21) Oil filter
(22) Generator fan
(23) Oil cooler
(24) Aviation lights
(25) Rotor lock
(26) Pitch bearing controller box
(27) Upper controller box
(28) Relay box
(29) Supply box
(30) Visibility instrument