Co-op Careers Uncovered
Geography Module – Climate Change

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What is Climate Change?

Climate Change – What is it?

- Climate change is the reference to the change in the average temperature of the earth. The changes usually occur over time and can come from earths own natural sources such as volcanic eruptions, however there is a general consensus that humans have contributed to the amount of greenhouse gases in the atmosphere. This has lead rapid changes in the worlds climate.

- The concentration of greenhouse gases released by humans within the earth atmosphere are carbon dioxide and methane for example. The ways in which the greenhouse gases can be released by **human activity** can be:

  Burning of fossil fuels, which releases carbon dioxide into the atmosphere.

  Release of global warming potential gases into the atmosphere, such as refrigerants.

  Deforestation, as trees absorb carbon dioxide and store carbon.

  Food waste, which creates methane when it breaks down.

- The earth reflects heat, a bit like controlling its own temperature. However greenhouse gases absorb this reflected heat. A greater concentration of greenhouse gases means that more heat is absorbed and so **OUR** planet warms up. However it is important that we do retain some greenhouse gases, or how will we stay warm!

- Climate change can be managed by mitigation and adaptation. We can reduce our greenhouse gas emissions by mitigation. We can also live with the widespread effects of climate change by adaptation

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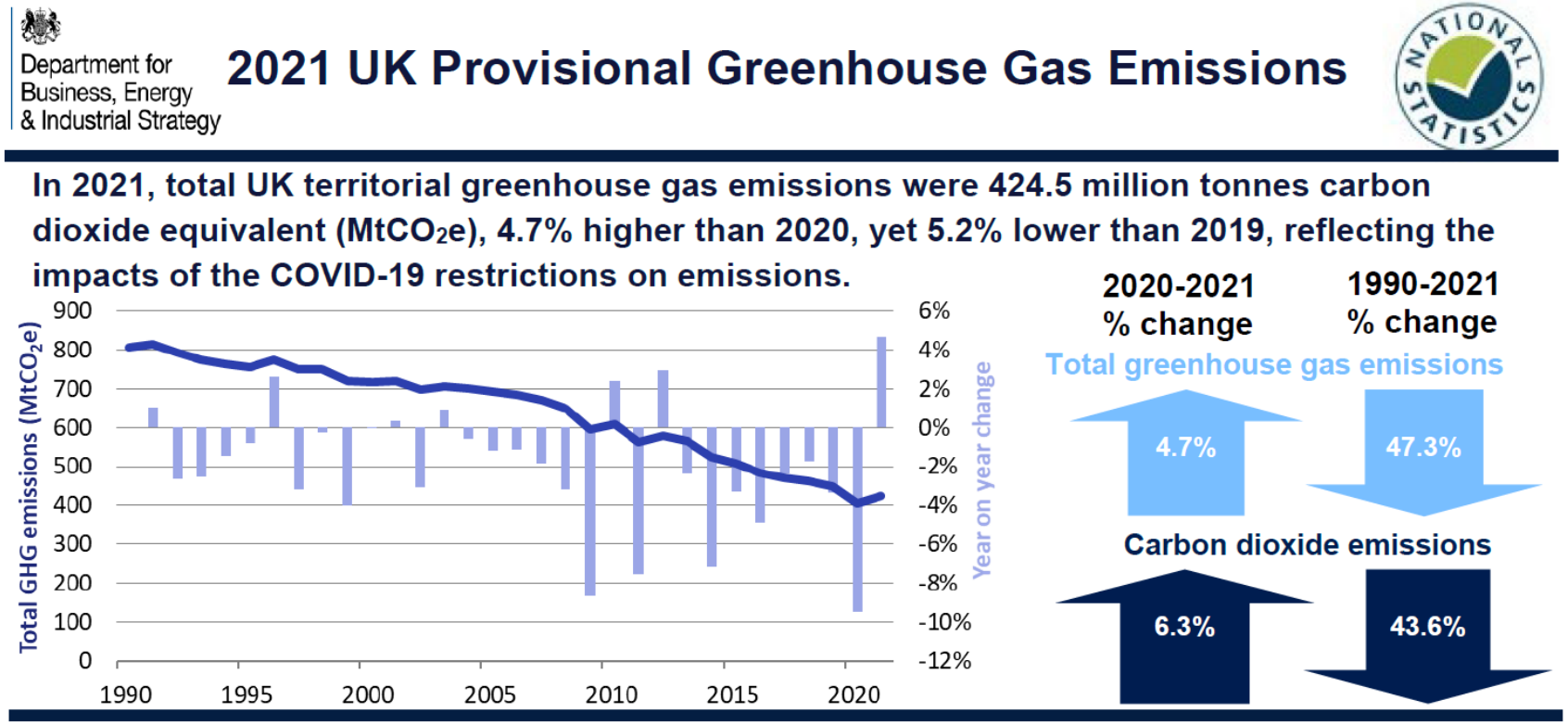
So, what are the UK CO2 emissions?

