Physics update
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The Great Grid Upgrade

A huge project is underway in the UK to upgrade the National Grid network for the future. **Carol Tear** looks at why this is needed and the changes they are making

As part of the Great Grid Upgrade, the National Grid has started 17 major infrastructure projects around the UK to scale up and update the network.

Why is it needed?

The National Grid was set up to transmit electricity around the UK. Originally this was mostly from large coal-fired power stations to centres of population and industry. It made sense to build the power stations close to sites where coal was mined, in the coalfields found in the middle of the country. Sites also needed water to produce the steam and coolant, from rivers like the Trent. It is more efficient to transmit electricity on high-voltage power lines than to transport coal to cities, and electricity can be diverted all over the country to where it is needed by a grid of interconnected cables.

However, we are currently living through a major change in energy generation, with more electricity generated using renewables. Farms of wind turbines and solar panels are replacing power stations burning fossil fuels, such as coal and gas. Solar farms are in different parts of the country to coalfields – for example, Project Fortress (373 MW), at Cleve Hill in Kent, started generating in July 2025. Many wind farms are offshore and distributed around the coasts. The UK is the world leader in offshore wind, producing 40% of global wind-generated power. Currently, the largest wind farm is set to be Dogger Bank (3.6 GW) in the North Sea. It is partially operational and will be complete by 2027.

Another change is the move to using electricity rather than other fuels, for example in cars and heating our homes. Demand for electricity is expected to increase by 50% by 2035, and to double by 2050. A large amount of new infrastructure, including powerlines and transformers, is needed to transport this clean energy from where it is generated to where it will be used. Electricity cannot be stored, but we can store the energy using pumped storage schemes – for example, at Dinorwig in Wales – and batteries. The former Ferrybridge power station site in West Yorkshire is now a 150 MW battery storage system. It has the advantage of already being well connected to the National Grid, but some other storage sites need to be connected, or to have connections increased.

What is changing?

Some of the National Grid's new infrastructure projects involve building new power lines. For example, one project is the new 180 km power line from Norwich to Tilbury. This will be a 400 kV transmission line with two new substations, one at Bamford and the other, called the East Anglia Connection Node (EACN), located east of Ardleigh. The EACN is where the line will be connected into the existing National Grid. Cables will be buried through

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the Dedham Vale Area of Outstanding Natural Beauty and carried by pylons on the rest of the route. Another example is a new 400 kV line from North Humber to High Marnham in Nottinghamshire.

New transmission lines

The supergrid power lines are long-distance and high-voltage. AC high voltages of 400 kV, 275 kV and 220 kV are used because it is more efficient than using lower voltages, and AC voltages can be easily changed using transformers at substations. A disadvantage of using AC is that, when switching between different generators and consumers, the voltage must be synchronised. DC does not have this problem, so some wind farms are being connected to the grid using high-voltage DC (HVDC) lines. Converter stations are being built, for example in Suffolk and Kent, with inverters to change the voltage from HVDC to AC.

Efficiency

Transformers at substations are used to reduce the voltage to the 230 V AC we use in our homes. A 400 kV transmission line is not connected directly to a 230 V line. There will be distribution lines at intermediate voltages, but we can show how much more efficient using a high voltage is when we consider transmitting 3 kW of useful power at 400 kV compared with 230 V.

At 400 kV

Using the equation: power (P) = voltage (V) × current (i)

$$i = \frac{P}{V}$$

For a 400 kV power line: $i = \dfrac{3\,\text{kW}}{400\,\text{kV}} = 7.5\,\text{mA}$

The power wasted by heating the transmission line depends on the resistance of the transmission line. With a line resistance of 9 Ω, the power wasted in heating is:

$$i^2R = (7.5 \times 10^{-3})^2 \times 9 = 0.51\,\text{mW}$$

A common mistake here is to try and calculate the resistance R using $V = iR$ and use $V = 400$ kV. This is the supply voltage, not the potential difference, V_R, across the transmission line:

$$V_R = 7.5 \times 10^{-3}\,\text{A} \times 9\,\Omega = 0.068\,\text{V}$$

At 230 V

Using the same method, you can show that the power wasted when 3 kW is transmitted over the same power line at 230 V is 1.52 kW. Write out the calculation for this – the answer is given at the end of this article.

New substations

A number of new substations are needed. One of the major projects, Yorkshire Green Energy Enablement (GREEN), will upgrade and reinforce the high-voltage electricity network in Yorkshire. The project requires two new substations, at Monk Fryston and Overton, to step down the voltage from 400 kV to 275 kV. This can be done with a step-down transformer with a turns ratio of 400:275. There will also be new overhead lines and underground cables.

Delivering the transformers, which have a mass of about 200 tonnes, is a major operation. Some street 'furniture', such as bus stops and bollards, has been temporarily removed and roads are closed. The trailer itself is 80 m long (see Resources for videos of deliveries).

Answer

$$i = \frac{3\,\text{kW}}{230\,\text{V}} = 13.0\,\text{A}$$

Power wasted = $(13.0\,\text{A})^2 \times 9\,\Omega = 1.52\,\text{kW}$

Resources

The Great Grid Upgrade:
https://tinyurl.com/Great-Grid

Transporting substation transformers by road:
https://tinyurl.com/girder-frame-trailer
https://tinyurl.com/girder-bridge