Year 13 Science: A physics issue: how should New Zealand make its electricity?

Name: _____ Date: _____

Try these without your notes first, then check the answer key.

Practice

1. The wind speed rises from 5 m s^{-1} to 10 m s^{-1}. By what factor does the power in the wind change?

2. Find the power in the wind through a turbine with 40.0 m blades in a 12.0 m s^{-1} wind, using $\rho = 1.20$ kg m^{-3}.

3. A line with resistance 5.00 Ω carries 400 A. Find the power lost as heat.

4. The same power is sent at twice the voltage. Find the new power lost.

5. Use the 2024 table to find hydro's share of New Zealand's electricity.

Fix the mistake

6. Correct this statement: "Wind is free, so doubling the number of turbines doubles our electricity whatever the weather."

7. Correct this statement: "My position is that renewables are good, and my action is to tell people to use less power."

8. Correct this statement: "This website says wind farms are unreliable, so they are."

9. Correct this statement: "Transmission loss is $P = V^2/R$ with the line's full voltage, so higher voltage loses more."

Answer key (for parents and tutors)

1. The wind speed rises from 5 m s^{-1} to 10 m s^{-1}. By what factor does the power in the wind change?
   $P \propto v^3$ and $10 \div 5 = 2$, so the power is multiplied by $2^3 = 8$.

2. Find the power in the wind through a turbine with 40.0 m blades in a 12.0 m s^{-1} wind, using $\rho = 1.20$ kg m^{-3}.
   $A = \pi \times 40.0^2 = 5027$ m², $P = 0.5 \times 1.20 \times 5027 \times 12.0^3 = 5.21 \times 10^6$ W, which is 5.21 MW.

3. A line with resistance 5.00 Ω carries 400 A. Find the power lost as heat.
   $P = I^2R = 400^2 \times 5.00 = 8.00 \times 10^5$ W, which is 800 kW.

4. The same power is sent at twice the voltage. Find the new power lost.
   Twice the voltage halves the current to 200 A, so $P = 200^2 \times 5.00 = 2.00 \times 10^5$ W, which is 200 kW, a quarter of before.

5. Use the 2024 table to find hydro's share of New Zealand's electricity.
   $23\,490 \div 43\,879 = 0.535$, so 53.5%.

6. Correct this statement: "Wind is free, so doubling the number of turbines doubles our electricity whatever the weather."
   Output depends on wind speed cubed, so in calm weather extra turbines add almost nothing; storage or backup is still needed.

7. Correct this statement: "My position is that renewables are good, and my action is to tell people to use less power."
   State a specific position and actions, and use the physics ($P = \frac{1}{2}\rho Av^3$, I^2R losses) to justify why each would work.

8. Correct this statement: "This website says wind farms are unreliable, so they are."
   Check who wrote it, when, and whether measured data such as MBIE's statistics support the claim.

9. Correct this statement: "Transmission loss is $P = V^2/R$ with the line's full voltage, so higher voltage loses more."
   The loss depends on the current through the lines, $P = I^2R$; higher voltage means a smaller current and less loss.