- During 2021 the total CO2 emissions produced by the UK alone was 424.5 Million tonnes or 424,500,000,000kg of CO2.



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- To put things into perspective 1 tonne of CO2 is larger than a double decker bus. So just think how big 424.5 million tonnes of CO2 would be!

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How Engineers Affect Climate Change?

How Engineers Affect Climate Change.

- Our job as an engineer is to provide a practical solution to a problem. Imagine the excitement being given the task of developing the Mars rover ‘Opportunity’ as a NASA mechanical engineer! Also think about the people they would have to collaborate with to find the solution. Surely this would involve geologists to understand what the engineers are working with!

- Coming back down to earth, as an engineer we need to think about how we affect the world and how the world affects us so we can both live in harmony. Some key words which you might have heard all relate to climate change but also engineering.
    - Sustainability.
    - Net Zero.
    - Decarbonisation.
    - Emissions.
    - Environment
    - Social
    - Political

- Mitigation and adaptation are really important for engineering.
- Mitigation by removing or designing out harmful greenhouse gases, planting trees, capturing carbon or using forms of alternative energy.
- Adapting to climate change can include coping with rising sea levels, managing water supplies or changing agricultural systems. It can also include designing in safety features such as more robust systems and safety systems. A refrigerant leak can be significant due to their high equivalent CO2 emissions so a leak detection system within a refrigeration system to give early warming is a good example of adaptation

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BRIEF

- Co-op are taking action on Climate Change! Our goal is to reach **net zero greenhouse gas emissions no later than 2035**, including product related emissions. We have already reduced emissions by **39% since 2016** and have a target of 50% reduction by 2025**.** To reach our target we will prevent refrigeration gas leaks, phase out damaging refrigerant gases and continue to improve our **energy efficiency**

- You have been asked to help with putting together a plan to reduce Co-op emissions by phasing out our damaging refrigerant gases. Your task will be:

  Reviewing refrigerant data tables to determine which refrigerant has the lowest global warming potential (GWP) which will contribute towards the reduction of CO_2 emissions in our atmosphere.

  Data analysis and calculation of the carbon emissions from a refrigerant leak between the highest GWP refrigerant within the Co-op estate and your chosen lowest GWP refrigerant.

  Discuss the environmental impact of a refrigerant leak on our world and what mitigation or adaptation can be used within a refrigeration system to help reduce greenhouse gas emissions.

Climate Change Mitigation:
Objective is to define key metrics and mitigation measures for climate change related risks to our estate.

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TASKS

Task 1.

- The refrigerant data table below can be used to determine which refrigerant has the lowest global warming potential (GWP) which will contribute towards the reduction of CO2 emissions in our atmosphere. This is because for every 1kg of refrigerant released into the atmosphere a refrigerant has a CO2 equivalent. For example refrigerant R404a has a GWP of 3922, this means that for every 1kg of R404a refrigerant released is the equivalent of releasing 3922kg of CO2 into our planet's atmosphere.

Refrigerant Type	GWP (Global Warming Potential)
R-134a	1,300
R-404A	3,922
R-448A	1273
R-454A	239
R-454C	148
R-744	1
R-1270	1.8

- From this above table can you determine which refrigerant will have the lowest global warming potential if 10kg of refrigerant is released into the atmosphere and what the equivalent CO2 value would be?
- Comparing the difference between refrigerant with the highest GWP and the refrigerant with the lowest GWP , what would be the difference in CO2 equivalent if 65kg of refrigerant is released into the atmosphere? How many double decker buses would this be?
- Discuss the environmental impact of a refrigerant leak on our world and what mitigation or adaptation can be used within a refrigeration system to help reduce greenhouse gas emissions.

