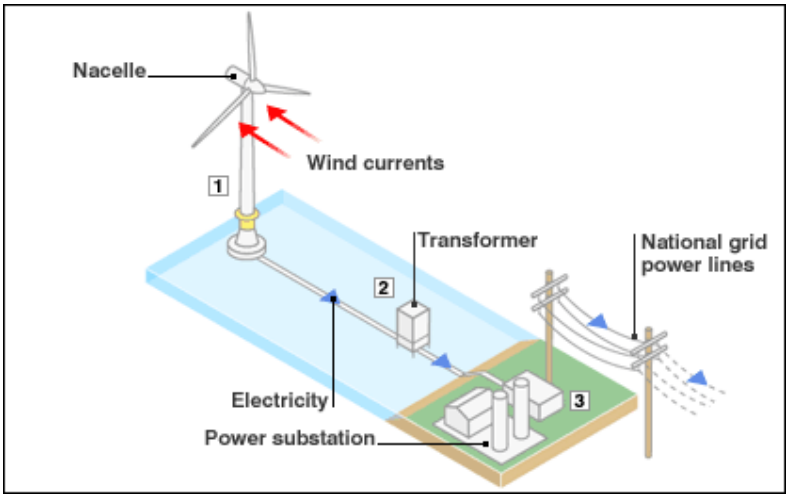
Wind Power

Task 1: Wind power generating electricity.

How does Wind Turbines Work?

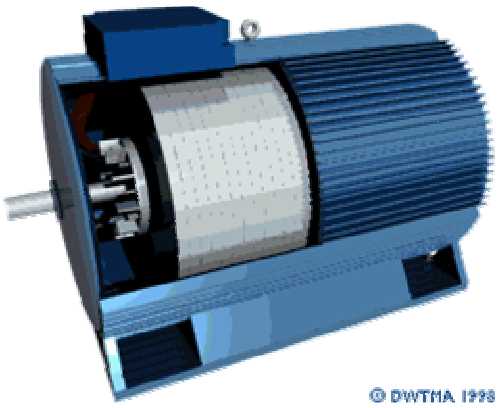
1. The wind blows and it turns the blades and makes them turn.
2. The blade turns a shaft inside the nacelle.(No 11 from the picture above)
3. The shaft goes into a gearbox which increases the rotation speed enough for the generator.
4. The generator uses magnetic fields to convert the rotational energy (kinetic energy) into electrical energy.

5. The power output goes to a transformer, which converts the electricity produced by the generator at around 700 Volts (V) to the right voltage for distribution system, usually 33,000 V.
6. The national grid transmits the power around the country.(Like shown below in the picture).



Energy conversion:

Induction generators: Induction generators work as device that converts the mechanical energy of rotation into electricity based on the electromagnetic inductions.



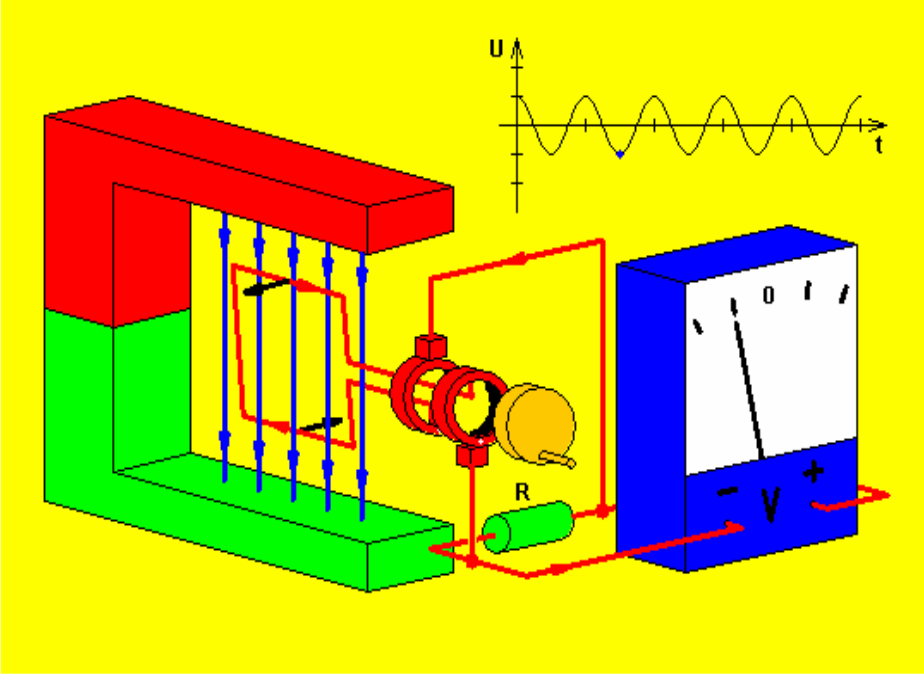
How induction generators work:

The energy transfer/conversion occurs in the generator. Most wind turbines use the induction generators despite the vast variety of generators because the induction generator is reliable and cost-effective. The motor consists of stationary coil of wire that carries the current to

function them, wound through slots in steel lamination or what also known as the squirrel cage rotors. An electric voltage (electromotive force) is induced in a conducting loop (or coil), when there is a change in the number of magnetic field lines passing through the loop. When the loop is closed by connecting the ends external load, the induced voltage will cause an electric current to flow through the loop and load.

The rotational energy is converted into electrical energy.

Below is model of the induction generator and how it works



Key

Blue lines = magnetic field

Red lines = induced current

Black arrows =direction

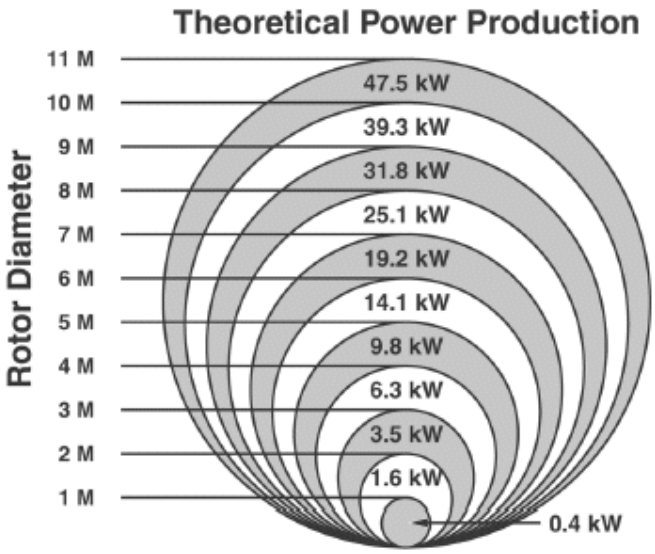


Fig illustrates the theoretical power production relative to the size of the rotor.

For example if wind turbine with rotor diameter 5M it's expected theoretically to produce 14.1KW

Task 2; Calculations on cost when generating electricity.

Cost:

The cost of generating electricity using wind turbines breaks up to:

- Capital costs ;the cost of building the power plant and connecting it to the grid
- Running costs e.g. Buying fuel and operation and maintenance.
- The cost of financing i.e. how the capital cost is repaid, interest on money invested
- The amount of energy produced.

	1981	1985	1990	1996	1999	2000
Rotor (meters)	10	17	27	40	50	71
Rating (KW)	25	100	225	550	750	1,650
Annual MWh	45	220	550	1,480	2,200	5,600

Fig illustrates the different turbine sizes and the amount of electricity they are each capable of generating and power ratings.

