NEBOSH Environmental Management Certificate

The Management of Environmental Risks in the Workplace

SAMPLE MATERIAL

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RMS PUBLISHING

ACID RAIN

Sulphur dioxide is produced from the combustion of fossil fuels containing sulphur. These are predominantly coal, diesel and fuel oil, since natural gas and petrol have relatively low sulphur content, and processing now removes all the sulphur from most high-sulphur liquid fuels like diesel.

In the air, the sulphur dioxide oxidises to sulphur trioxide, which then combines with atmospheric water to form sulphuric acid.

Other oxides such as nitrous oxide from vehicle exhausts, carbon dioxide from burning fossil fuels, wood and respiration, and VOCs can also cause acidic atmospheric water, but these are of a milder acidity but still contribute to the effect.

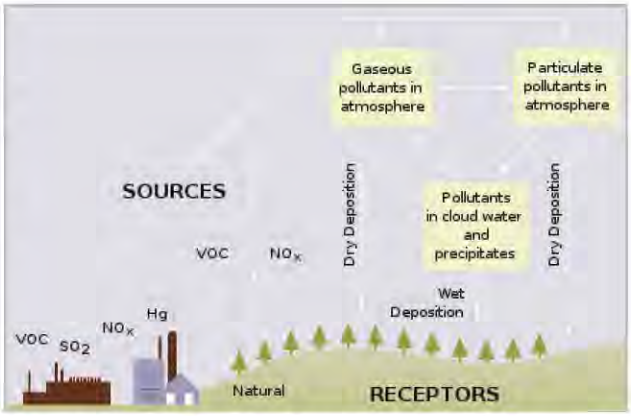

Figure 1-6: Graphic of acid rain deposition. *Source: NH Savage.*

This acidified water falls to ground as rain (precipitation) and has several effects:

- Acidic soils are intolerable to trees and plants.
- Acidic water is intolerable to fish, and acidic water stops shellfish shells from forming.
- Acidity leaches from the soil heavy metals such as aluminium, lead and mercury, these are then washed into watercourses. Heavy metals can cause neurological diseases and can affect the central nervous system.
- Acidic waters leach essential minerals such as calcium and potassium from the water.

The above not only impacts those animals and plants directly, but also the food chain above them that are reliant on them.

Figure 1-7: Effects of acid rain in the Czech republic. *Source: Nick Bdka.*

Acid rain also causes corrosion of the facades of stone buildings and metals structures.

These dioxide gases can be transported over very large distances in the atmosphere. In the United Kingdom, the prevailing wind, the "Gulf Stream", is from the south-west so this blows much of the pollution to Eastern Europe, affecting a region from Poland northward into Scandinavia. Scandinavian conversely produce very little sulphur gases as they produce nearly all their power from renewables but suffer the effects. In other parts of the world, regional transport of the gases from their own or neighbouring activities affects the eastern third of the United States, south eastern Canada, south eastern coast of China and Taiwan.

Acid rain can be prevented by the use of cleaner fuel technologies and the effective cleaning of industrial and transport emission gases.

NITROGEN COMPOUNDS

The nitrogen compounds include Nitric Oxide (NO) and Nitrogen Dioxide (NO2) which are grouped together and known as NOx.

Nitrogen Oxide (N2O) is formed by natural microbiological processes in the soil and naturally by lightning - worldwide there are some 6000 + strikes per day.

The major source of human made NOx is from high temperature combustion processes such as burning diesel and petrol in vehicles, and from nitrogenous fertilisers used in agriculture. These are increasing atmospheric levels of nitrous oxide.

NOX produce acids which will contribute to the phenomenon known as 'acid rain'.

NOx contributes to the formation of ground level ozone and the formation of smog, affecting local air quality.

In the UK the Air Quality Standards Regulations (AQSR) 2010 place a duty on Local Authorities to maintain levels of nitrogen dioxide below set air quality limit values.