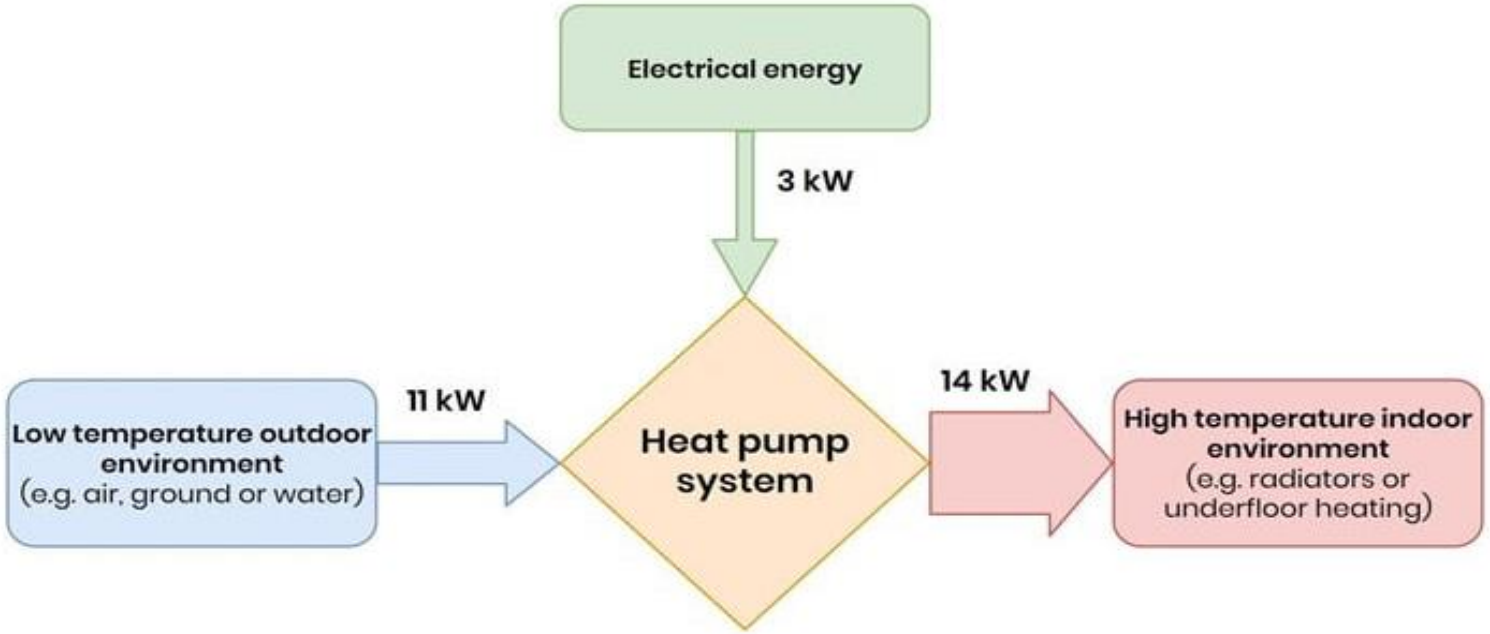
Can you think of anything where engineering is trying to work in harmony with our world to actively reduce greenhouse gases? A good example to start with would be solar power or heat pumps.

Heat pumps can contribute towards decarbonisation because they are energy efficient.

Decarbonisation is reducing the carbon emissions we produce this could be directly though our heating or indirectly by the power produced by a power station. By reducing our carbon emissions this also contributes to NetZero.

Task 2.

- A heat pump captures heat from outside and moves it into your home. It uses electricity to do this, however the quantity of heat delivered into your home is much greater than the quantity of electricity used to power the system.
- Heat pumps are more efficient than other heating systems because the amount of heat they produce is more than the amount of electricity they use. The amount of heat produced for every unit of electricity used is known as the Coefficient of Performance (CoP). So, if a heat pump has a CoP of 3.0, then it will give out three units of heat for every unit of electricity consumed.
- The diagram below shows the basic energy flow of a 14-kilowatt (kW) heat pump to help show how the CoP is calculated. In this example, the heat pump has an electrical power input of 3kW and a heat output of 14kW. The remaining 11kW are obtained from the environment. To calculate the CoP, you divide the heat output by the electrical input, which in this example results in a CoP of 4.7. Low power input and high heat output = high energy efficiency.



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Task 2.

