Wigton
WINDFARM LTD

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The Wigton Windfarm Resource Centre

Wigton Windfarm Limited, the largest wind energy facility in the English-Speaking Caribbean, is a subsidiary of the Petroleum Corporation of Jamaica (PCJ). It was established in 2004 with 20.7MW capacity and then expanded to 38.7MW six years later. Wigton's vision is to be a catalyst for increased usage of wind power and other renewable energies for electricity to Jamaicans and the company also seeks to support the growth of Jamaica's renewable energy industry by developing human capital.

Against this background, the Wigton Resource Centre was opened at the company's windfarm complex in Rose Hill, Manchester in 2010.

In 2014 Wigton received a grant of £ 27,887 from the British High Commission to support the establishment of a renewable energy training lab at the Resource Centre. The grant was awarded from the High Commission's Bilateral Programme and Caribbean Regional Prosperity Fund. The allocation went towards the installation of a solar roof, an off-grid demonstration photovoltaic system and a small demonstration wind turbine for renewable energy training.

The lab's equipment includes a 12 kW Grid Tied PV System (48 x 250 W panels) and a 250 W demonstration off grid system. With approximately 5 sun hours per day, the estimated production is 48 kWh daily, 1,440 kWh monthly and 17,280 kWh annually. The estimated savings based on the Jamaican electricity rate of US $37 cents/ kWh is US $17.76 daily; US$532.80 monthly and US$ 6,393.60 annually.

Wigton's vision is for the lab to serve as a premier learning facility offering training in several aspects of renewable energy including solar thermal, photovoltaic technologies, wind power, concentrated solar power, small-scale hydro and bioenergy.

WHAT ARE PHOTOVOLTAICS ?

Photovoltaics is a method of generating electrical power by converting solar radiation into direct current electricity using semiconductors that exhibit the photovoltaic effect. Photovoltaic power generation employs solar panels composed of a number of solar cells containing a photovoltaic material. Mainstream materials presently used for photovoltaics include monocrystalline silicon, polycrystalline silicon, amorphous silicon, cadmium telluride, and copper indium gallium selenide/sulfide.

PHOTOVOLTAIC EFFECT

This is the creation of an electric current in a material upon exposure to light. When the sunlight or any other light is incident upon a material surface, the electrons present in the valence band (highest range of electron energies) absorb energy and, being excited, jump to the conduction band and become free. These highly excited, non-thermal electrons diffuse, and some reach a junction where they are accelerated into a different material by a built-in potential (Galvani potential). This generates an electromotive force which converts some of the light energy into electric energy. The photovoltaic effect was first observed by French physicist A. E. Becquerel in 1839.

MAIN SYSTEM COMPONENTS: GRID TIED

Inverter: Schneider – Electric (conext TL-15000) Grid Tied Inverter

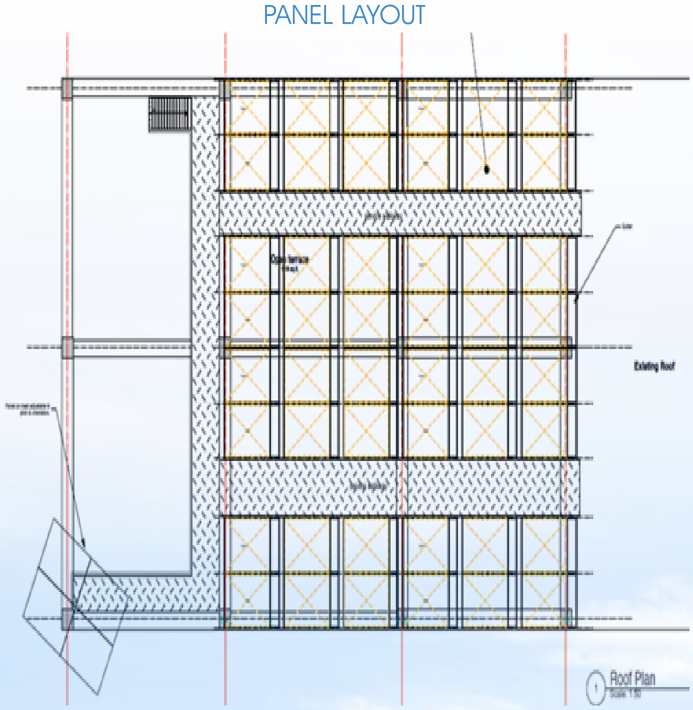
Solar panels: Ningo Qixin 250 W Monocrystalline Solar Panels

Monitoring system: Solare Datensysteme GmbH – Solar Log 500 (internet enabled monitoring)

Combiner: For multiple strings of PV panels.