Figure 1-8: Lightning Strikes. *Source: Posdiff.*

Some carbon is released directly into the atmosphere as carbon dioxide, where it is re-absorbed by living plants and marine plants and through chemical deposition into rocks and soils.

Some of the carbon is deposited into the soil where it acts as a soil improver. As soil levels build up over millions of years it is compressed into peat and to other minerals. Millions of years ago before funghi appeared it was then converted into what we call "fossil fuels" - coal, oil and gas. These are stored deep underground. These absorption and deposition processes are called "Carbon Sinks".

The world evolved over millions of years to balance the natural sources of carbon production with the carbon sinks whilst maintaining a suitable temperature and oxygen level in the atmosphere.

As the human race developed, they found that the fossil fuels burnt very easily to provide heat and power for their needs. When fossil fuels are burnt the combustion processes produce carbon dioxide which is released into the atmosphere. As these carbon sources were trapped in the ground and have been released over a very short amount of time starting in the late 1700s but rising dramatically since 1945, the world has not had time to increase its carbon sinks.

Whilst Carbon Dioxide is the main greenhouse gas emitted by humans, several other gases are Green House Gases, such as:

- Methane, for example, from cattle such as cows and sheep, landfill sites, water pollution, and melting permafrost.
- Nitrous oxide, for example, from vehicle exhausts.
- Fluorinated compounds, for example, from leaking air conditioning and refrigeration units.
- Volatile organic compounds (VOCS) from unburnt hydrocarbons, for example, solvents, vehicle exhausts, oil refining, fuel stations, agriculture, air fresheners.
- Sulphur Hexafluoride SF6 – used in high voltage electrical distribution where it is used as an electrical insulator and arc suppressant.
- Water vapour - though naturally present in the atmosphere water vapour has a strong effect on the greenhouse effect by increasing dust and chemicals in the air by bonding the elements in air, a process called nucleation.

This has resulted in a building up of the greenhouse gases in the atmosphere, therefore increasing global warming and leading to climate change (see as follows).

The increase in Green House Gases warms the atmosphere causing human made or *Anthropogenic* Climate Change which has global implications:

- The release of the melted fresh water into the oceans changes global energy flows affecting weather patterns. The increased air temperature provides more energy for storms.
- The heating of the oceans increases its volume and combined with the ice melt results in rising sea levels which will flood low lying land.