- To reduce our dependency on fossil fuels such as gas, Co-op are moving to electrification of heat. This means using heat pumps instead of gas boilers to provide heating to our food stores.
- Heat pumps are not just used for commercial and retail buildings. They can also be used in our homes. The following task will include selection of a heat pump and the calculation/comparison of carbon emissions with a fossil fuel.
- You are choosing a new heat pump for a house which requires 10kW of heating. The heating system will also include new radiators which require a water supply temperature of 55°C and the heat pump must be able to supply meet these design conditions when the outside ambient temperature is -5°C and higher. From the table below please answer the following questions:-

    1. Select the heat pump which has the highest efficiency to meet the design conditions.
    2. What is the Co-efficient of Performance for your selected heat pump.
    3. A heat pump takes **heat energy** from the surrounding outside ambient air. Where would be the best position to place a heat pump to maximise this heat energy?

Heat Pump Model	Water Supply Temp	Design Ambient	Heating Output	Power Input (kW)	Water Supply Temp	Design Ambient	Heating Output	Power Input (kW)
HP-01	55°C	-5°C	6.50	1.86	45°C	-3°C	7.00	1.84
HP-02	55°C	-5°C	8.00	2.29	45°C	-3°C	8.50	2.24
HP-04	55°C	-5°C	9.00	2.57	45°C	-3°C	10.00	2.63
HP-04	55°C	-5°C	10.00	2.86	45°C	-3°C	11.50	3.03
HP-05	55°C	-5°C	11.00	3.14	45°C	-3°C	13.00	3.42
HP-06	55°C	-5°C	13.00	3.71	45°C	-3°C	14.50	3.82
HP-07	55°C	-5°C	16.00	4.57	45°C	-3°C	16.50	4.34

Task 3.

- The UK Government issue carbon co-efficients each year. These help businesses calculate their carbon emissions. For 2022 the co-efficient for electricity was 0.19121 $kgCO_2e$ of CO_2 per unit and for gas was 0.18219 $kgCO_2e$ of CO_2 per unit. Carbon emissions (CO_2e) can be calculated by multiplying kWh of consumption by the appropriate co-efficient. For example, 3500kWh of electricity x 0.19121 $kgCO_2e$ of CO_2 per unit =

- Using your selected heat pump, can you calculate the indirect annual carbon emissions (CO_2e) if it is operated for 6hrs per day 200 days per year? You will require the power input shown in the table of your selected heat pump for this exercise.

- Gas boilers aren't as efficient as a heat pump. A gas boiler which is 90% efficient means every 1kWh of gas used will only deliver 0.9kW of heat output. For the purpose of this exercise we will assume we have a 10kW gas boiler which is 100% efficient and operates for 6hrs per day 200 days per year what are the annual carbon emissions (CO_2e) of this boiler?

- What has the highest carbon emissions? The Gas Boiler or the Heat Pump? Can you draw this into a graph?

- Using your graph, which system would contribute to decarbonisation/Net Zero? What is the difference in carbon emissions between the two systems? ? Just think of the reduction in green house gases been released into our atmosphere!

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Task 4.

- You should now be able to understand how a heat pump can help make us more sustainable by reducing our carbon footprint. However, sustainability and energy efficiency which helps reduce our contribution to greenhouse gases does not just stop at heat pumps:

How efficient can we make a house? Heat pump is one solution but what other ways can we make our homes more efficient?

Will the energy efficiency changes suggested in your answers to the last question reduce the heating capacity (kW) of the heat pump?

How will making our house more energy efficient reduce greenhouse gas emissions?

How can using a heat pump and other sustainable solutions benefit social, political and environmental situations we are currently experiencing? An example would be the Ukraine/Russian War and the European dependency on Russian Gas. What other examples can you give?