Surge Protector: Lightning arrestor

PANEL LAYOUT



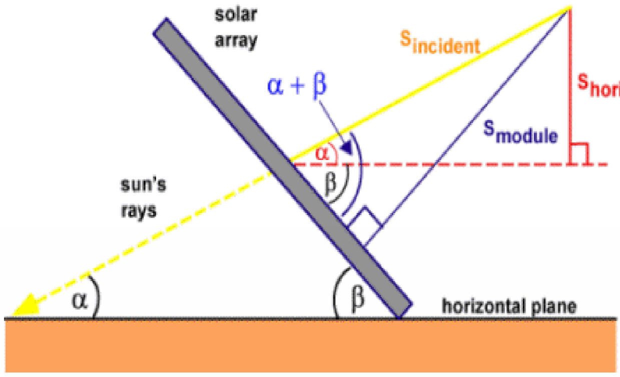
HOW DOES A GRID TIED SYSTEM WITHOUT BACK-UP BATTERIES WORK?

Light energy is converted to electrical energy (direct current - DC) by the photovoltaic cells. Electrical energy is then transformed to alternating current by the inverter (97% efficient). Inverter synchronizes electricity produced with the grid. Grid tied electrical system is a semi-autonomous electrical generation system which links to feed excess capacity back to the electrical grid. When insufficient electricity is generated, or a battery system is not fully charged, electricity drawn from the main's grid makes up the shortfall.

FACTORS IMPACTING SOLAR PERFORMANCE

Impact of Tilt Angle

A solar photovoltaic module generates more electrical power when more sunlight power incidents on it. The sunlight power incident on a module depends not only on the power contained in the sunlight but also on the angle between the module and the sun's rays. When the sun's rays fall normally (perpendicular) on the module's surface, the incident sunlight power is maximum. The amount of sunlight power incident on the module's surface is the component of the incoming sunlight power perpendicular to the module's surface.



$S_{module} = S_{incoming} \sin(\alpha+\beta)$

Where α is the elevation angle; and

β is the tilt angle of the module measured from the horizontal.

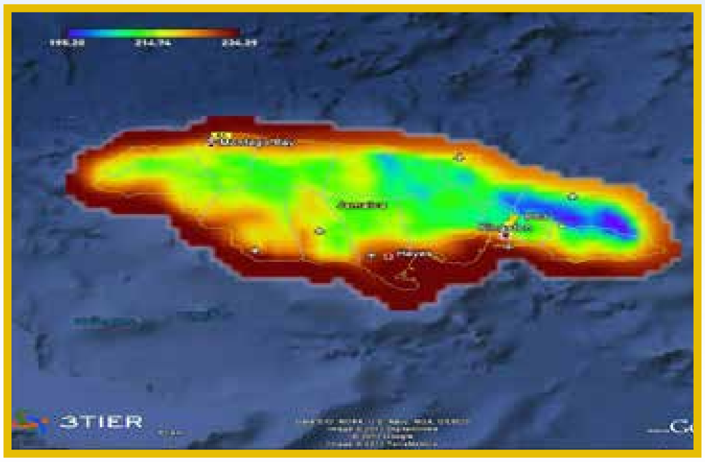
The power incident on a PV module depends not only on the power contained in the sunlight, but also on the angle between the module and the sun. When the absorbing surface and the sunlight are perpendicular to each other, the power density on the surface is equal to that of the sunlight (in other words, the power density will always be at its maximum when the PV module is perpendicular to the sun). However, as the angle between the sun and a fixed surface is continually changing, the power density on a fixed PV module is less than that of the incident sunlight.

An ideal system would be positioned at 180°, due south. However, this is not always possible, so the closest space to south-facing is normally selected. For a fixed tilt angle, the maximum power over the course of a year is obtained when the tilt angle is equal to the latitude of the location. Therefore 18° N for Jamaica.

Iradiance

Irradiance is the power of electromagnetic radiation per unit area (radiative flux) incident on a surface.

AVERAGE IRRADIANCE OF JAMAICA OVER A 24 HOUR PERIOD IN WATTS PER SQUARE METRE



Impact of Shading

When even a small portion of a solar cell, module, or array is shaded, while the remainder is in sunlight, the output falls dramatically due to internal 'short-circuiting' (the electrons reversing course through the shaded portion of the p-n junction).

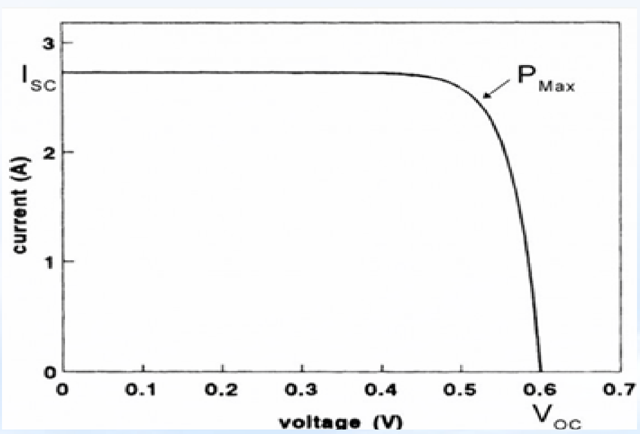
If the current drawn from the series string of cells is no greater than the current that can be produced by the shaded cell, the current (and so power) developed by the string is limited.