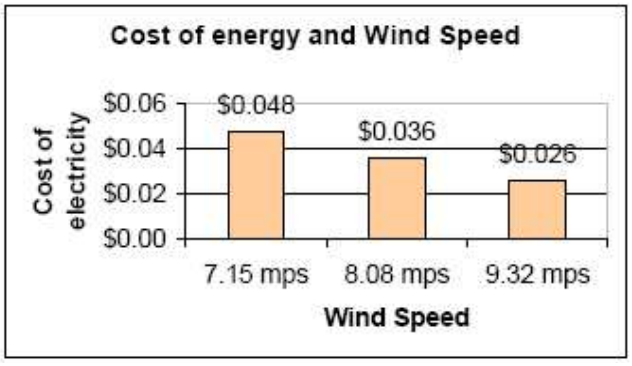


Fig illustrates the three examples of cost per KWh for 51MW wind farm at the three different wind speeds in mps

7.15mps costs = $0.048

1mps=$0.048/7.15

=0.00671.

How much electricity can one wind turbine generate?

The output of a wind turbine depends on two man factors the turbine's size and the wind's speed through the rotor. At the moment wind turbines being manufactured now have power ratings ranging from 250 watts - 5 megawatts (MW).

A 10-kW wind turbine can generate about 10,000 kWh annually at a site with wind speeds averaging 12 miles per hour, or about enough to power a typical household.

A 5-MW turbine can generate more than 15 million kWh in a year which is enough to power more than 1, 400 households. The typical U.K household consumes about 10,000 kWh of electricity per year.

How many homes can one megawatt of wind energy supply?

An average U.K household uses about 10,655 kilowatt-hours (kWh) of electricity each year. One megawatt of wind energy can generate from 2.4 surplus 3 million kWh annually. Therefore, a megawatt of wind generates about as much electricity as 225 to 300 households use.

Comparison of Different Energy Sources

	Non-renewable			Renewable			
	Coal	**Gas**	**Nuclear**	**Solar**	**Wind**	**Hydro-electric**	**Geothermal**
Efficiency	2 - 3 kWh/kg	4 - 5 kWh/kg	45 - 50 000 kWh/kg	comparative figures not available	comparative figures not available	comparative figures not available	comparative figures not available
Cost (US cents/kWh) OECD 1998 (exc.Japan)	2.5 – 4.5	2.3 – 4.7	2.5 – 4.1	12-20	5	comparative figures not available	comparative figures not available
Cost effective	yes	yes	yes	comparative figures not available	intermittent, cannot meet base load	yes	in a few localities
Ability to meet base load demand	yes	yes	yes	no	no	yes	no
Source reliability and availability	good	good	good	variable daily & weather dependent	variable & weather dependent	seasonal dependence	not many suitable sites
Back-up power	not needed	not needed	not needed	needed	needed	needed	needed
Export dollars for Australia (end of 2000)	$8.7 billion	$1.9 billion	$.367 billion	some from sale of technology	some from sale of technology	some from sale of technology	unknown
Greenhouse gas emission	1kg of CO_2/kWh	0.5kg of CO_2/kWh	none	none	none	none	none
Emissions to environment	NO_x, SO_2	NO_x, SO_2	steam	nil	nil	nil	nil
Other wastes	ash, flyash		4 milligrams of radioactive spent fuel/kWh	toxic waste from production of solar panels	nil	nil	nil
Other environmental impacts	extensive mining, major transportation, acid rain	production facilities, pipelines, acid rain	limited mining and associated tailings storage facilities	on roofs	can be unsightly, noisy, birds fly into rotors	changes in ecosystems through dams flooding large areas	

Fig 1; illustrates a comparison between renewable and non-renewable energy sources.

It is complicated to compare the cost of generating electricity from different energy sources because many of the benefits of renewable energy are for example no pollution and never-ending supply. These benefits do not have a generally acknowledged price.

" However, it is important to try and compare 'like with like' when comparing with generation costs with those of the fossil fuel sources and so prices bid into the Non-Fossil Fuel Obligation, which offers 15-year contracts, are a good guide. In the last round of all, the first Scottish offer, around 1000 MW of wind was bid at 2.8 pence per kilowatt hour (p/kWh) or less - 3.2 p/kWh at 2004 prices while the minimum bid was about 2.2 p/kWh at 2004 prices."
(From http://www.bwea.com/ref/econ.html)

Task 3; Evaluation and comparison:

Advantages of wind energy

- Wind is a renewable source of energy.
- Wind is free and wind farms don't need fuels.
- Doesn't produce any waste or greenhouse gases.
- The land beneath the wind turbines can usually still be used for farming.
- Wind farms can act as tourist attractions.
- Wind turbines are a good method of supplying energy to remote areas.
- Each 1 MWh of electricity that is generated by wind energy contributes to reduce the 0.8 to 0.9 tonnes of greenhouse gas emissions that are produced by coal or diesel fuel generation each year.

