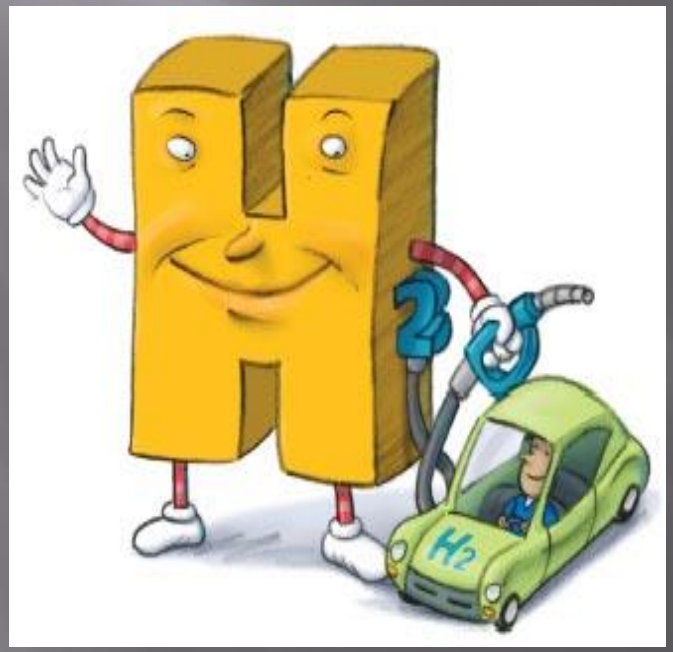
Unit 1 An introduction to Sustainable Energy and Hydrogen



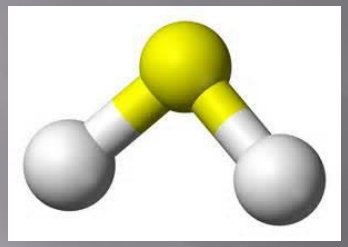
HyTrEc
Hydrogen Transport Economy for the North Sea Region
The Interreg IVB North Sea Region Programme
Investing in the future by working together for a sustainable and competitive region
European Union
The European Regional Development Fund

Aims

The aim of this unit is to:-

- understand the alternatives to fossil fuels use with respect to energy and the emergence of a sustainable hydrogen economy.
- understand the role played by hydrogen in our economy making clear reference to electricity production.
- understand the impact of adopting hydrogen technologies into our communities with specific reference to transport providers.
- identify the improvements to the sustainable environment by embracing a hydrogen economy.

What is Hydrogen ?



The Hydrogen Economy

Video Clip; The Hydrogen

- http://www.bing.com/videos/search?pq=hydrogen+econ&sc=4-13&sp=1&sk=&sid=29F64FEC18974888849DD6D405A4D2C2&q=hydrogen+economy&qft=+filterui:duration-short&FORM=R5VR1#view=detail&mid=31A200B6C29871B80A0A31A200B6C29871B80A0A

What is Hydrogen ?

1. The most common element on earth, it can be extracted in a number of ways.

2. It is not a fuel source, it is used as a way for storing and transporting energy.

3. It was initially used during the Apollo missions to the moon in the 1960s.

4. Hydrogen is also found in many organic compounds, notably the ***hydrocarbons*** that make up many of our fuels, such as gasoline, natural gas, methanol, and propane.

What is Hydrogen ?

5. Hydrogen can be separated from hydrocarbons through the application of heat - a process known as reforming. Currently, most hydrogen is made this way from natural gas.

6. Hydrogen is high in energy, yet an engine that burns pure hydrogen produces almost no pollution. NASA has used liquid hydrogen since the 1980s to propel the space shuttle and other rockets into orbit.

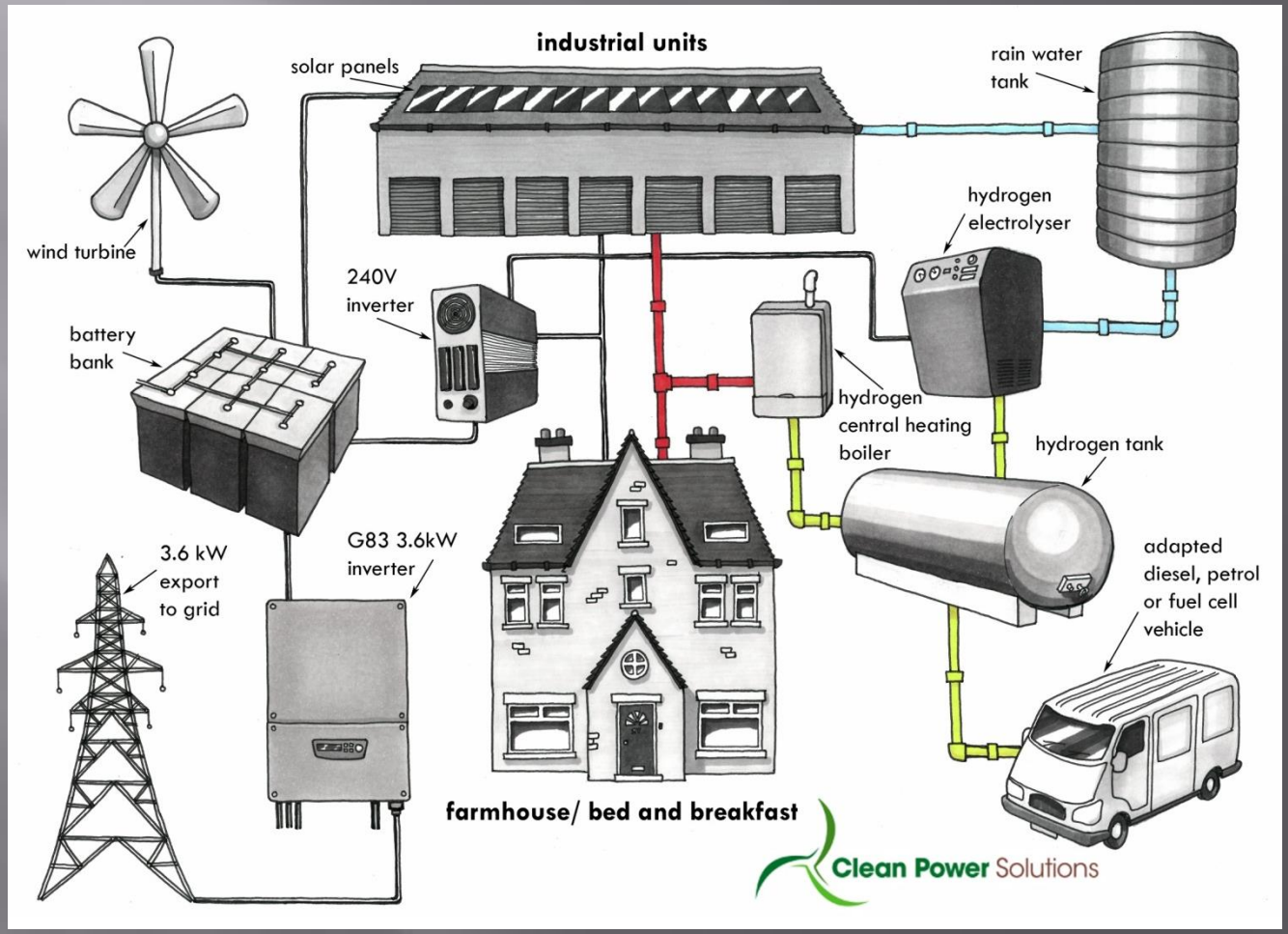
Why Hydrogen ?

1. In the future, hydrogen could also join electricity as an important energy carrier. An energy carrier moves and delivers energy in a usable form to consumers.

2. Renewable energy sources, like the sun and wind, can't produce energy all the time. But they could, for example, produce electric energy and hydrogen, which can be stored until it's needed.

3. Hydrogen can also be transported (like electricity) to locations where it is needed.

The Hydrogen Economy



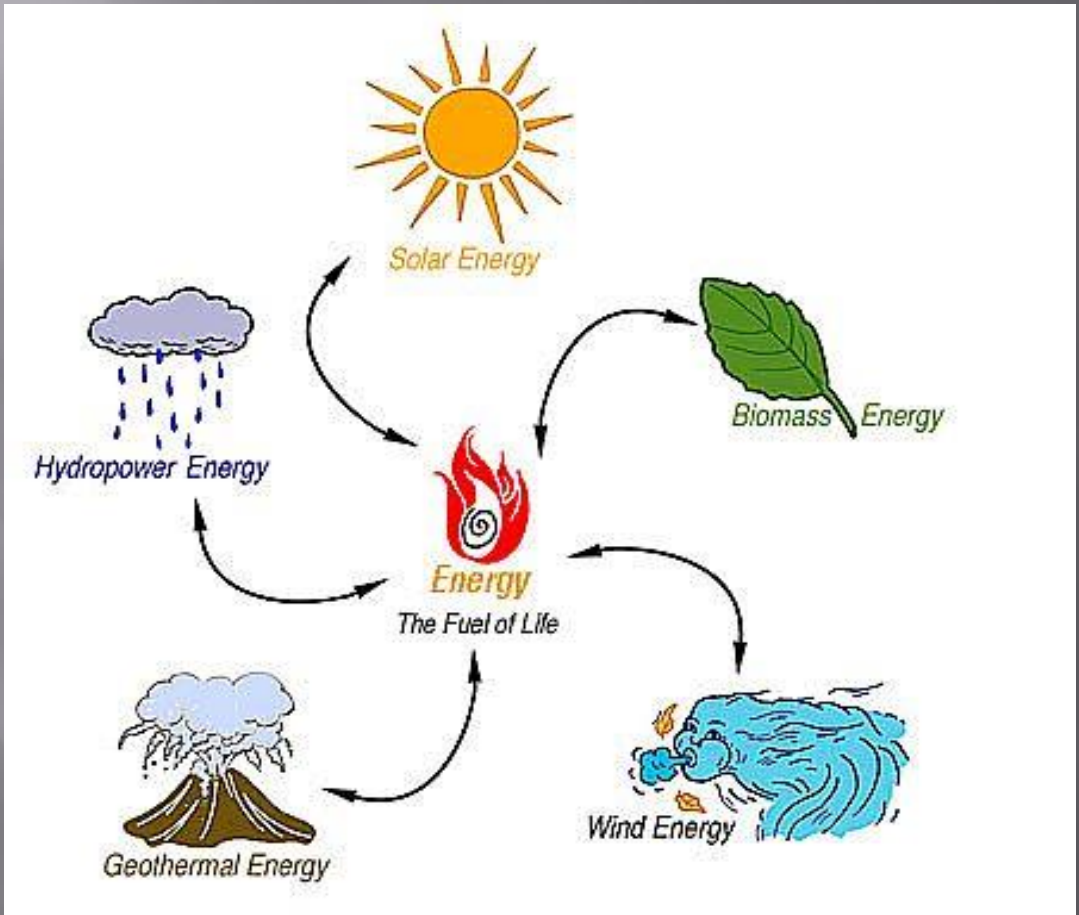
What are the converging issues ?