If enough voltage is available from the rest of the cells in a string, current will be forced through the cell by breaking down the junction in the shaded portion. This breakdown voltage in common cells is between 10 and 30 volts. Instead of adding to the power produced by the panel, the shaded cell absorbs power, turning it into heat.

Impact of Temperature

Module output and life are also degraded by increased temperature. Allowing ambient air to flow over, and if possible behind, PV modules reduce this problem.

TYPICAL PERFORMANCE OF A SOLAR CELL



DEMONSTRATION OFF-GRID PV WITH STORAGE

Battery Storage: Trojan Battery – sealed, maintenance free type 31-Gel

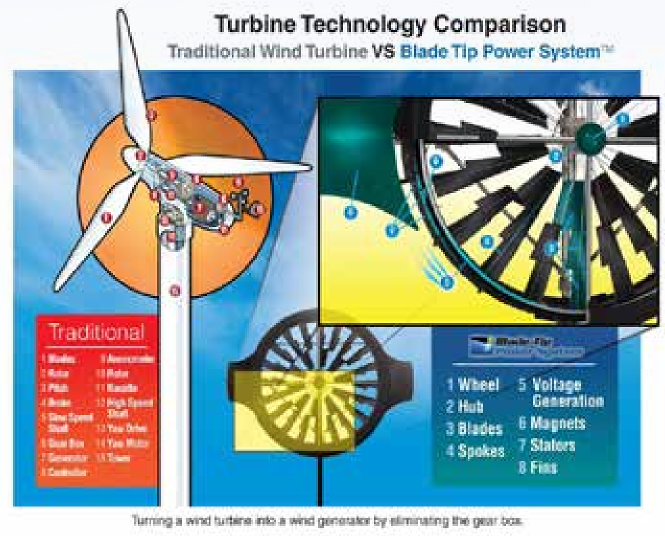
Inverter: Xantrex PROwatt SW Sine Wave Inverter (600 W)

Charge Controller: Xantrex C12

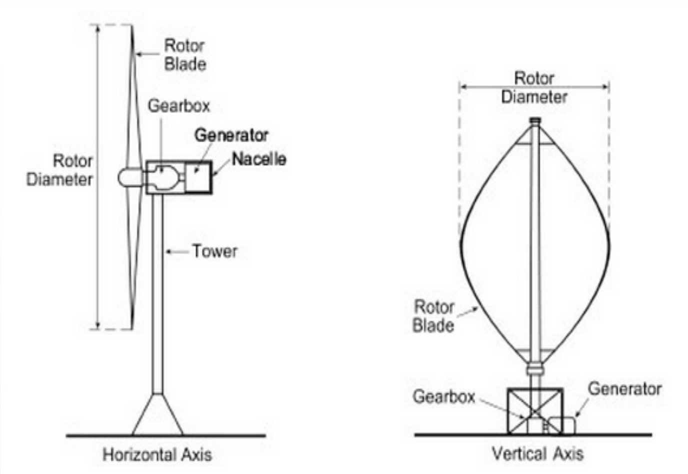
Solar Tracker: Sun Tracer ST44M2V2P Dual Axis

SMALL DEMONSTRATION WIND TURBINE GENERATOR

A wind turbine is a device that converts kinetic energy from the wind into electrical power. The wind spins the shaft of the generator converting mechanical energy into electrical energy.



HORIZONTAL AXIS VERSUS VERTICAL AXIS WIND TURBINES



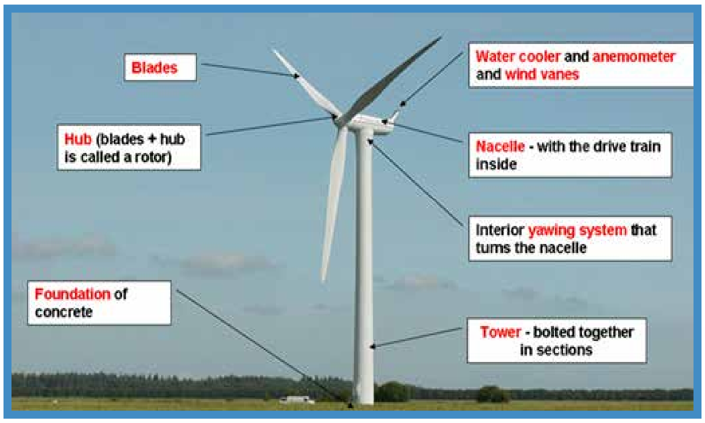
Horizontal-axis wind turbines (HAWT) have the main rotor shaft and electrical generator at the top of a tower, and must be pointed into the wind. Small turbines are pointed by a simple wind vane, while large turbines generally use a wind sensor coupled with a computer driven motor. The theoretical maximum efficiency of a horizontal axis wind turbine is 59% and typically, large scale manufacturers achieve 45%.