Disadvantages of wind energy

- The wind is not always predictable/reliable.
- Suitable areas for wind farms are often near the coast, where land is expensive.
- Can kill birds.
- Affects television reception in the nearby surroundings.
- Can be very noisy.

Advantages of Fossil fuels:

- Very huge quantities of electricity can be produced in one place using coal, for reasonably cheap prices.
- Oil and gas transportation from and to he power stations are easy.
- The efficiency of Gas-fired power stations.
- A fossil fuel power station can be situated anywhere as long It has easy road access for transportation of fuel.

Disadvantages of Fossil fuels:

- Fossil fuels are non-renewable source of energy.
- Fossil fuels cause pollution. Burning any fossil fuels produce CO_2 which add to he green house effect causing the Earth to warm up.
- Burning coal releases more CO_2 than burning oil or gas. It also produces sulphur dioxide which contributes to acid rain.
- Mining coal proved to be difficult and dangerous plus strip mining causes for large areas of the landscape to be destroyed.
- Coal-fired power stations need huge amounts of fuel, which means huge amounts of coal needs to transported constantly to the power station. In order to prevent delays in coal deliveries the power station needs reserves. This means large areas of land next to the power station will be covered with piles of coal which helds up the land.

Overall, from the above I conclude that the advantages of wind energy are slightly less than powerful than those of fossil fuels. On the other hand the disadvantages of fossil fuels outweigh those of the wind energy. I conclude that wind energy provides clean and pure energy however it's hard to obtain and expensive to generate electricity from compared to that of the fossil fuels which are more efficient and cost effective.

Is wind energy expensive?

Yes, wind energy is very expensive that's due to the wind speed variation on the day to day bases which effects the operation of the wind plant, therefore also varying the operations costs. But a recent research by utility engineers has revealed that the costs are comparatively small –to be *"less than about 2 mills/kilowatt hour (KWH) at penetration under 5% and possibly rising to 5 mills at 20% penetration".* However is the capital cost added to the interest on the investments costs that add to total cost.

Over the last 20 years, wind electricity costs have drooped by more than 80%. In the early 80s, when the` first utility-scale turbines were installed, wind-generated electricity cost as much as 30 cents /KWh. however, now due to the state-of-the-art wind power plants can generate electricity for less than 5 cents/kWh with the Production Tax Credit.

This builds a little hope the wind power will keep decreasing regarding it's costs so maybe in the future it will be the realistic option to depend on.

Wind energy at small scale large scale wind turbines related problems.

Large wind farms are more cost-efficient than small projects.

For Example:

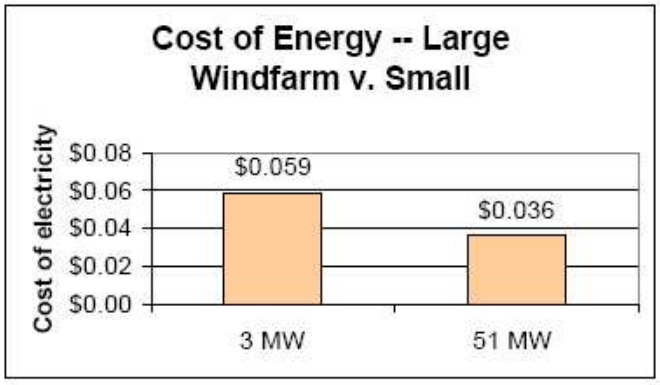
Suppose the same average wind speed of 18mph there was the larger project which had a 51 MW wind turbine and produced electricity at a cost of a $0.036.however there was a smaller project which had 3 MW wind turbines and produced electricity at a cost of $0.059.the cost has increased by =0.059-0.036

=0.023

The percentage of increase=0.023/0.036 X 100

=64%

Any project has transaction cost that can be spread over more KWh with the larger projects. So basically the more KWh produced the cheaper the cost. Also, a larger project has lower operation and maintenance costs per KWh because of the efficiency of managing a larger farm.