Hydrogen Technologies is being driven by 5 converging issues:-

1. Energy
2. Fossil Fuels
3. Transportation
4. Fuel Poverty and increasing Energy Bills
5. Global warming and climate change

1. Energy

Where does Energy come from?



Energy

The demand for energy is not only about the total amount of energy used, it is also about the location, type of fuel and characteristics of the end use technology.

Studying energy requires an understanding of:-

- the lifestyle and social drivers of the demand for energy services
- the changing technologies
- the interactions between all of these

Energy systems face increasing pressures from many directions, most notably for a rapid transition to a secure, low carbon energy system.

Energy

The energy we produce underpins pretty much everything we do.

Without it, there would be no artificial light, no long-distance communication, no mass transport or large-scale manufacturing.

Question:- How much energy do we use, and where does it come from?

Answer:- In fact, we consume less energy in the UK today than we did in 1970, and this despite an extra 6.5 million people living here.

Energy

Question:- Why are we consuming less energy?

The reason is very simple - we are more efficient both in producing energy and using it.

Households use 12% less, while industry uses a massive 60% less.

This is largely offset by a 50% rise in energy use in the transport sector, due to the huge rise in the number of cars on the road - more than 27 million today compared with 10 million in 1970. The big increase in the number of flights is another important factor.

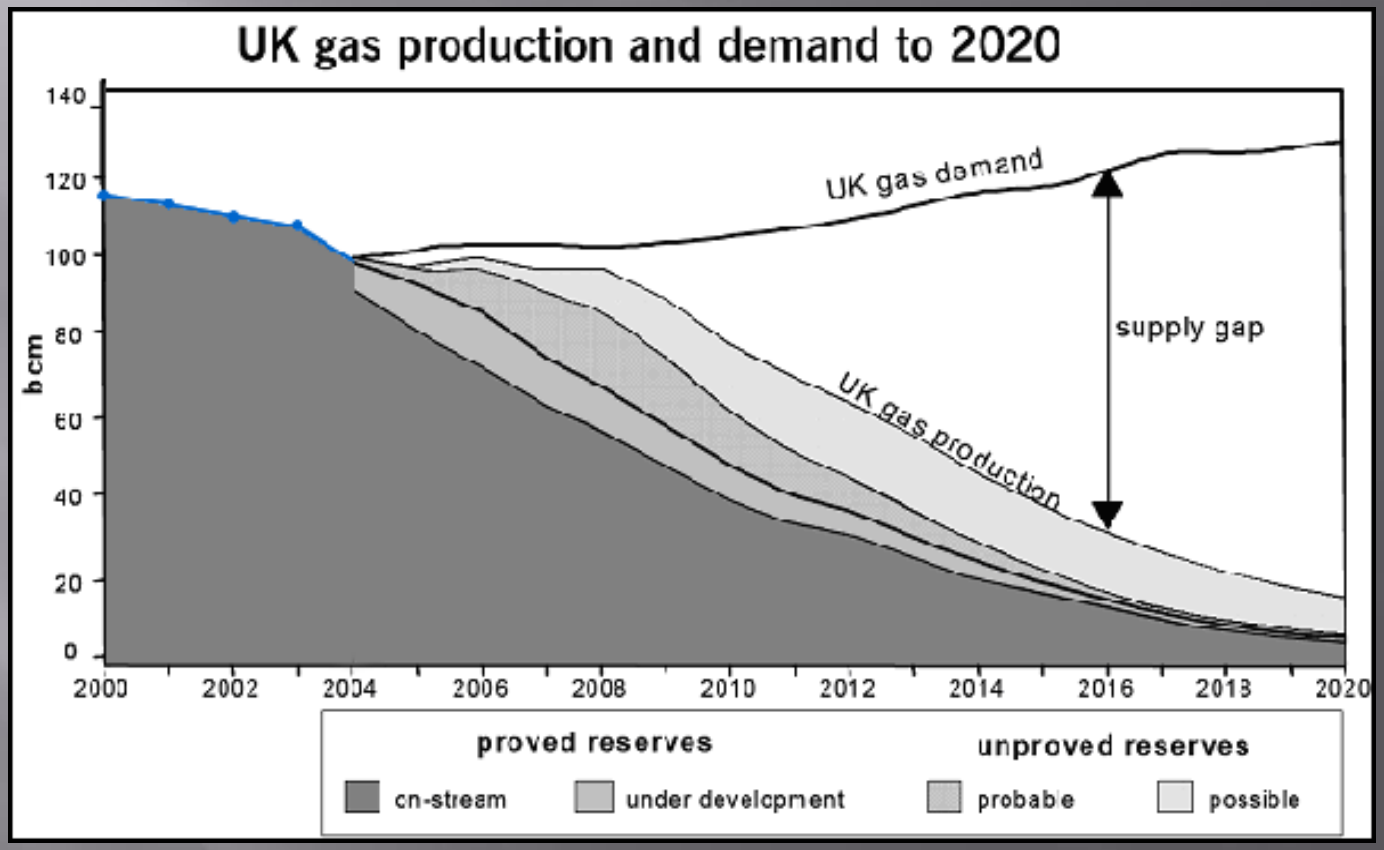
Energy Production

Figures from 2005 show total UK energy production to be 216.2 million tonnes of oil equivalent, this 9.3 per cent lower than in 2004. This trend has steadily been increasing over the last 10 years. For example the three months October 2014 to December 2014 compared to the same period a year earlier:

- production of petroleum fell by 12.1 per cent
- production of natural gas fell by 8.8 per cent
- production of coal and other solid fuels fell by 11.7 per cent
- electricity produced from nuclear sources fell by 1.6 per cent
- electricity produced from wind and natural flow hydro fell by 10.4 per cent

*** Note *** At the same time consumption has risen sharply increased.

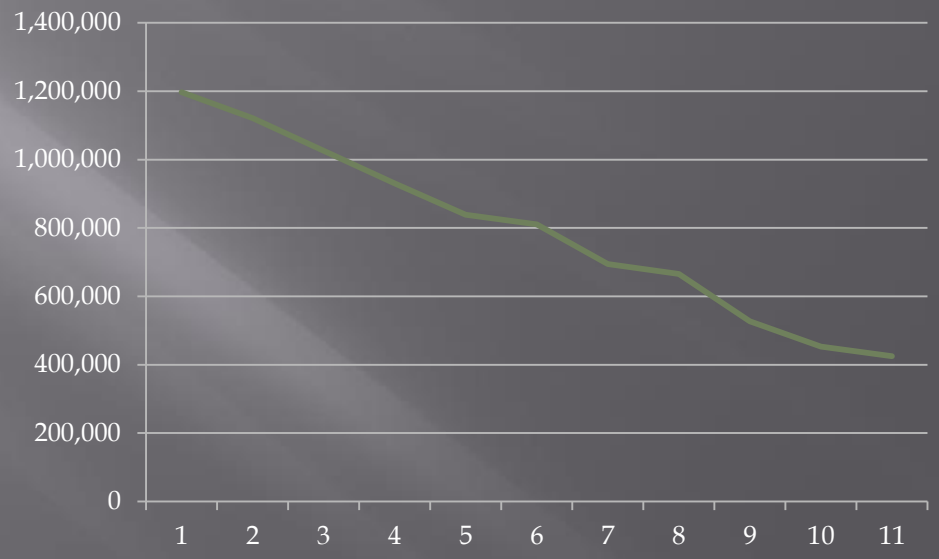
UK Gas Production and Demand



UK gas extraction from the North Sea peaked in 2000, the UK remained a net exporter of gas until 2005