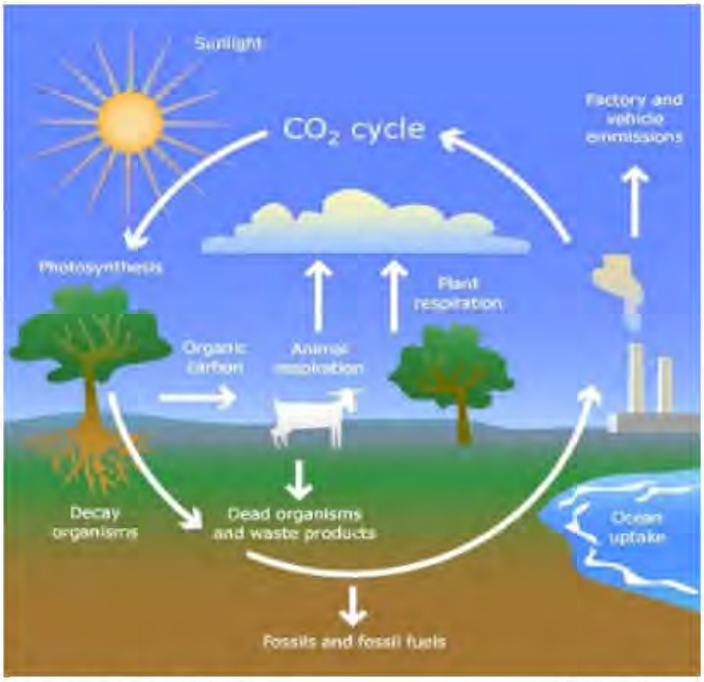

Figure 1-10: The Carbon Cycle. *Source: RMS.*

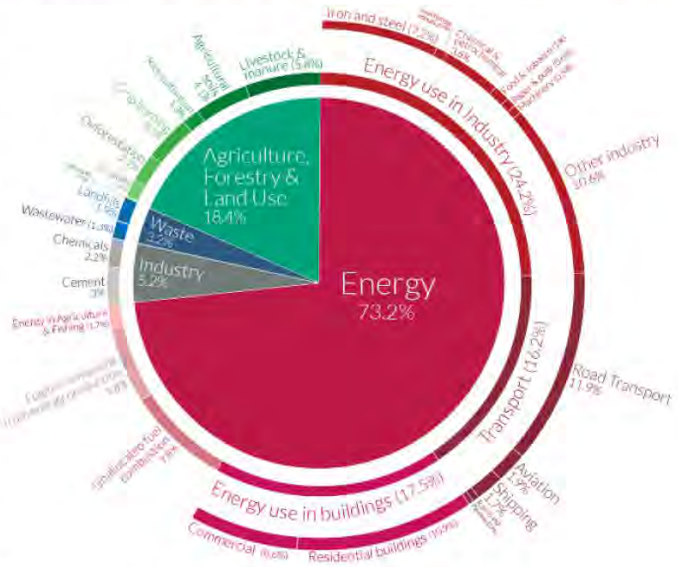

Figure 1-11: Greenhouse gas emissions sources.
Source: https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions

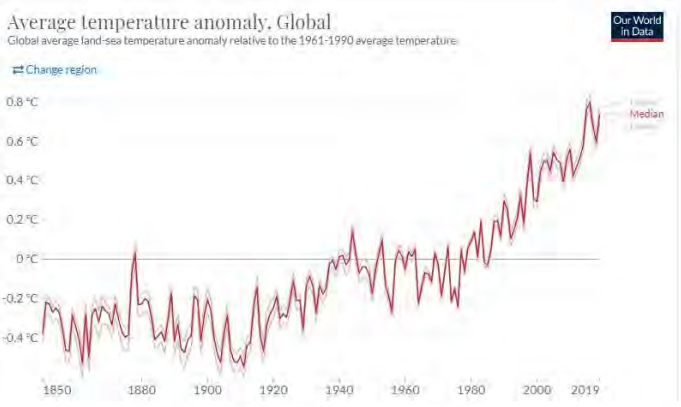

Figure 1-12: Global Temperature Change.
Source: https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions

annual flow of the River Nile. In the USA, over reliance on groundwater sources combined with low rainfall over many years has affected areas such as California and its citrus fruit growing industry and Arizona.

WATER COOLING

Water cooling is a method of heat removal from equipment or processes. Water cooling is commonly used for cooling large industrial facilities such as electric power plants, petroleum refineries and chemical plants.

Other uses include cooling purposes in heat exchangers, cooling products from tanks, fractionating or condensing columns.

In a cooling tower the main mechanism for water cooling is to allow process cooling water to fall from a height through an updraft of air; the water temperature is reduced by a combination of heat conduction and evaporation of water to the air.

The cooled water is then returned to the process and the cycle is repeated continuously. Water is treated to kill bacteria and to control corrosive effects; make-up water to replace that evaporated is usually taken from a water source close to the tower; typical volumes of water abstracted are of the order of one million gallons (4540 cubic meters) per day.

Industrial cooling towers may use river water, coastal water (seawater), or well water as their source of fresh cooling water. This can deplete local water sources.

Water cooling towers produce large amounts of steam, and some children refer to them as cloud factories. This is partly true. It should be noted that this is clean water vapour but large towers can affect local areas by creating "micro-climates". Water vapour is also a global warming gas.

Another source of pollution from cooling processes is that warmed water was historically discharged to rivers, making them warmer.

Combined with high organic levels from sewage this was often highly beneficial for the fish and other aquatic animals who moved to a four-season breeding season, however this greatly increased pollution from fish faeces. In the UK this activity has now been stopped.