Vertical-axis wind turbines (VAWT) have the main rotor shaft arranged vertically. One advantage of this arrangement is that the turbine does not need to be pointed into the wind to be effective, which is an advantage on a site where the wind direction is highly variable, for example when the turbine is integrated into a building.

However, the key disadvantages to VAWT include:

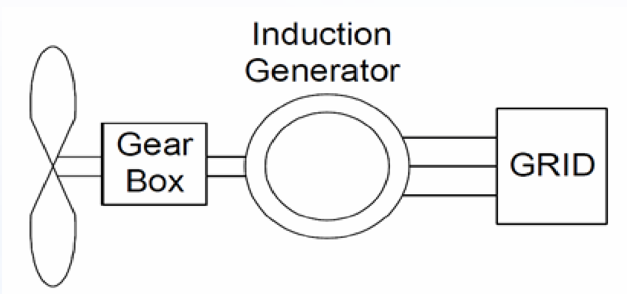
- The relatively low rotational speed with the consequential higher torque and hence higher cost of the drive train
- The inherently lower power coefficient, the 360 degree rotation of the aerofoil within the wind flow during each cycle and hence the highly dynamic loading on the blade
- The pulsating torque generated by some rotor designs on the drive train, and the difficulty of modelling the wind flow accurately and hence the challenges of analysing and designing the rotor prior to fabricating a prototype

TYPICAL WIND TURBINE COMPONENTS – HORIZONTAL AXIS TYPE

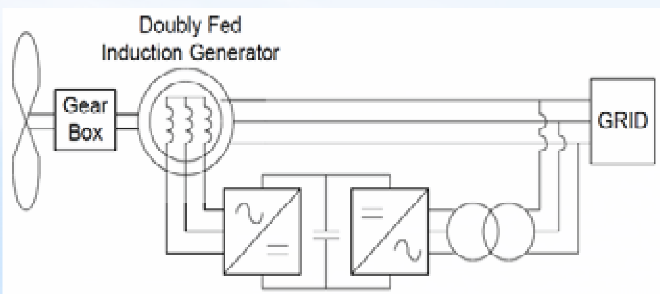


TYPES OF WIND TURBINE GENERATORS (HAWT)

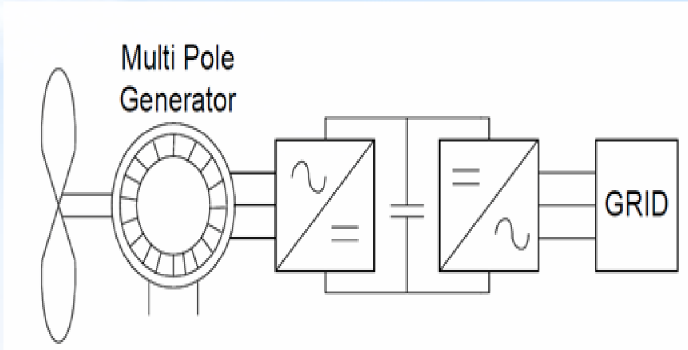
Type 1 & 2



Type 3



Type 4



FEATURES OF DIFFERENT TYPES OF WIND TURBINE GENERATORS

	Type 1	Type 2	Type 3	Type 4
Speed	Very Limited	Limited	Flexible Range	Wide Range
Active Power	Uncontrolled	Limited Control	Controlled	Controlled
Gearbox (noise)	√	√	√	Gearless
VARs	Consumer	Consumer	Controlled	Very Controlled
Voltage/ PF	Uncontrolled	Uncontrolled	Controlled	Very Controlled
VRT	Limited	Limited	√	√

RESIDENTIAL AND COMMERCIAL SCALE WIND

- Larger wind farms require class 4+ winds
- Residential applications class 2+ winds

Classes of Wind Power Density at 10 m and 50 m

	10 m		50 m	
Wind Power Class	Wind Power Density (W/m²)	Speed m/s	Wind Power Density (W/m²)	Speed m/s
1	<100	<4.4	<200	<5.6
2	100 - 150	4.4 - 5.1	200 - 300	5.6 - 6.4
3	150 - 200	5.1 -5.6	300 - 400	6.4 - 7.0
4	200 - 250	5.6 -6.0	400 - 500	7.0 - 7.5
5	250 - 300	6.0 -6.4	500 - 600	7.5 - 8.0
6	300 - 400	6.4 -7.0	600 - 800	8.0 - 8.8
7	>400	>7.0	>800	>8.8

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