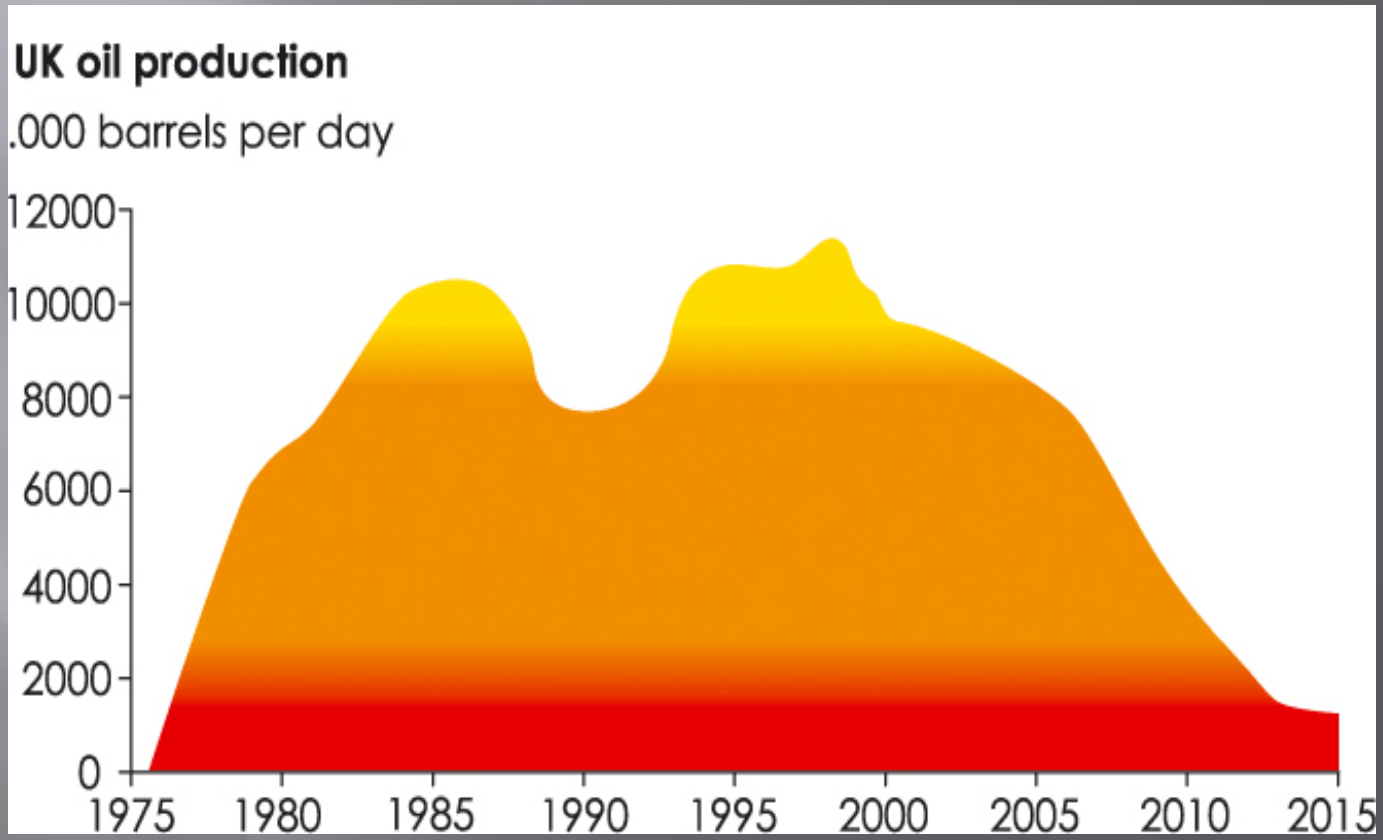
UK Gas Production and Demand

Year	Gas Production (Gwh)
2003	1,197,030
2004	1,121,257
2005	1,025,989
2006	930,538
2007	838,809
2008	810,390
2009	694,687
2010	665,182
2011	526,711
2012	452,696
2013	424,757



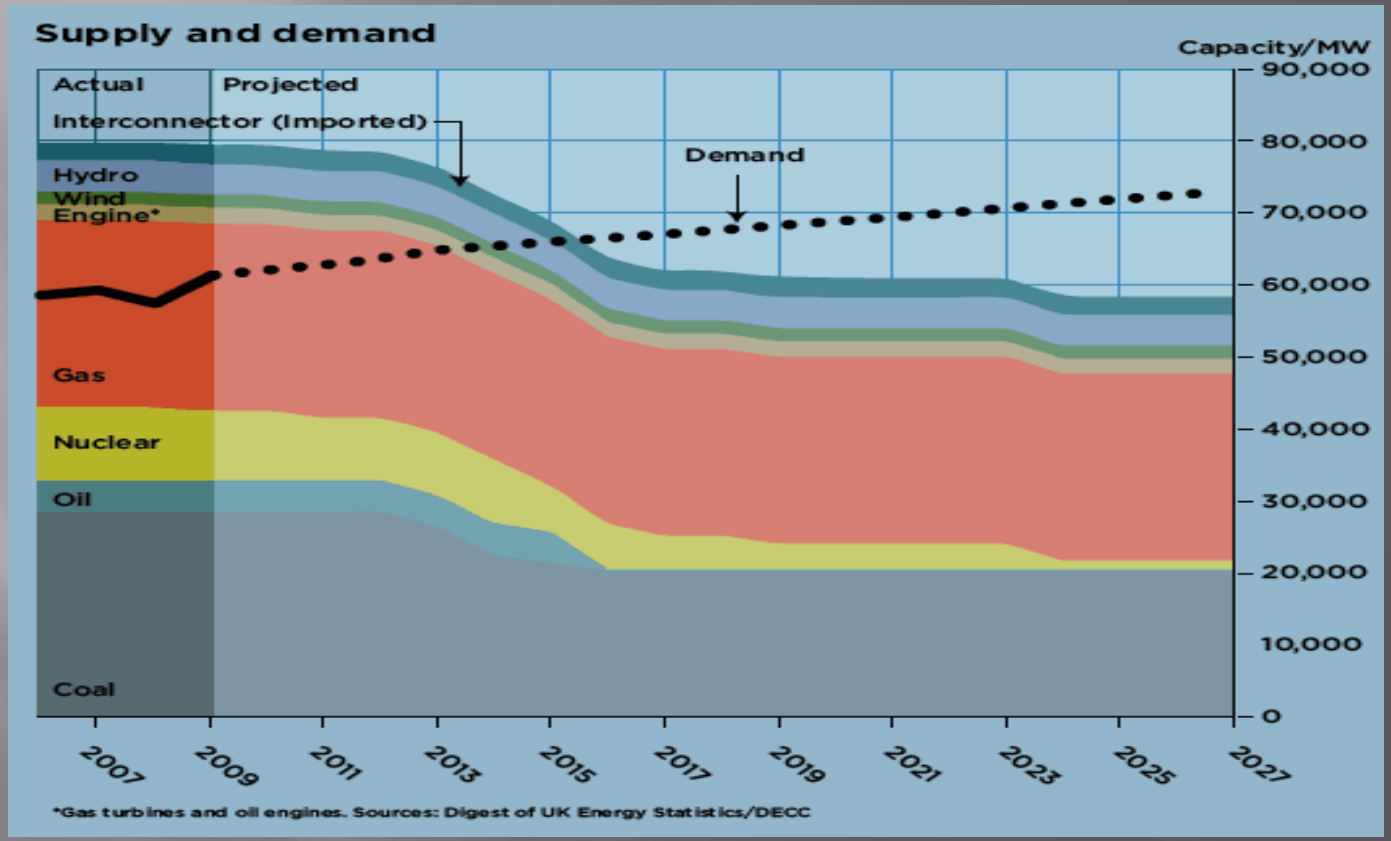
UK gas extraction from the North Sea peaked in 2000, the UK remained a net exporter of gas until 2005

UK Oil Production



UK oil production from the North Sea peaked in 1999

UK Energy Gap



UK energy demand is steadily increasing

Q&A

2. Fossil Fuels

2. Fossil Fuels

- The three fossil fuels natural gas, oil and coal, were formed millions of years ago when dead plants and animals were trapped under deposits and became buried underneath land
- Compression over time fossilised the remains, creating carbon-rich fuel sources
- All fossil fuels are finite, the deposits that exist cannot be replenished once they are used
- While **CO_2** is naturally occurring, its concentration is rapidly increasing because of the **burning of Fossil fuels, this process is called Global Warming**

Natural Gas

Some experts believe that current natural gas deposits fill around 6000 trillion cubic feet that could, with the current level of usage, last for **about 50 years**. This assumes that there are still no new sources of natural gas still to find.

Oil

The world could still have oil reserves that would fill between 850-900 billion barrels (USGS data September 2013). The world consumes about 85 billion barrels of oil per year.

Because we use oil to manufacture many materials, including plastics, we use oil at a much faster rate than either natural gas or coal.

Oil it is currently getting scarcer, and as a result more expensive, but current estimates suggest we will not actually run out until between **2025 and 2050.**

Coal

Coal is the fossil fuel with the greatest reserves. Most of the coal deposits have not been tapped. If we carry on using coal at the same rate as we do today, we could have enough coal to last well over **1000 years**.

*** Note *** As other fossil fuels run out, particularly oil, the use of coal may increase, reducing that time span considerably.

Q&A

3. Transportation

Traffic congestion is a condition on road networks that occurs as use increases, and is characterised by slower speeds, longer trip times, and increased air pollution.

ONS forecasts for car travel demand assumes that the population in England will rise by around 20% (or 10.5 million people) from 2010 to 2040, this will put substantial additional pressure on the network.

3. Transportation

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4. Fuel Poverty and Energy Bills

A household is said to be fuel poor if it needs to spend more than 10% of its income on fuel to maintain a satisfactory heating regime (usually 21 degrees for the main living area, and 18 degrees for other occupied rooms).

Rising fuel costs are seeing more and more vulnerable people and families falling into fuel poverty.