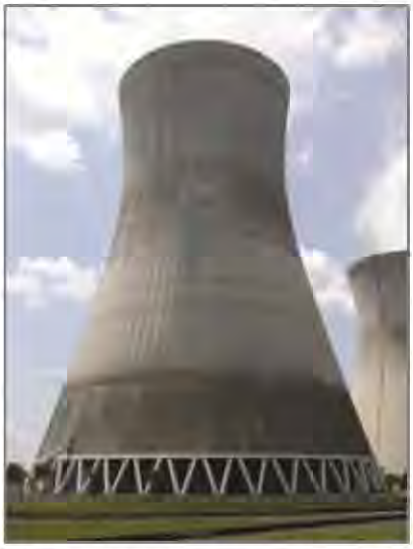

Figure 1-76: Coal (fossil fuel) fired power station cooling water tower. *Source: Globalspec.com.*

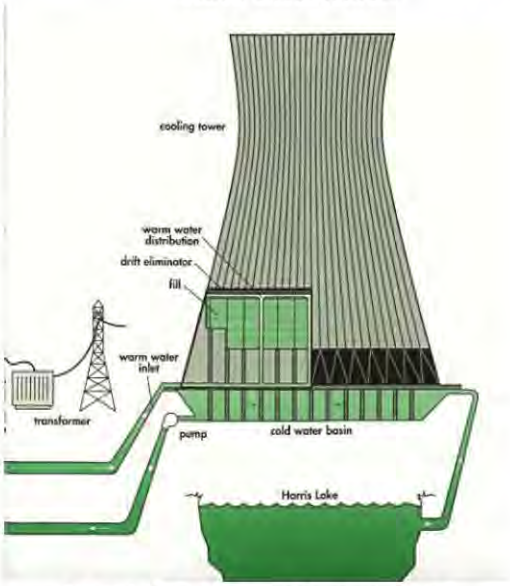

Figure 1-27: Cooling water tower schematic. *Source: Powerplantstechnology.co.uk.*

WATER SHORTAGES AND SCARCITY

Globally, as of 2021 the world's population is 7.9 billion with the UN forecasting 8.6 billion in 2030 and 9.8 billion in 2050.

The United Nations Water Programme estimate that around 1.2 billion people, or almost one-fifth of the world's population, live in areas of scarcity. Another 1.6 billion people, or almost one quarter of the world's population, face economic water shortage. With the existing climate change scenario, by 2030, water scarcity in some arid and semi-arid places will displace between 24 million and 700 million people.

This is coupled with a forecast that by 2025 the demand for freshwater is expected to rise to 56 per cent more than the amount that is currently available. *[Source: UN Water – Water Scarcity]*

Figure 1-28: African Union peacekeepers distribute water to internally displaced people in Mogadishu, Somalia. *Source: Associated Press.*

Geothermal energy can be exploited by the use of ground-source heat pumps (GSHPs). The heat is either collected through a series of underground pipes laid about 1.5m below the surface, or from a borehole system. Borehole systems, involving drilling a pipe 50m+ into the ground are in use in the UK in Cornwall and Newcastle-upon-Tyne.

In both of these options, water is re-circulated underground via a closed loop pipework system and delivered to the heat pump. The heat pumps, which can range from a few kW to many hundreds of kW, provide heat for buildings. GSHPs can also be driven in reverse to provide comfort cooling, a process called adiabatic cooling (this is how refrigerators work). A 5-10kW GSHP system would be large enough to heat a small office.

BENEFITS

Geothermal power generation (energy from the ground) is favoured as an alternative to fossil fuels and it provides a continuous source of renewable energy with a similar output to that of coal generators.

- In the case of thermal springs, the operating costs are low.
- In the case of ground sources, whilst the costs of extraction may be quite considerable this cost will be compensated three or four times over by the energy gained.
- Carbon emissions are low (input energy needed to drive heat pumps etc.)