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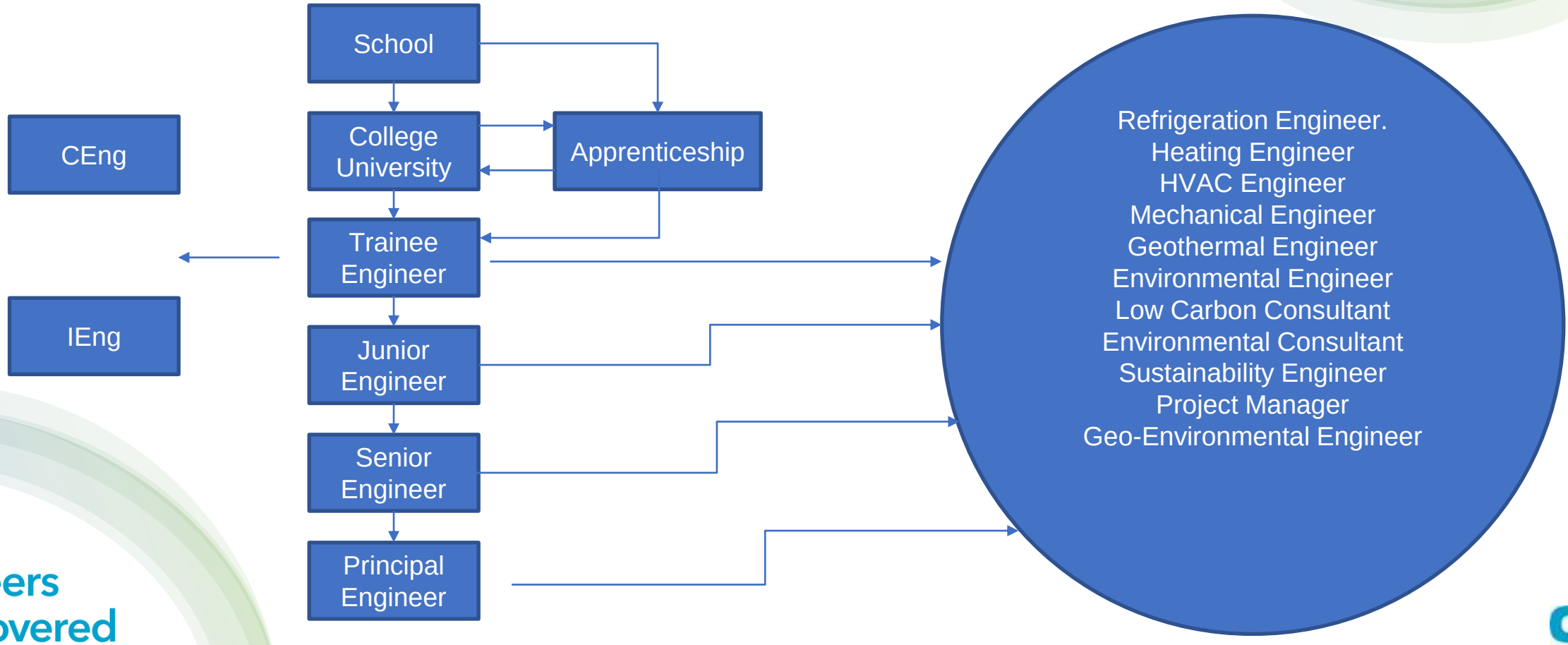
CAREER TREE

Career Tree.

There are a wide range of engineering careers which require a geography-based subjects. Each role offering the opportunity for professional recognition. Examples of a career path and role types are shown below.



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ANSWERS

Task 1.

Q: From this above table can you determine which refrigerant will have the lowest global warming potential if 10kg of refrigerant is released into the atmosphere and what the equivalent CO2 value would be?
A: ***Refrigerant with lowest GWP is R744, it has a GWP of 1. Therefore, if 10kg of R744 is releases the equivalent CO2 value is 1 GWP x 10kg = 10***

Q: Comparing the difference between refrigerant with the highest GWP and the refrigerant with the lowest GWP , what would be the difference in CO2 equivalent if 65kg of refrigerant is released into the atmosphere? How many double decker buses would this be?
A: ***R404a has the highest GWP at 3922, R744 has the lowest at 1. Therefore R404a CO2 equivalent emissions = 3922 GWP x 65kg = 254930 kg of equivalent CO2 emissions released into the atmosphere. R744 CO2 equivalent emissions = 1 GWP x 65kg = 65kg of equivalent CO2 released into the atmosphere. The difference in CO2 equivalent emissions between R404a and R744 = 254930 – 65 = 254865 kg of CO2 equivalent, 252.9 tons or approx. 253 double decker buses.***

Q: Discuss the environmental impact of a refrigerant leak on our world and what mitigation or adaptation can be used within a refrigeration system to help reduce greenhouse gas emissions.
A: ***Use of lower GWP refrigerants will help reduce the amount of equivalent CO2 being released into the atmosphere in the event of a leak. A good example is the difference in CO2e between R404a and R744. 253 double decker buses for 65kg release of refrigerant. Imagine if this release was 650kg and the impact it would have on global warming, our climate and the effects of that climate change. We are already seeing warmer ambient temperatures and frequent hose pipe bans. Extremes of weather becoming more frequent and costal erosion. If we are going to use refrigerants, then we should be using low GWP variants.***

Task 2.