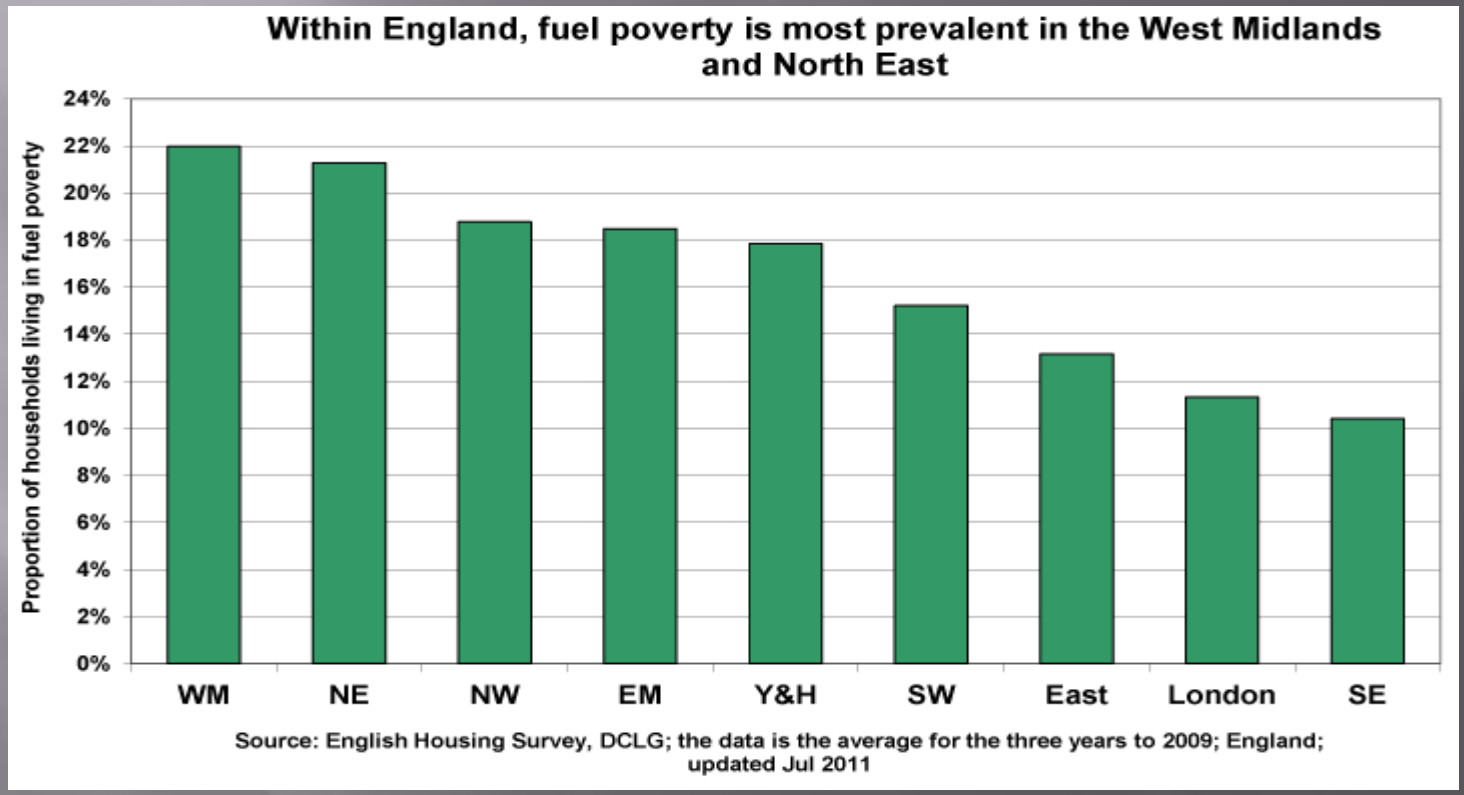
What is Fuel Poverty?

Last winter, more than five million households in the UK struggled to heat and power their homes.

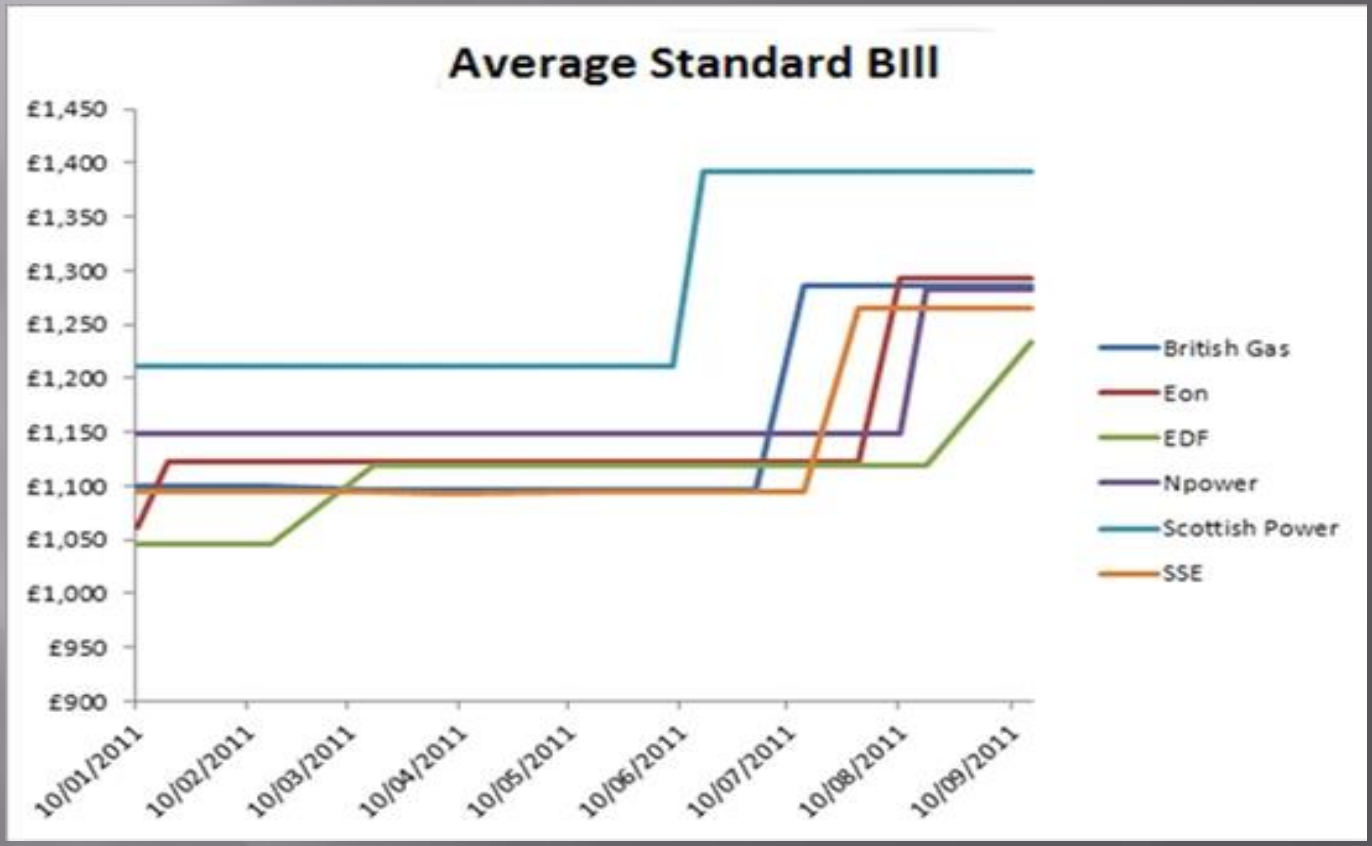
Those most affected are likely to be older people, disabled people, families on low incomes with children, large families, one parent families, people who are unemployed and people who are already in debt.

Over 20,000 people die from the cold during the winter and many more become ill. Households try to cope in different ways, but often go into debt, and choose between food or warmth.

Fuel Poverty

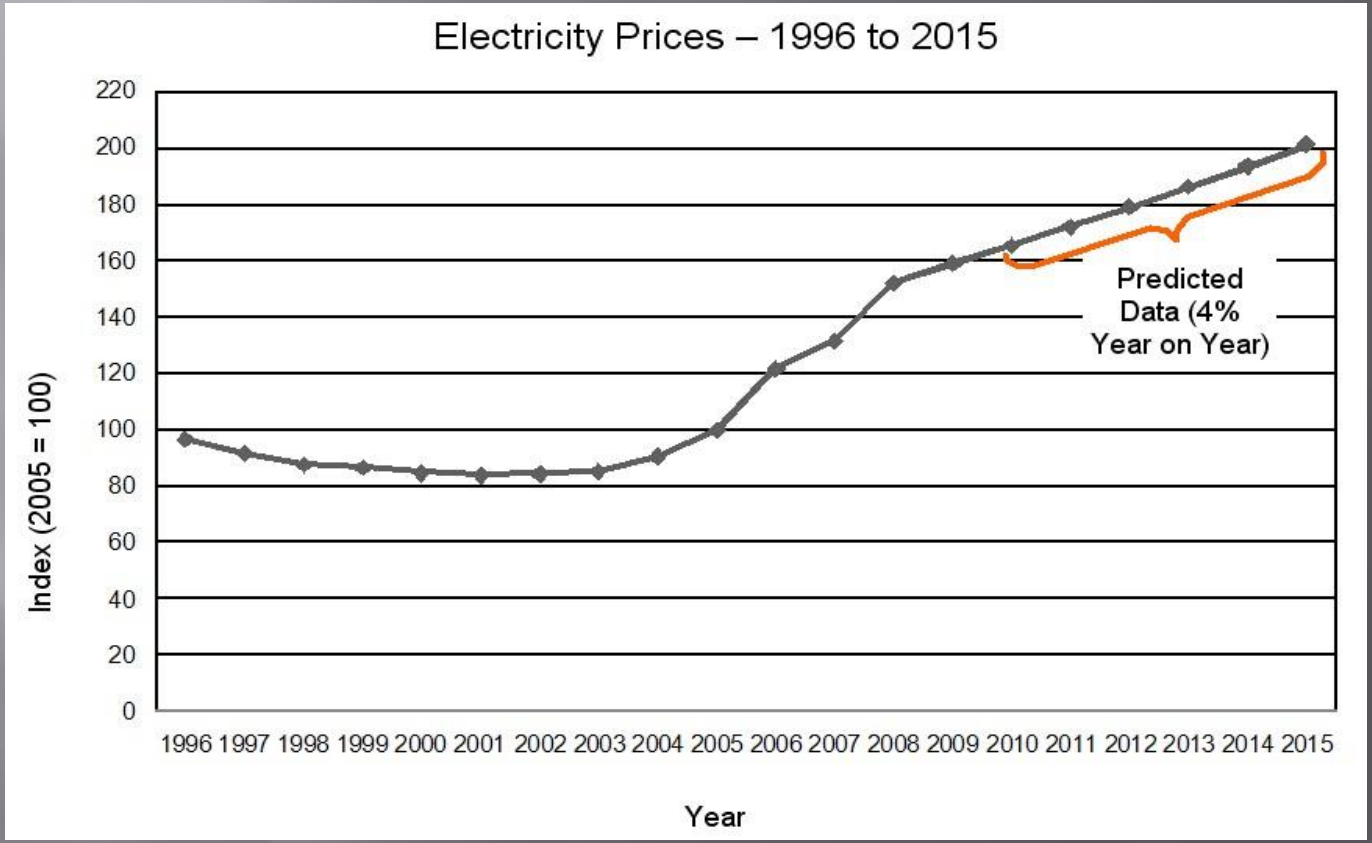


UK Energy Bills



Average energy bills started to dramatically increase in the summer of 2011.

UK Electricity Prices



Electricity bills started to dramatically increase in 2005.