LIMITATIONS

- The feasibility of borehole GSHPs depends on the geological conditions at the site.
- Ground loops require the correct ground conditions and require land area, though if the building has a large car park or landscaped areas the pipes can be laid unobtrusively underneath.
- Connecting a GSHP into an existing heating system is often constrained by the requirement of the existing system to operate at temperatures higher than that delivered by the GSHP, though it can provide beneficial pre-heating of water or air to reduce the energy demand on the main heat generating system.
- GSHPs are generally best suited to new-build projects, where they can be included in the building design, as retrofitting can be expensive.
- There is an initial high capital cost of installation of ground source systems due to drilling of boreholes etc.
- Geothermal wells tend to release greenhouse gases trapped deep within the earth, but these emissions are much lower than those of conventional fossil fuels.

Source: Carbon Trust (Modified).

Air source heat pumps

Air source heat pumps takes the small amount of heat from the air and turns it into large amounts of heat. IT should be remembered that Absolute Zero is minus 273ºC, or Zero Kelvin, so even on an icy 0ºC day there is still a great deal of energy in the air.

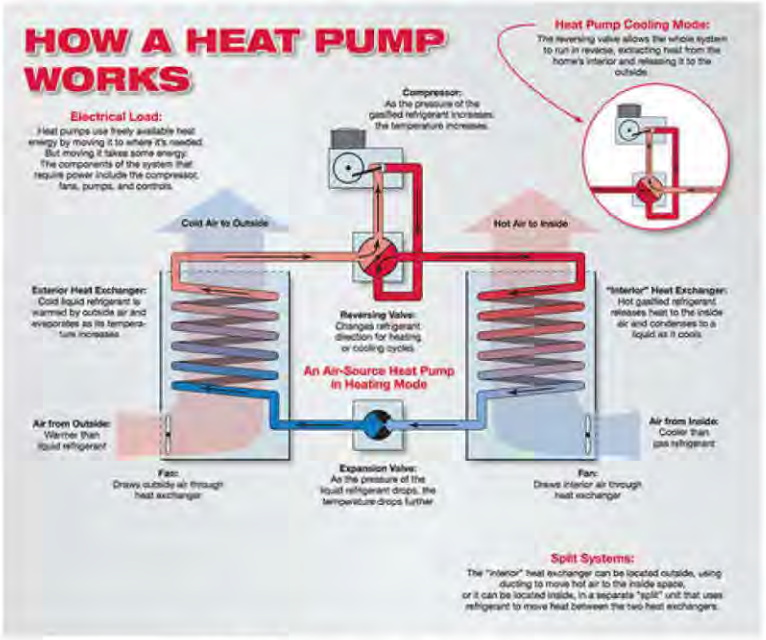

Figure 8-11: How a heat pump works.
Source: www.buildinggreen.com

Figure 8-12: Heat pump and pre-plumbed cylinder.
Source: Samsung.

To enable the EU to move towards a low-carbon economy and implement its commitments under the Paris Agreement, the EU have a set of binding legal climate and energy targets, set in packages, based on a 1990 baseline:

Period	*2010-2020*	*2021-2030*	*Target 2050*
Cut in Greenhouse Gas Emissions	20%*	40%	Climate Neutral
Renewable Energy Generation	20%	32%	Climate Neutral
Energy Efficiency Improvement	20%	32.5%	-

*(at 2017: 22% achieved whilst economy grew 58%)

In the UK the Climate Change Act 2008. Amended 2019, commits the UK to reductions in CO_2 emissions of at least 26% by 2020 and a long-term goal of an 100% reduction (carbon neutral) by 2050. At 2018, the UK had achieved 41% below 1990 levels.

Unfortunately, at the time of writing, whilst EU emissions targets for 2020 have been achieved they are now flat-lining, but emissions in China, India and all other countries are rapidly rising, and global carbon emissions have increased since the 1990 baseline from 22 billion tonnes to 38.1 billion tonnes, with 6% rise in emissions in 2018 alone.

UK Government Net Zero Strategy

In 2018 the UK published the UK Government Net Zero Road Map which provides a high-level summary of what each sector has to do to achieve net zero.