- Q: You are choosing a new heat pump for a house which requires 10kW of heating. The heating system will also include new radiators which require a water supply temperature of 55°C and the heat pump must be able to supply meet these design conditions when the outside ambient temperature is -5°C and higher. From the table below please answer the following questions:-

1. Select the heat pump which has the highest efficiency to meet the design conditions. ***HP-04***
2. What is the Co-efficient of Performance for your selected heat pump. *Co-efficient is calculated by dividing the heating duty of the heat pump by the power input of the heat pump. So for HP-04 at 55C water supply temperature is 10/2.86 = 3.49*
3. A heat pump takes **heat energy** from the surrounding outside ambient air. Where would be the best position to place a heat pump to maximise this heat energy? *In a open non-sheltered/shaded space where maximum opportunity is available to transfer heat energy from the air surrounding the heat pump.*

Task 2.

- Q: Using your selected heat pump, can you calculate the indirect annual carbon emissions (CO2e) if it is operated for 6hrs per day 200 days per year? You will require the power input shown in the table of your selected heat pump for this exercise. *If the power input is 2.86kW then 2.86kW x (6hrs x 200days) = 3431kWh/annum. Therefore if the carbon co-efficient is 0.19121 kgCO2e of CO2 per unit then the carbon emissions are 3431kWh x 0.19121 =*
- *656 kgCO2e (less than 1 double decker bus of CO2)*

- Gas boilers aren't as efficient as a heat pump. A gas boiler which is 90% efficient means every 1kWh of gas used will only deliver 0.9kW of heat output. For the purpose of this exercise we will assume we have a 10kW gas boiler which is 100% efficient and operates for 6hrs per day 200 days per year what are the annual carbon emissions (CO2e) of this boiler? *10kW x (6hrs x 200days) = 12000kWh. The carbon co-efficient of gas is 0.18219 kgCO2e of CO2 per unit. Therefore 12000 x 0.18219 = 2186 kgCO2e (approx. two double decker buses of CO2)*

- What has the highest carbon emissions? The Gas Boiler or the Heat Pump? Can you draw this into a graph? *The graph will be Gas and Heat pump along the X-axis and kgCO2e along the Y-axis ranging from 500 to 13000. The graph will be very basic but gives a good visual representation.*

- Using your graph, which system would contribute to decarbonisation/Net Zero? What is the difference in carbon emissions between the two systems? ? Just think of the reduction in green house gases been released into our atmosphere! *Electricity will contribute towards decarbonisation/NetZero due to its lower emissions compared to gas. Difference in emissions is 2186 – 656 = 1530. So the heat pump carbon emissions are 1536kgCO2e lower than the gas boiler in this example.*

Task 4.

Q: You should now be able to understand how a heat pump can help make us more sustainable by reducing our carbon footprint. However, sustainability and energy efficiency which helps reduce our contribution to greenhouse gases does not just stop at heat pumps:

A; How efficient can we make a house? Heat pump is one solution but what other ways can we make our homes more efficient? *Solar panels, Batteries, insulating cavities-floors and roof spaces, heat emitters such as radiators car thermostatically controls and correctly balanced across the system, lowering thermostat set points, reducing thermostat setting to minimum on heat emitters in rooms which aren't used often and closing doors, use highly efficient appliances, use 24v appliances where possible, LED/lower voltage lighting, switch off unused electrical products (chargers, televisions etc), use the maximum space available in domestic fridges and freezers, wash clothes at lower temperatures. Reduce boiler water temperature, insulate water pipework.*

A: Will the energy efficiency changes suggested in your answers to the last question reduce the heating capacity (kW) of the heat pump? – *Yes, preventing heat loss from a home will help reduce the amount of heat the heat pump has to provide.*

A: How will making our house more energy efficient reduce greenhouse gas emissions?*- Reduction in the amount of heating will reduce the power consumption of the heat pump due to less frequent usage which will reduce the carbon emissions.*

A: How can using a heat pump and other sustainable solutions benefit social, political and environmental situations we are currently experiencing? An example would be the Ukraine/Russian War and the European dependency on Russian Gas. What other examples can you give? *Using decarbonisation products such as heat pumps and reducing our energy usage will reduce fossil fuel dependency such as what is required for manufacturing of gas and power. The reducing in fossil fuels and deforestation will help improve or return biodiversity, restoring natural balance to areas. The social impact is improved due to being more sustainable but also this helps countries achieve the Netzero targets set by governing bodies and policy holders.*