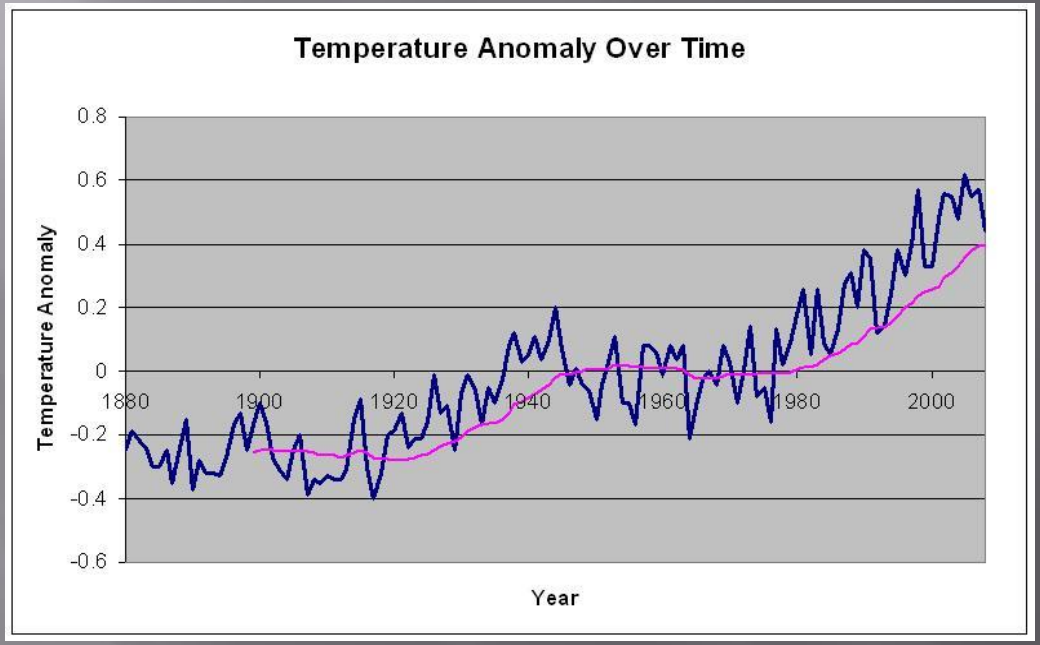
Q&A

5. Global Warming and Climate Change

Global warming is the observed century-scale rise in the average temperature of Earth's climate system.

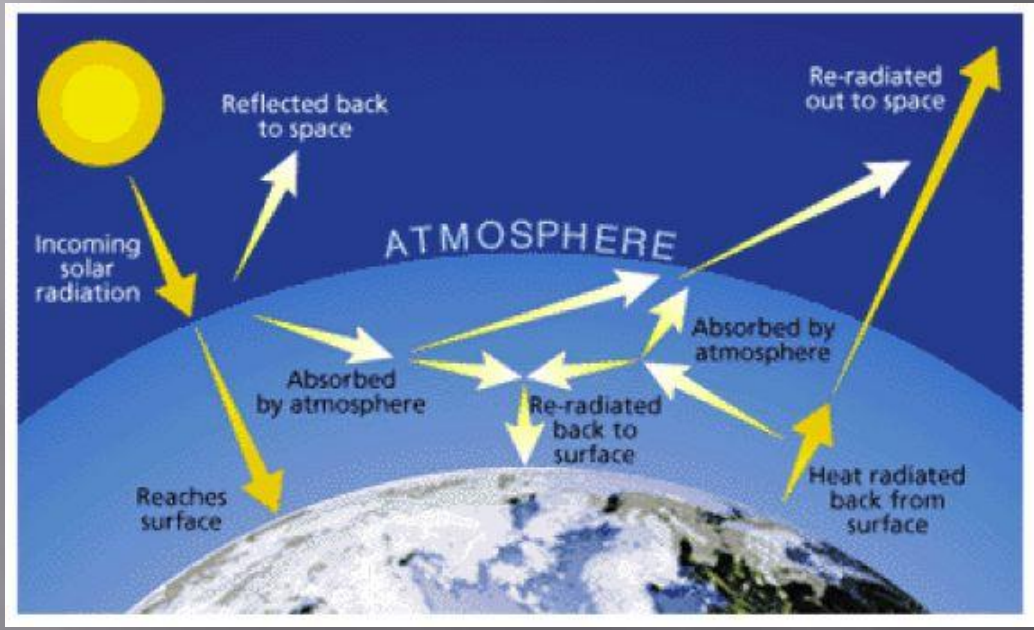
Source: Wikipedia 2014

Temperature Changes



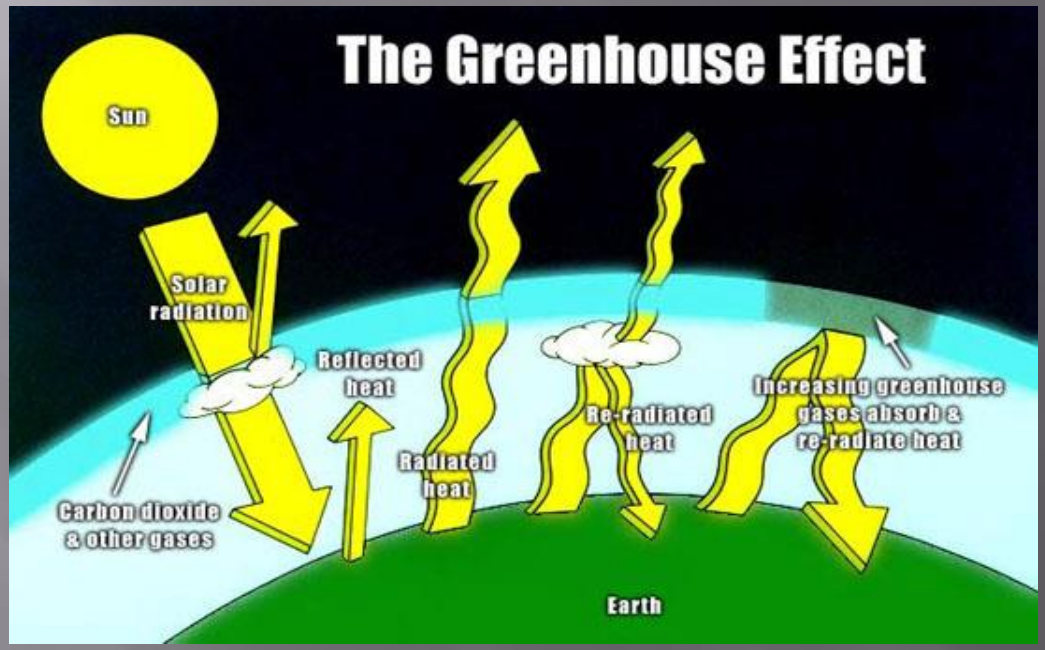
Global temperatures have risen and fallen naturally over the years, scientists today believe that the increases in global temperature over the past 1000 years have been significantly affected by human activity, altering a natural phenomenon known as the greenhouse effect.

Natural Warming



The greenhouse effect is a natural warming process. CO_2 and certain other gases are always present in the atmosphere. These gases create a warming effect that has some similarity to the warming inside a greenhouse, hence the name " greenhouse effect. "

Amplified Warming



Increasing the amount of greenhouse gases intensifies the greenhouse effect. Higher concentrations of CO_2 and other greenhouse gases trap more infrared energy in the atmosphere than occurs naturally. The additional heat further warms the atmosphere and Earth's surface.

Greenhouse Effect

The greenhouse effect is the natural process by which Earth's atmosphere traps some of the energy from the Sun, warming the planet enough to support life.

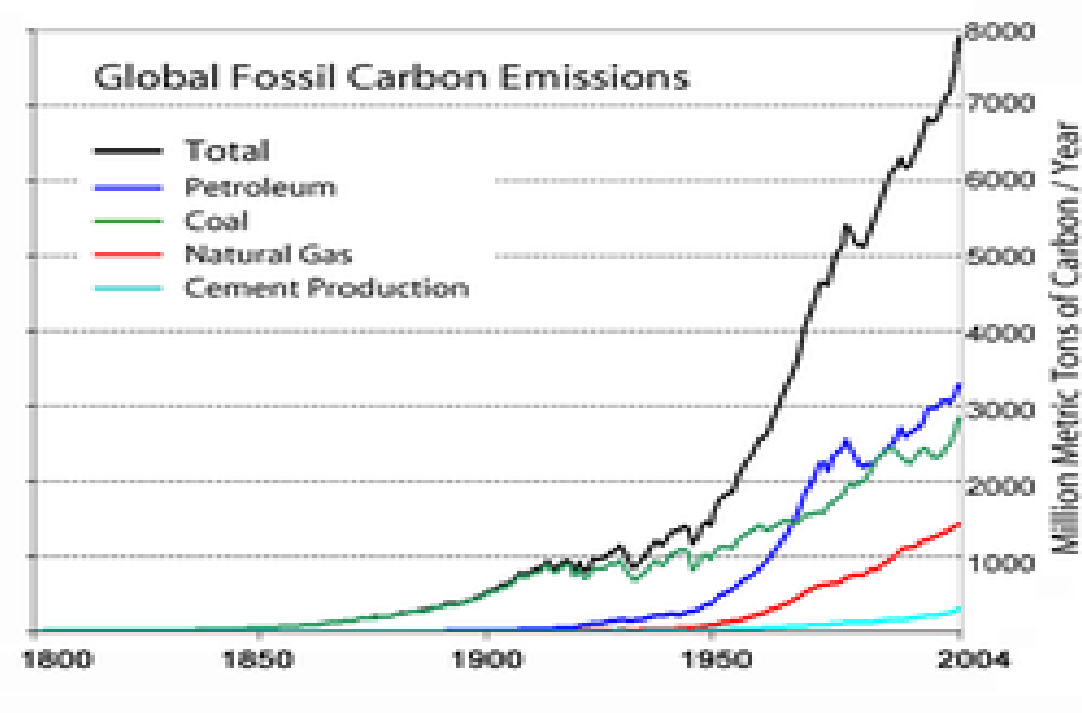
Many scientists believe that the increase in "greenhouse gases" from human activity is increasing the effect artificially.

