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Christmas '25: explored with energy and power!



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The worst Christmas ever…

For hundreds of years good children have woken up on Christmas Day and found gifts ranging from phones to bikes. However a few unlucky people (although we know it isn't a problem of luck) receive coal. This year's question is: how much energy could we get if every single person received one kilogram of coal on Christmas?

Firstly we need to know how many people there are in the world: 8.2 billion (approximately)

Next we need to know how much energy is released by burning 1kg of coal: 30 Megajoules

Now to find the total energy we simply multiply the two numbers together:

8.2billion x 30MJ = 246,000,000,000,000,000J = 246 Petajoules! But what can we do with this energy? Very little, this is thermal energy and we can only heat things. We have to convert this to electricity to accomplish anything. In the UK in 2024, the energy efficiency of converting coal's chemical energy into electricity was 41.5% meaning we need to take our 246PJ and multiply it by 41.5 and then divide it by 100 (since 41.5 is a percentage) giving us 102.09PJ, Well, in year 9 in the physics topic you learn about specific heat capacity which relates to how much energy is needed to change the temperature of something since we have all of this energy we might as well use it for something good to prevent Santa giving us coal next year the equation is:

Energy needed = mass x specific heat capacity x ΔT (ΔT simply means the change in temperature) .So we know how much energy we have, we know how much energy we are using and the specific heat capacity (the amount of energy needed to change the temperature of 1kg of an object by 1 degree celsius) and we can easily Google the mass of all giving us the equation meaning we can find out how much we can cool the earth by: the air on earth weighs 5.15 quadrillion tons (approximately) and the specific heat capacity of air is 1005J/Kg and we know how much energy we have, we can rearrange this to give us: $\Delta T = \Delta Energy/(Mass \times Specific\ heat\ capacity$ which means we get ΔT= 102.09PJ/(5.15 quadrillion x 1005) giving us a staggering change of 0.0197°C. This may seem tiny but this is actually quite impressive, with this energy we could reverse the last few years of climate change (of course having burnt 8 billion tons of coal wouldn't help climate change but this number would have much more of an effect if we could increase our efficiency in coal burners). It could soon be used to solve climate change not via this silly demonstration but via CO_2 filters that are being developed. They do exist they are just expensive to make and aren't being invested enough. We used this as a fun demonstration of lots of energy and its uses but we can't deliver that energy instantly to a device for obvious reasons (this isn't related to climate change - fridges simply use lots of energy and we can run so many anyway). It needs to be regulated, we need to know how much power to deliver, this is easy to calculate, power=energy/time so we get 102.09PJ/8760 (the number of hours in a year until next Christmas) giving us 11,654,109,586,800Watt-hours to work with the amount of energy used each hour which is what most devices use, still an impressive amount, but now able to accomplish things like running 23,308,219,175 fridges all year round meaning everyone on earth can have almost 3 fridges each (this isn't related to climate change fridges simply use lots of energy and we can run so many anyway). Alternatively, since we have 11TWH we can power all of China for a year and we still have enough left over to power India as well, all from people St Nicholas and 8.2 billion unlucky people with a small amount of coal each. This just goes to show 1) how many people there are on earth 2) How much energy we have access to (since there is actually 1.1 trillion tons on earth which means we could have changed the temperature of earth by 2.70875 completely erasing all global warming so far and if we burnt it all on the Moon we could get rid of all the effects of coal). But more on that next year, until then, make sure you don't get coal at Christmas.

Reindeerpower: creating a Christmassy unit

We all know units. Whether measuring length in metres, time in seconds or finding mass in grams, they serve as a useful way of knowing what quantity you're measuring (and an easy way to lose 1 mark on a test!) In this article, we'll explore some fun facts about units and incorporate a festive twist.

Most scientists use a group of units called SI units. These include: the second (time), metre (length), kilogram (mass), ampere (electric current), kelvin (temperature), mole (amount of substance) and candela (intensity of light). Together, they create a coherent system of measurement from which other quantities, like energy or frequency, can be derived.

Sounds good, right? Why use anything else? Well, some of the SI units are too small or big for certain applications - for example, 1 second is a very short amount of time for everyday measuring, hence why we use minutes or hours. Additionally, some countries don't follow the metric system exactly, such as the US which uses a system of imperial units like the pound and foot. Finally, some measurements produce complicated numbers with SI units - the speed of light = 299792459m/s for example. So, sometimes we define new units as parts or multiples of SI units.

For example, horsepower is one of these units, measuring power (the rate of energy transfer). It was first named by James Watt to compare the power of steam engines to horses. 1 horsepower (hp) is the rate of energy transferred by a horse during sustained activity. Nowadays, we measure power in watts (named after James Watt!), which are derived from SI units. 1hp = around 740W depending on the measurement used.

Now, hearing the name "horsepower" might make you wonder what other animals we could make a power unit from. Of course, in honour of the Christmas season, I'm going to define the reindeerpower unit. What is a reindeerpower? It's the energy used by one of Santa's reindeer during its circumnavigation of the world. Let's do the calculations to make it:

Per the Mirror, Santa's distance = 66 million km (that's 66,000,000,000m)
Due to time zones, Santa's journey takes 31 hours in total (111,600 seconds)
So velocity = distance ÷ time = 66,000,000,000 ÷ 111,600 ≈ 591,398 m/s
The mass of one reindeer, per Wikipedia, is 150kg.
So the kinetic energy transferred by one reindeer = 0.5 x 150 x $(591,398)^2$ ≈ 26,231,356,226,153 joules (J)
Now we can find the power by dividing that by our time from earlier:
Power = energy ÷ time = 26,231,356,226,153J ÷ 111,600 ≈ 235,047,995 W
So one reindeerpower (1rp) = 235,047,995W, or about 235MW. That's equal to about 317,632hp!
That means for all 9 of Santa's loyal reindeer, they need 9rp, which is about 2.115GW (that's 2 billion watts!) of power.

So what else could you power with 9 reindeerpower? How about 182 commercial aeroplanes? A Boeing 737 uses about 15,700hp, which is of course around 0.05rp, so once we convert we see that Santa's sleigh is carried by the power of 182 Boeing 737s - quite the vehicle!
9rp is also equal to the rating of around 133 million Bosch Series 2 fridges, or about 2.6 million 800W microwaves constantly running. Santa's operation evidently takes a lot of power.

Finally, let's answer the most important question - are we feeding the reindeers enough? Well, we know that each reindeer takes 26,231,356,226,153J of energy to complete the journey from earlier. This is equal to 6,269,444,604kcal (kilocalories), the unit of energy used for food. One carrot contains around 25kcal Santa visits around 301 million households along his path. So, the energy from all the carrots is equal to about 7,525,000,000kcal - enough energy to sustain around 1 reindeer. So perhaps if every household provided one carrot per reindeer, we could provide enough energy from carrots alone!

Science competition

Answer these questions below to enter the competition
Email your answers to Mr Downing to enter
(dow@fallibroome.org.uk)
1st correct entry wins a prize for the form!

1. What is specific heat capacity?

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1. How many tons of coal are there on Earth?

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1. Who is the SI unit of energy named after?

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1. What is the unit of energy used for food?

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Scientist of the month

Year 7 – Seb Reddie

Year 8 – Natalie Gibb

Year 9 – Rosabella Gibson

Year 10 – Joseph Osuji

Year 11 – Amber Edwards

Year 12 – Gwen Alcock

Year 13 – Henry Hunter

Come and collect your prize from:

Mr Downing in **A43**