However there is advantage of the small scale wind farms:

- The small wind turbines can be installed in hedges so there is no farming land lost.
- The small wind turbines are comparatively less nosy than the large ones.
- No power lines are required for the mini wind turbines

- No specialised personnel needed to install.
- The turbines have an expected life span of 25 years.

However small scale wind farming aren't cost-effective and will not produce as much electricity as the larger wind farms.

How many wind turbines do we need to generate electricity for the England and Wales.

I stated before; A 5-MW turbine can generate more than 15 million kWh in a year which is enough to power more than 1, 400 households. The typical U.K household consumes about 10,000 kWh of electricity per year. A Census in 2001 has revealed that there are 22million houses in England and Wales.

For Example:

Let say that the 22miliion house use about 10 000 KWh per year.

The 5MW produce about 15million KWh enough for 1 400

The NO of turbines we will need =22million ÷ 1 400

= 15714.285714

Aprox=15714 5MW turbines

We will need 15714 5MW turbines to provide the electricity for the whole of England and Wales. Now this number has been generate don the data is approximate and it is only for England and Wales and still is a huge number. This shows that we can't depend on wind energy alone to provide the electricity for the whole of UK because we don't have the land or the capital money.5MW turbines cost 5million plus the installation at 0.8million. So for just the 15714 5MW turbines we will need = 91141.2million this doesn't include the land rent and operation cost maintenance etc. simple is impossible to depend on wind energy alone but perhaps it can be used combined with other conventional ways of producing energy like fossil fuels.

Environmental impact:

Wind turbines environmental impact consists of the noise, birds getting killed and space or landscape usage. All these are minor issues that are easy to overcome. The noise, as aerodynamic designs have improved modern wind farms is much quieter. A lot quieter than fossil fuel power stations; and wind farms tend not to be close to residential areas anyways. The small modern wind generators used on boats and caravans make hardly any sound at all. Nevertheless, some migrating flock tend to attract to strong winds and in some cases are attracted by the strong wind produced by turbines and get killed. However this very rare, because prior to installation of any wind farms the area is checked for migratory routes to prevent the migrating flock. Lastly the land fill of wind farms is not a bad impact as the land can still be used for farming as the towers f the turbines are very high. the landscape issues is easy to resolve if the wind farms are installed in organized and creative array they could act as tourist attraction site for example;

the picture below is of a wind farm on coast(wind speed is highest) in Denmark.

References;

All these websites were last accessed on the 12/06/08.

- http://www.uraniumsa.org/esd/energy_comparison.htm
- http://www.bwea.com/ref/econ.html
- http://www.depweb.state.pa.us/energy/cwp/view.asp?a=1377&Q=484130
- http://www.windpower.org/en/tour/wtrb/electric.htm
- http://www.daviddarling.info/encyclopedia/I/AE_induction_generator.html
- http://www.canren.gc.ca/tech_appl/index.asp?CaId=6&PgId=232
- http://news.bbc.co.uk/2/low/uk_news/6969865.stm
- http://www.walter-fendt.de/ph14e/generator_e.htm
- http://www.omafra.gov.on.ca/english/engineer/facts/03 -047f11.gif
- http://www.awea.org/faq/wwt_basics.html
- http://www.nrel.gov/docs/fy05osti/37657.pdf
- http://home.clara.net/darvill/altenerg/wind.htm
- http://www.redriven.net/pages.php?pageid=56
- http://www.awea.org/pubs/factsheets/EconomicsOfWind -Feb2005.pdf
- Physics second edition by Ken Dobson, David Grace, David Lovett published by Collins.