These gases include carbon dioxide, emitted by fossil fuel burning and deforestation, and methane, released from farming and landfill sites.

Scientists believe that an increase in average global temperature of only 2 degrees could be disastrous.

Even more importantly, many believe that the tipping point – i.e. the level of carbon dioxide in the atmosphere that will take the greenhouse effect into a runaway state could be reached within the next 20 years.

Carbon Dioxide



Fossil fuel use is the primary source of CO_2 emissions. Since the industrial revolution these fuels have drastically increased. CO_2 levels are 30% higher than they were 650,000 years ago whilst methane is 130% greater.

Consequences

Many experts warn, that global warming will cause sea levels to rise dramatically. Thermal expansion has already raised the oceans 4 to 8 inches (10 to 20 centimetres).

A global average sea level rise of 9-88 cm (3.5-34.6 inches) is expected over the next hundred years, thanks to the greenhouse gasses we have emitted to date and likely future emissions. This will come in roughly equal measure from melting ice and from thermal expansion of the oceans(water expands as it heats up).

Between the Greenland ice sheet and the Western Antarctic ice sheet the world could well be facing a 13 metre (43 foot) rise in sea level if we do not drastically curb our greenhouse gas emissions. Even a small fraction of this much sea level rise would be an economic and humanitarian disaster.

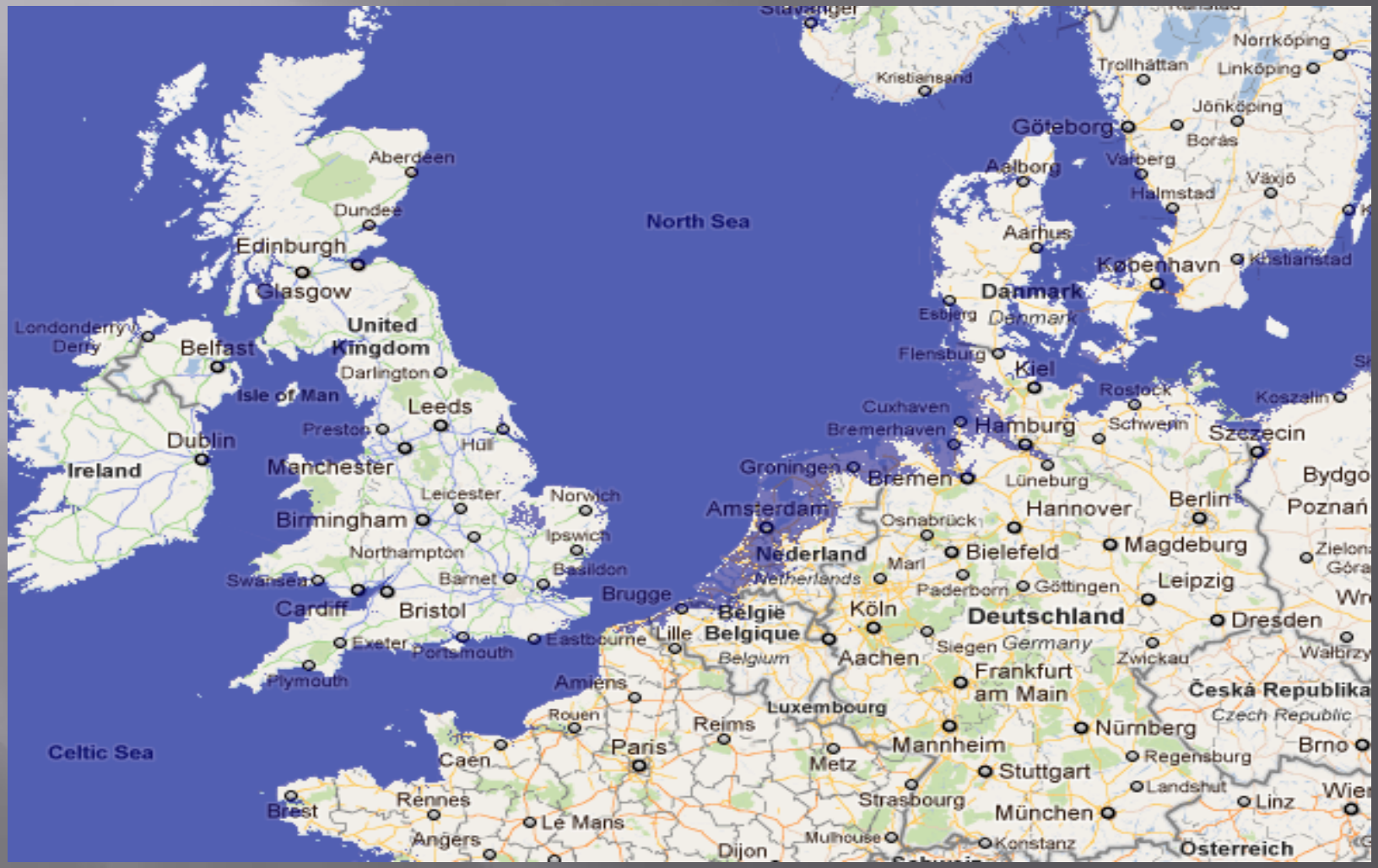
Consequences

A few possible consequences of rising sea levels:

Billions spent on adaptation - if you can afford it. The US has roughly 20,000 km (12,400 miles) of coastline and more than 32,000km (19,900 miles) of coastal wetlands. A recent study estimated the costs of adapting to even a one metre sea level rise in the US would amount to US$156 billion (3 percent of GNP). Most countries don't have this kind of money to spend.

With only a one metre sea level rise some island nations, such as the Maldives, would be submerged. Already, two of the islands that make up Kiribati (a Pacific island nation) have gone under the waves, and in early 2005 others were inundated by a high spring tide that washed away farmland, contaminated wells with salt water, and flooded homes and a hospital.

1m Sea level rise



7m Sea level rise

1m Sea level rise

7m Sea level rise

Q&A

Global and National Targets

At the Kyoto Summit in 1997, the UK agreed to a 12.5% reduction in greenhouse gas emissions below 1990 levels by 2008 to 2012.

In the April 2009 budget the government treasury committed the UK to a 34% reduction in carbon emissions by 2020.

In addressing climate change and the UK's impact on global warming, government has set some challenging targets, including;

- A 80% reduction in UK carbon dioxide emissions by 2050
- A 30% reduction in carbon emissions from central government buildings by 2020, and **20% of UK energy generation from Renewables by 2020.**

Durban 2011

Climate change conference:

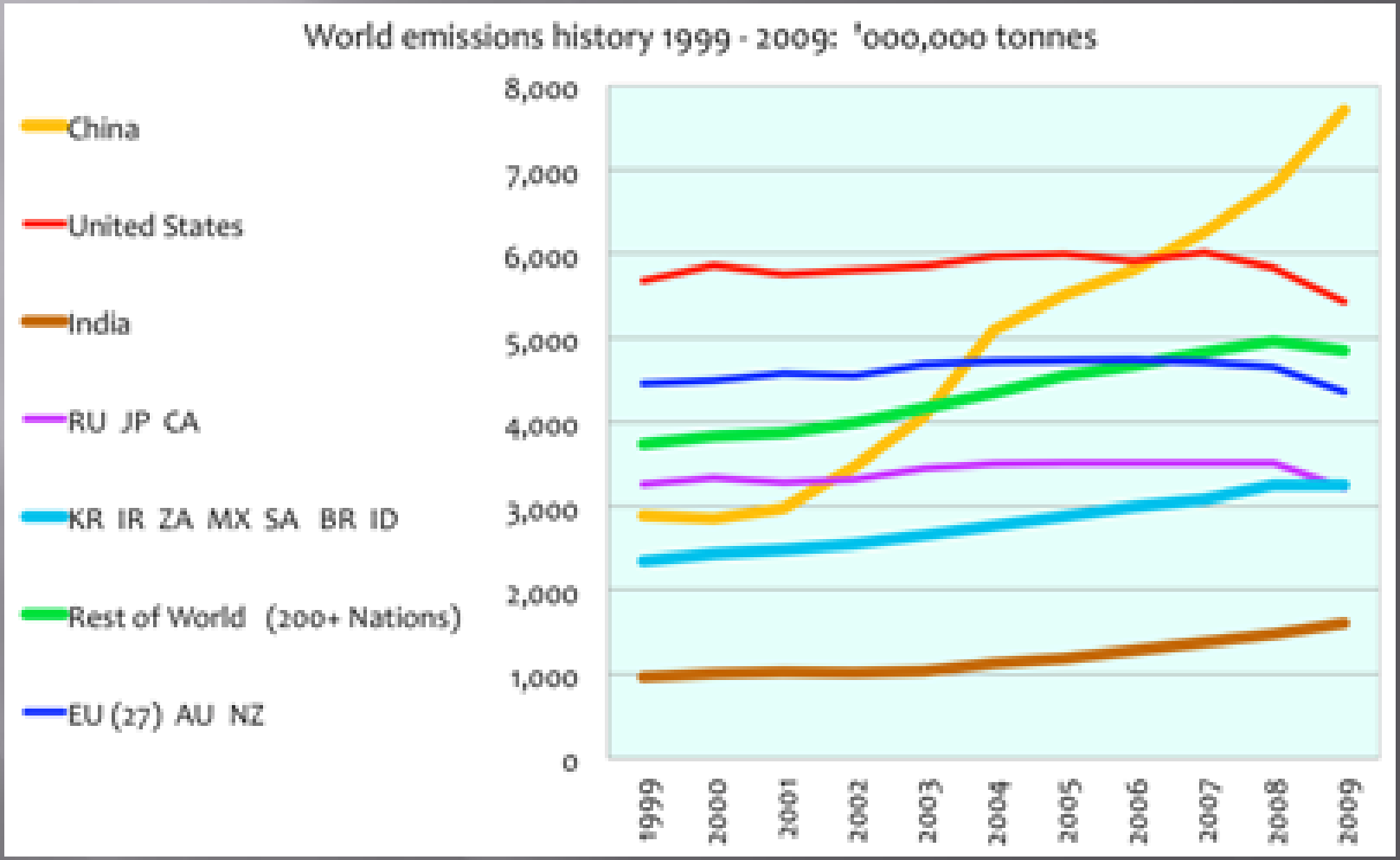
This conference outcomes were:

- Global agreement achieved on a roadmap to a legally binding deal
- Second commitment period of Kyoto Protocol to be agreed 2012
- Green Climate Fund to be set up

Paris 2015

The conference objective is to achieve a legally binding and universal agreement on climate, from all the nations of the world.

