8 Wind power can be used for the generation of electric power. Fig. 8.1 illustrate one particular type of wind turbine.

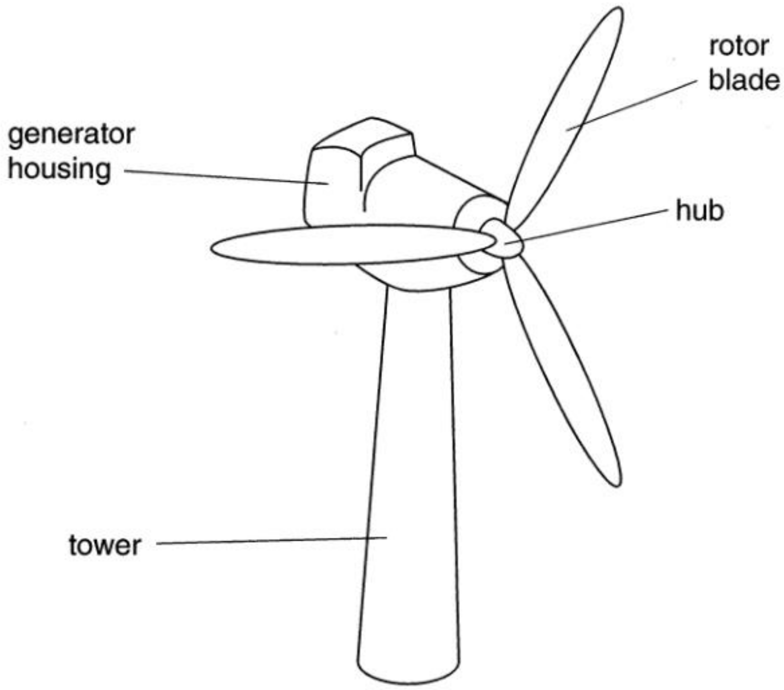

Fig. 8.1

The wind causes the rotor blades to turn and these drive an electric generator. The electric generator is situated in the housing at the top of the tower, as illustrated in Fig. 8.2.

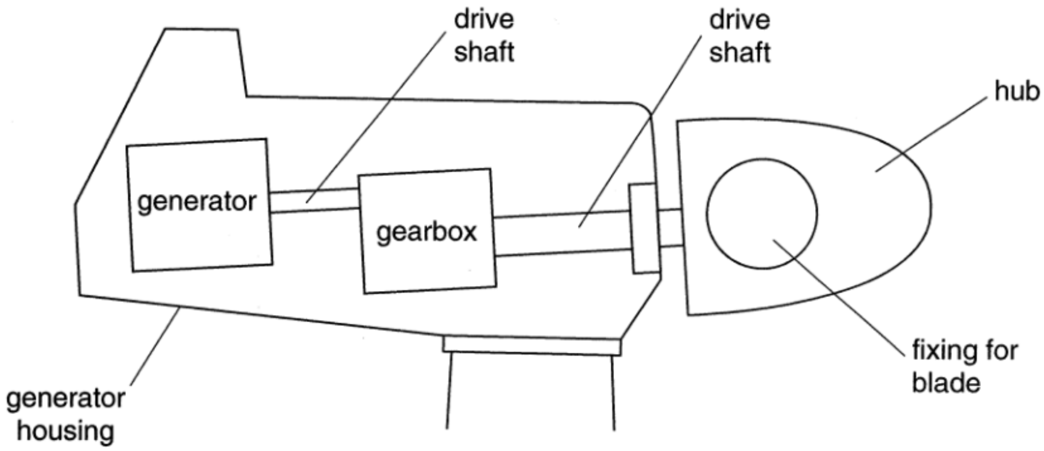

Fig. 8.2

Some information provide by a manufacturer of wind turbines are given in Fig. 8.3.

height of tower from ground to hub	56 m
rotor diameter	44 m
number of blades	3
nominal output	500 kW
voltage	690 V
frequency	50 Hz