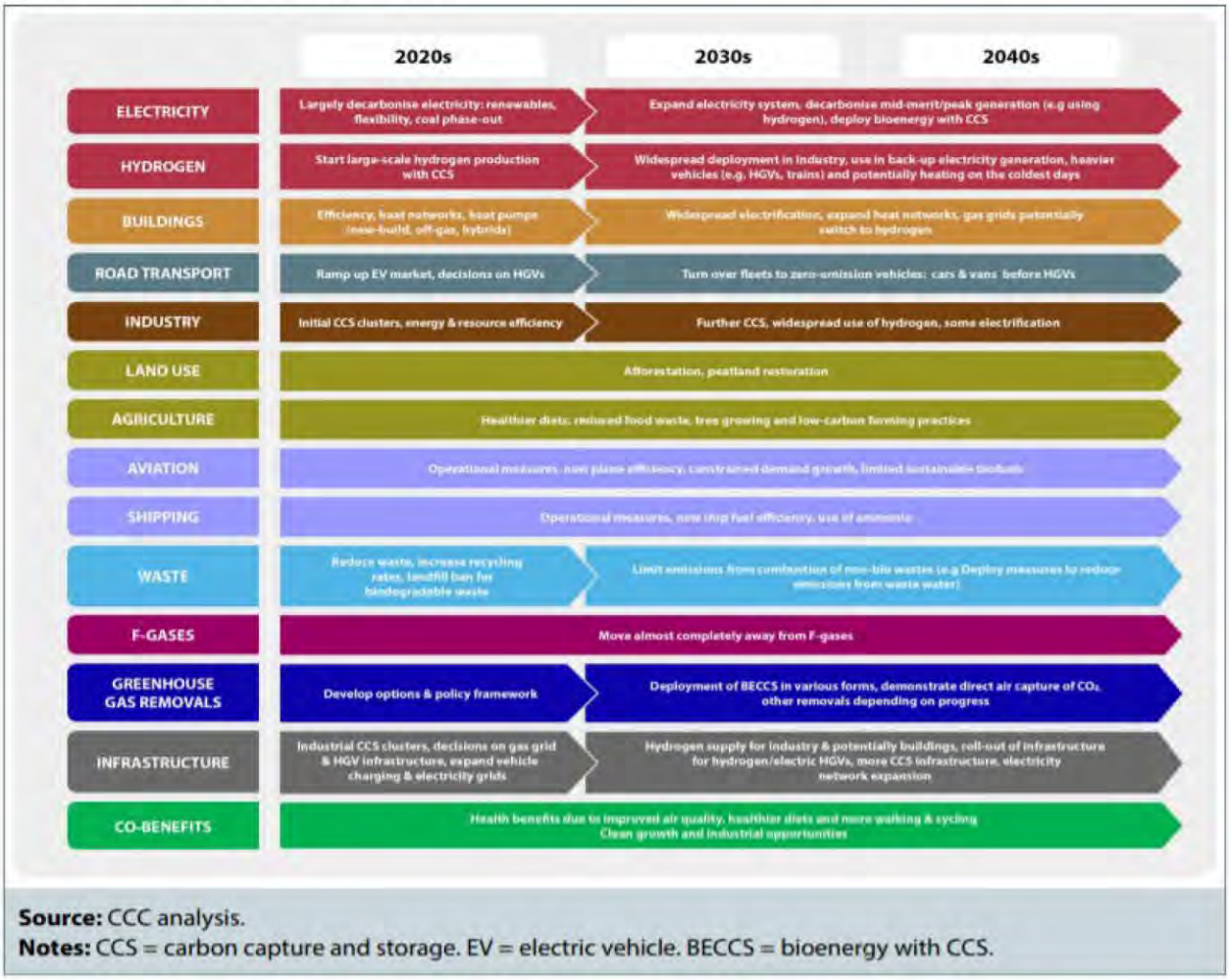

Figure 8-14: UK net-zero GHG scenario. Source: UK Government.