Carbon Dioxide Emissions

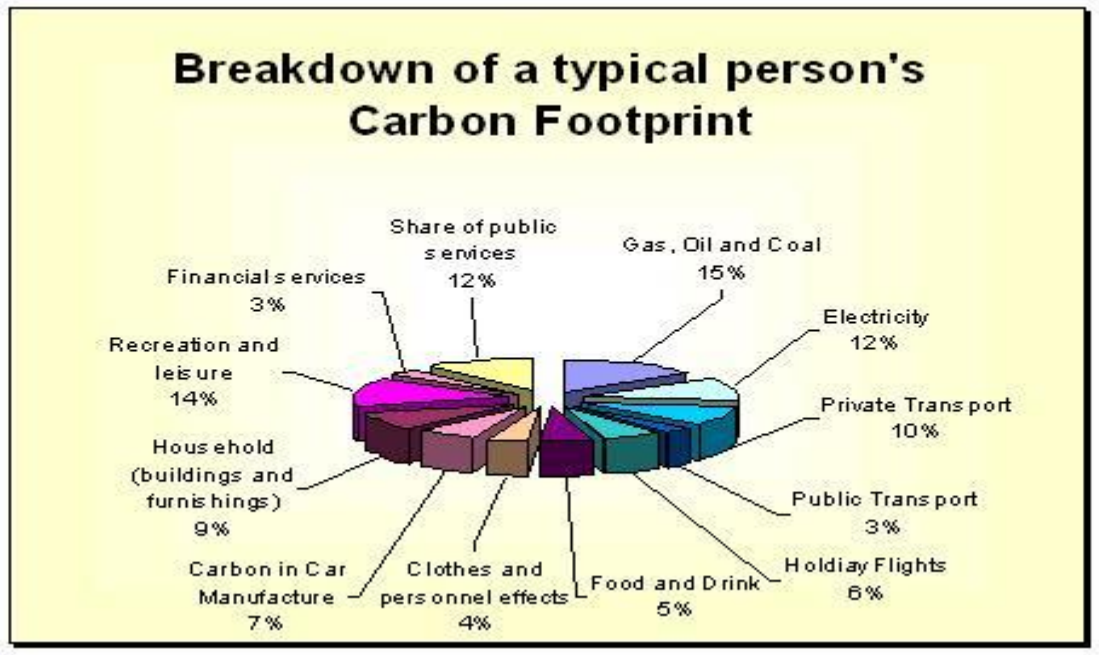


Carbon Footprint

A **carbon footprint** is the total amount of greenhouse gas emissions caused by an organisation, event or product" For simplicity it is often expressed in terms of the amount of carbon dioxide, or its equivalent of other greenhouse gases released into the atmosphere.

There are two key strategies to reducing carbon footprint, the first is to reduce the greenhouse gases produced through our need for energy (renewables, nuclear power etc.), the second is to increase the efficiency of energy consumption (more efficient appliances, reducing waste and changing behaviours)

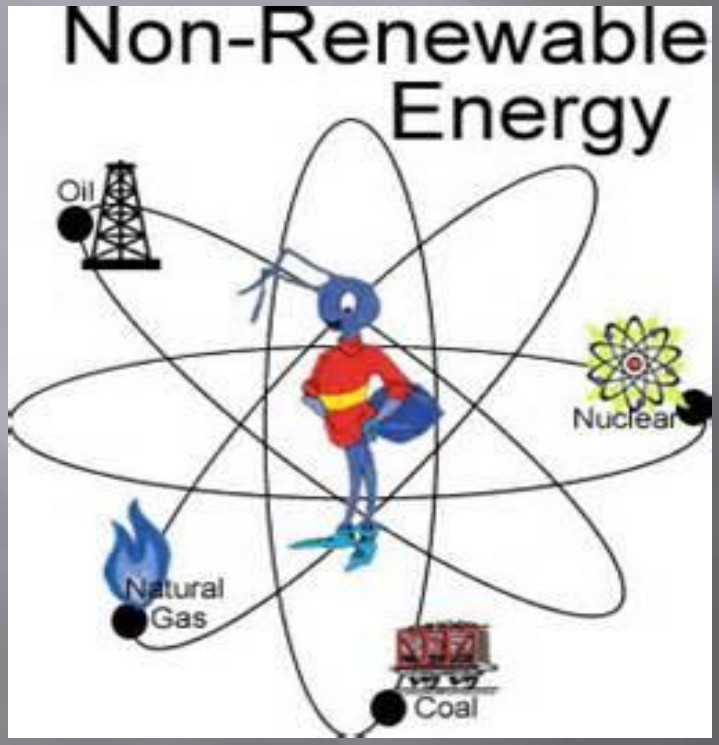
Your Carbon Footprint



Looking at the break down you can see that transportation accounts for 13 % of a person's total carbon footprint. Factor in holiday flights and carbon in a car's manufacture and that figure suddenly jumps up to 26%

Q&A

Non Renewable & Renewable Energy Sources



Non Renewable Energy

Non-renewable fossil fuels (crude oil, natural gas, coal, oil shale and tar sands) currently supply the majority of the world's electrical energy needs.

Non-renewable energy is energy produced by burning fossil fuels such as coal.

They are non-renewable because there are finite resources of fossil fuels on the planet. If they are continually used, one day they will run out.

Renewable Energy

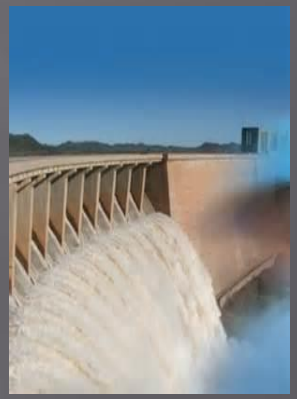


Alternative energy is any energy that is produced from sources other than fossil fuel energy.

Renewable energy is any source of energy that doesn't consume the finite resources of the Earth and can be easily and quickly replenished.

At present only a small proportion of the world's energy needs come from alternative and renewable energy sources.

Renewable Energy



These exist in many forms including Solar Thermal, Photovoltaics, Wind, Hydro, Tidal/Wave and Bioenergy (including Biomass, Biogas and Biofuels).

As with fossil fuels the sun's energy is the ultimate source of these energies.

Advantages of Non Renewables

There are a few major advantages with non-renewable energy.

1. Fossil fuels, such as coal, oil and gas are abundant so this means they are a relatively cheap fuel and readily available.

2. In the UK there enough coal resources to last over two hundreds years.

3. Very large amounts of electricity can be generated from fossil fuels.

Disadvantages of Non Renewables

1. Fossil fuels are non-renewable and will eventually run out because we are using them much faster than they can be restored within the earth.

2. Burning fossil fuels produces photochemical pollution from nitrous oxides, and acid rain from sulphur dioxide.

3. Burning fuels also produce greenhouse gases including vast amounts of carbon dioxide that may be causing the phenomenon of global warming that the planet is currently experiencing.

Advantages of Renewables

The main advantage is the fact that these sources of energy are renewable. We will never run out of renewable energy.

Solar Energy - the sun will always be there, and in abundance - the amount of solar energy intercepted by the Earth every minute is greater than the amount of energy the world uses in fossil fuels each year.

Wind Energy - the wind will always exist; for example the energy in the winds that blow across the United States each year could produce more than 16 billion GJ of electricity - more than one and one-half times the electricity consumed in the United States in 2000.

Tidal Energy - the moon which provides the forces that causes the tides will always be there.

Hydroelectric Energy - unless there is a drastic change in rain patterns, it will always be there

Advantages of Renewables

A second advantage is that we can stop using fossil fuels to generate electricity.

With renewable energy we can use as much electricity as we like without adding to global warming.

Renewable resources are 'green', or environmentally friendly. This is because they do not emit carbon dioxide (the biggest contributor to global warming) into the atmosphere.

Disadvantages of Renewables

One disadvantage with renewable energy is that it is difficult to generate the quantities of electricity that are as large as those produced by traditional fossil fuel generators. This may mean that we need to reduce the amount of energy we use or simply build more energy facilities.

Another disadvantage of renewable energy sources is the reliability of supply. Renewable energy often relies on the weather for its source of power.