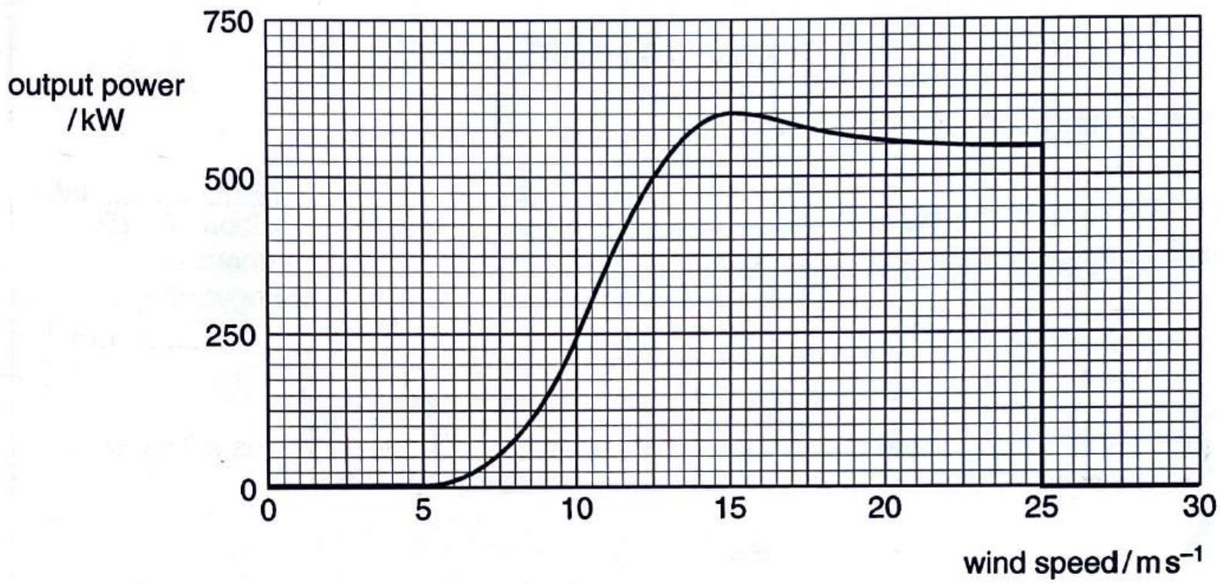

Fig. 8.3

One such wind turbine is built near a town. The local newspaper reported that the wind turbine 'could serve 200 homes'.

(a) Suggest one reason,

(i) why the manufacturer specifies a *nominal* output power for the wind turbine,

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..[1]

(ii) why the report that the wind turbine can serve 200 homes can be misleading.

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………………………………………………………………………………………………
..[1]

(b) Determine the minimum height of the tip of a rotor blade above the ground level.

height = ………………………………… m [1]

(c) **(i)** Use the manufacturer's data to give values of

1. the maximum power output,

maximum power = ……………………………….. kW [1]

2. the wind speed for this maximum power.

wind speed = …………………………….. m s^{-1} [1]

(ii) Air of density ρ and speed v is incident normally on a rotor of radius r. The kinetic energy E of the air incident on the rotor in unit time is given by

$$E = \tfrac{1}{2}\pi r^2 v^3 \rho.$$

The air has density 1.25 kg m^{-3}.

Calculate, for the wind turbine operating at maximum output power,

1. the kinetic energy of air incident per second on the rotor (the incident wind power),

incident wind power = ……………..…………………………….. W [2]

2. the overall efficiency of generation of electric power.

efficiency = …………………………………….. % [2]

(iii) In addition to the power usefully transformed in the wind turbine, 10% of the incident wind power is lost. Calculate the power of wind after it has passed through the rotor.

power = ………………………….…………….. W [2]

(iv) At high wind speeds, the turbine is ‘cut out’, that is, the generator is no longer turned by the blades.

1. Use Fig. 8.3 to determine this cut-out speed.

cut-out speed = …………………………………….. m s^{-1} [1]

2. Suggest one reason why it is necessary to have a cut-out speed.

…………………………………………………………………………………………………..

……………………………………………………………………………………………...

…………………………………………………………………………………………..…[1]

(d) **(i)** State whether the generator produces direct current or alternating current, explaining how you came to your conclusion.

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..[2]

(ii) Calculate the nominal current from the generator.

current = ……………..……………………….. A [2]

(e) The wind turbine must be protected from lightning strike.

(i) Suggest, with reasons, which part of the wind turbine is most likely to be struck by lightning.

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..[2]

(ii) Suggest how the risk of damage by lightning may be minimised.

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..[1]

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