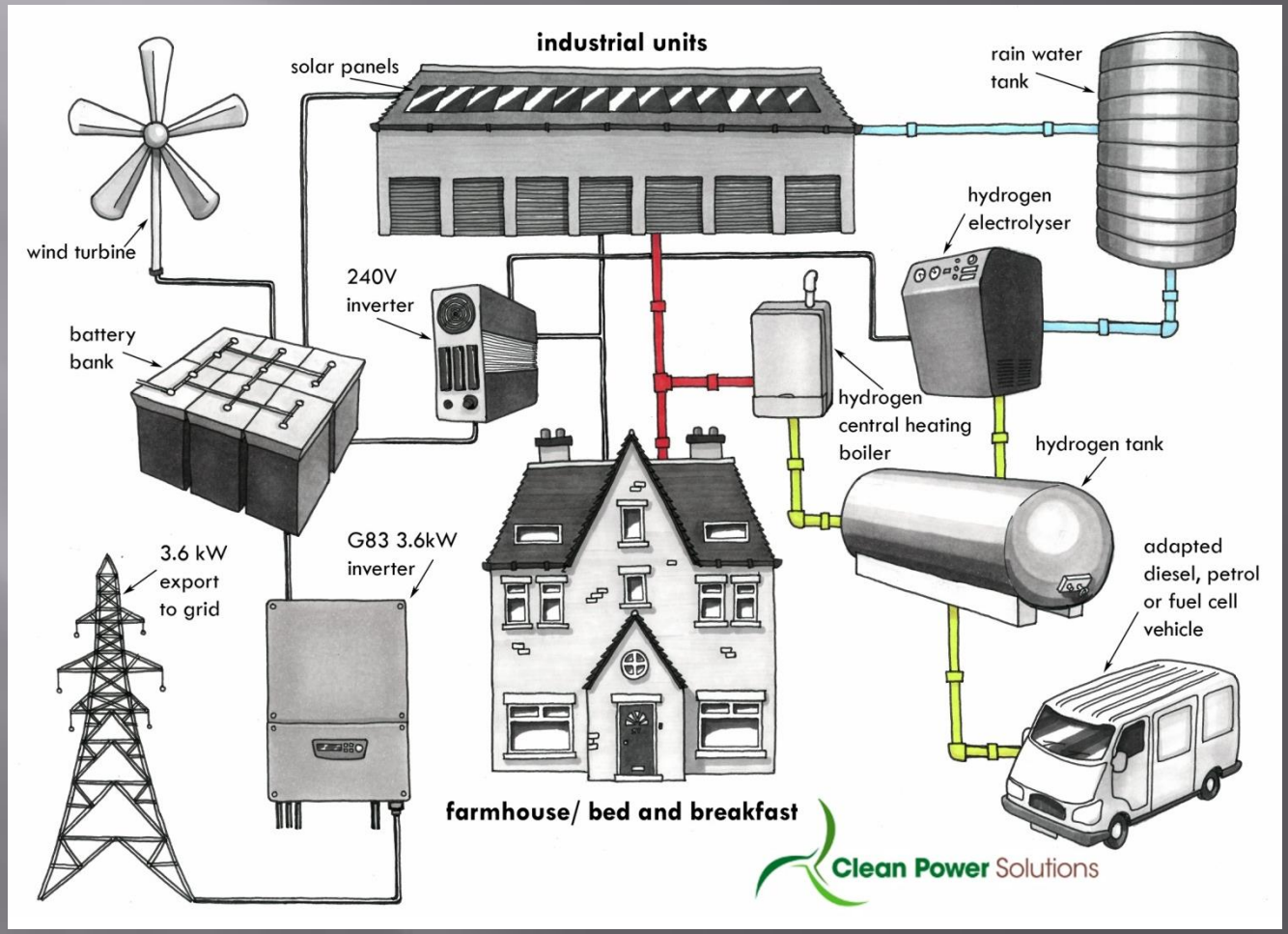
Hydro generators need rain to fill dams to supply flowing water.

Wind turbines need wind to turn the blades.

Solar collectors need clear skies and sunshine to collect heat and make electricity.

When these resources are unavailable so is the capacity to make energy from them. This can be unpredictable and inconsistent. The current cost of renewable energy technology is also far in excess of traditional fossil fuel generation. This is because it is a new technology and as such has extremely large capital cost.

The Hydrogen Economy



Hydrogen Technologies

The profile of hydrogen as an environmentally friendly energy carrier is growing due to its large operating range and quick refuelling capabilities.

Hydrogen fuelling is seeing a surge in popularity, and there are currently some 200 hydrogen refuelling stations in operation around the world with concrete plans for 100 more in Japan and another 68 stations in California, both by 2016, plus 400 more within 2023 in Germany.

These regions have been the pioneers in implementing H2 infrastructure and fuelling, with a number of stations, in many cases supported by a push for further initiatives including pilot programs creating and storing hydrogen for fuelling made from renewable sources including wind power stations.

Hydrogen Technologies

In the UK a significant number of the technical challenges to getting hydrogen into vehicles have been addressed and key industry stakeholders and the UK Government are focusing on how to roll out this new fuel and vehicle technology to the mass market.

Leading the effort in addressing the many challenges and issues (pipeline transportation, production and fuelling) to rolling out hydrogen fuel cell electric vehicles is UK Hydrogen Mobility, a joint project involving key stakeholders including the industrial gas industry, OEMs, the UK Government and refuelling infrastructure providers.

Hydrogen Technologies

Hydrogen Technologies has made great strides to become more sophisticated, with new ways to harness resources becoming available every day.

As Europe moves toward reducing carbon emissions, with strict emission targets to be achieved by 2020, the door has been opened for wide adoption of hydrogen technologies.

Pros and Cons of Existing Hydrogen Technologies

The use of hydrogen as a fuel has specific advantages and disadvantages.

Hydrogen fuel cells are already in use as electrical generators, and they have also been used in the space program.

Fuel cells operating on hydrogen technologies is a way to generate electrical power. The only by-product of using a hydrogen fuel cell to power a car is water or water vapour, which exits through the tailpipe.

Much of the impact of adopting hydrogen as an energy source would be positive for the environment.

The use of hydrogen would likely come with a reduction of the use of fossil fuels as energy sources. With this reduction would perhaps come a reduction in global warming, because fossil fuel use is believed to be an important contributor to global warming.

Pros and Cons of Existing Hydrogen Technologies

The production of hydrogen can potentially affect the environment in a negative way.

Depending on the production method, carbon dioxide and other negative emissions can enter the atmosphere while hydrogen is being made.

This issue can be addressed by catching and storing the carbon dioxide, but even this storage can potentially affect the environment.

However, if environmentally friendly, renewable resources such as solar or wind are used to power the means of producing hydrogen, the negative impact can be eliminated.

As hydrogen becomes widely used, it could leak into the atmosphere. If the amount is significant enough, this hydrogen could change the percentage of hydrogen present in Earth's atmosphere. Some scientists believe that this could have a profound effect on the atmosphere, including increasing the size of the hole in the ozone layer.

Water or water vapour produced by cars using hydrogen fuel cells will be pure, therefore it will freeze in temperatures below 32F (0C). Scientists will have to come up with a solution for this by-product on the roadways and the environment in colder climates.

Transportation & Hydrogen

Hydrogen fuel cells for vehicles are very easy to manufacture and they have no moving parts. This means that there is little maintenance that needs to be performed on each fuel cell.

With no moving parts, fuel cells will be quiet, light and versatile.

Depending upon the size of the vehicle the fuel cell can be manufactured big or small and used on a large or small scales.

As the fuel cell id modular in design, one can work on its own or many can function together as one.

Hydrogen fuel cell-powered cars are very efficient producers of power. They are more efficient than internal combustion engine cars. About 60 % of the potential energy in hydrogen is made into electricity by a fuel cell.

These fuel cell-cars can respond instantaneously to provide fuel when it is needed.

Transportation & Hydrogen

However, there are several major drawbacks to the development and use of fuel cells across the transportation sector

The lack of a worldwide standards for fuel cells between manufacturers or most governments.

Hydrogen infrastructure needs to be support emerging hydrogen technologies

Governments and businesses do not want to invest money in creating an infrastructure

The cost of the energy produced by a fuel cell is also very high.

The costs for fuel cells have been going down as technology has been developed and improved.

Global Warming and Hydrogen

Hydrogen has to come from somewhere- it doesn't naturally occur on its own (at least not in any significant quantities)

The two current sources for hydrogen:-

1. Separate it from natural gas in an energy intensive process, the by product of which is CO2
2. Crack it from water, using large amounts of electricity.

Hydrogen doesn't solve our fuel problem, its just another way of moving around the energy we have created.

The water vapour exhaust will not be a big deal, consider that much of the current auto exhaust is water vapour, as with any combustion of a hydrocarbon.

Factor in the life cycle costs of producing and disposing of fuel cells

They aren't the solution to global warming. Changing how we get our energy and how we use it (and how much) is the critical

Q&A

Hydrogen Economy Opportunities

Today, the biggest forms of energy are fossil fuels - oil, gas, coal. But that is set to change in the future for at least two reasons:-

1. “Easy" oil and gas sources are declining
2. Emissions of greenhouse gases related to fossil fuels are rising to unacceptable levels

But what are the alternatives and can they ever become a reality?

Hydrogen is already providing a growing alternative energy source for transportation in several countries, including the US and Japan.

In a bold move, Iceland has set itself the challenge of becoming the world's first hydrogen economy, with the aim of the fuel supporting all its energy needs by 2050.

Hydrogen Economy Opportunities

The most obvious step that we are beginning to see is the introduction and take-up of fuel-cell powered vehicles.

These cars offer immediate benefits - they are about twice as efficient as current fossil fuel transport and can significantly reduce air pollution in cities.

Since the first hydrogen filling station was set up in 2000 in the US, we have seen a steadily growing number opening up to meet the increased demand, especially in the US, Japan, Germany and Iceland.

For example many buses in Iceland are already converted to use hydrogen and are refuelled by a filling station on the outskirts of its capital, Reykjavik. There are also plans to convert the country's entire fishing fleet.

Hydrogen Economy Opportunities

Unfortunately, whilst moves towards an increased use of hydrogen are starting to gather speed, as things stand this growth is restricted by a number of constraints at the political, commercial, technical and social levels.

Safety concerns are still widespread, with the spectre of the Hindenburg accident still in the minds of many.

The public perception of the dangers around hydrogen's transportation and distribution need to be addressed if we're to see widespread use in the future.

At a practical level, there are real issues in terms of how we store and transport hydrogen. Hydrogen is a very light gas making it far more difficult to work with than gasoline.

National and international government organisations must get behind the technology and provide the support for research, and ultimately the commercialisation of hydrogen, if we are to succeed in developing a viable and green alternative to fossil fuels.

The hydrogen economy is developing but more must be done if we're to see real progress in the medium to long term; only then will it cease to be a theory and become a reality.

Hydrogen Economy Opportunities

The future is bright for hydrogen fuelling, and the industry is reaching a stage where ‘just' opening a hydrogen refuelling station is no longer ground-breaking.

As clean technology companies and auto manufacturers continue to make strides in the hydrogen infrastructure, the mind-set will become more widespread and more hydrogen-powered cars, as well as a need for more fuelling stations, will be apparent on British roadways.

That's it! Well done.

Once you have successfully completed the Unit 1 test you are ready to move onto Unit 2 Hydrogen Fundamentals.

If you would like to learn more about Unit 1 Sustainable Energy and Hydrogen, please ask.

In the mean time, thank you for your attention.

Next step

Well done with the test everyone.

Your next unit of study is Unit 2 Hydrogen Fundamentals .

Thank you for your attention.