Path towards Decarbonisation: UK Perspective

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Decarbonisation refers to the process of reducing carbon intensity. Generally, this involves decreasing carbon dioxide output per unit of energy generated. Reducing carbon dioxide emissions emerging from transport, power generation and other sectors of the economy is essential to meet global temperature standards set by the Paris Climate Agreement. This essay paints a picture of identifying the fundamental challenges concerning the current causes of greenhouse gas (GHG) emissions, potential opportunities for harnessing technologies to overcome the challenges and how science diplomacy and appropriate policy response can play a part in the UK context.

Current Emission

The Intergovernmental Panel on Climate Change (IPCC) has concluded that the current global warming trend has unequivocally been due to human activity. Rapid industrialisation and global growth have increased GHG emissions, particularly carbon dioxide, in the atmosphere at an alarming rate.[1] In addition to the IPCC, other research[2] shows that the first half trillion tons of carbon burnt in the last 250 years. On current trends, the next half trillion will be released into the atmosphere in less than forty years. An analysis of the National Oceanic and Atmospheric Administration (NOAA) indicates that the global average atmospheric carbon dioxide was 414.72 parts per million (ppm) in 2021, setting a new record high despite the continued economic drag from the COVID-19 pandemic. Data from NOAA[3] further suggests that the amount of carbon dioxide in the atmosphere (See green line Figure 1) has increased along with human emissions (grey line) since the

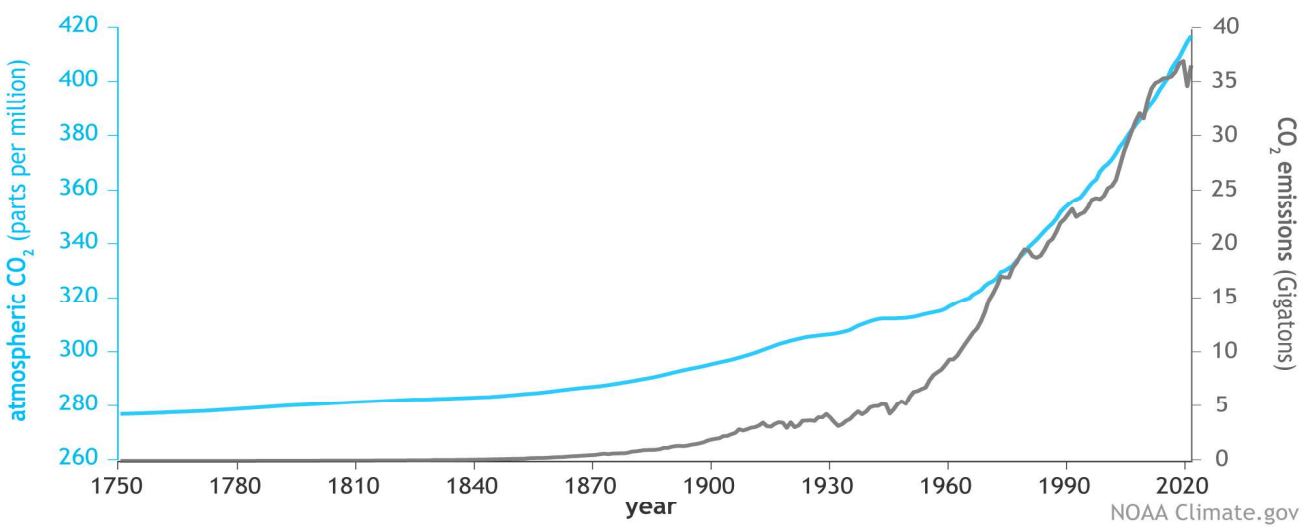


Figure 1. Atmospheric Carbon dioxide amount and emission trend (1750-2021) (Source: NOAA Climate.Gov graph 2022)

start of the Industrial Revolution in 1750. Emissions rose slowly to about 5 billion tonnes per year in the mid-20th century before escalating steeply to more than 35 billion tonnes per year by the end of the century.

In comparison with the global trend shown above, the UK's cumulative carbon dioxide emissions[4], which represent the total sum of carbon dioxide emissions produced from fossil fuels and cement production since 1750 (measured in tons), can be seen in Figure 2. It did not include land use change. However, a steep rise in emissions can be noticed clearly by the end of the last century.

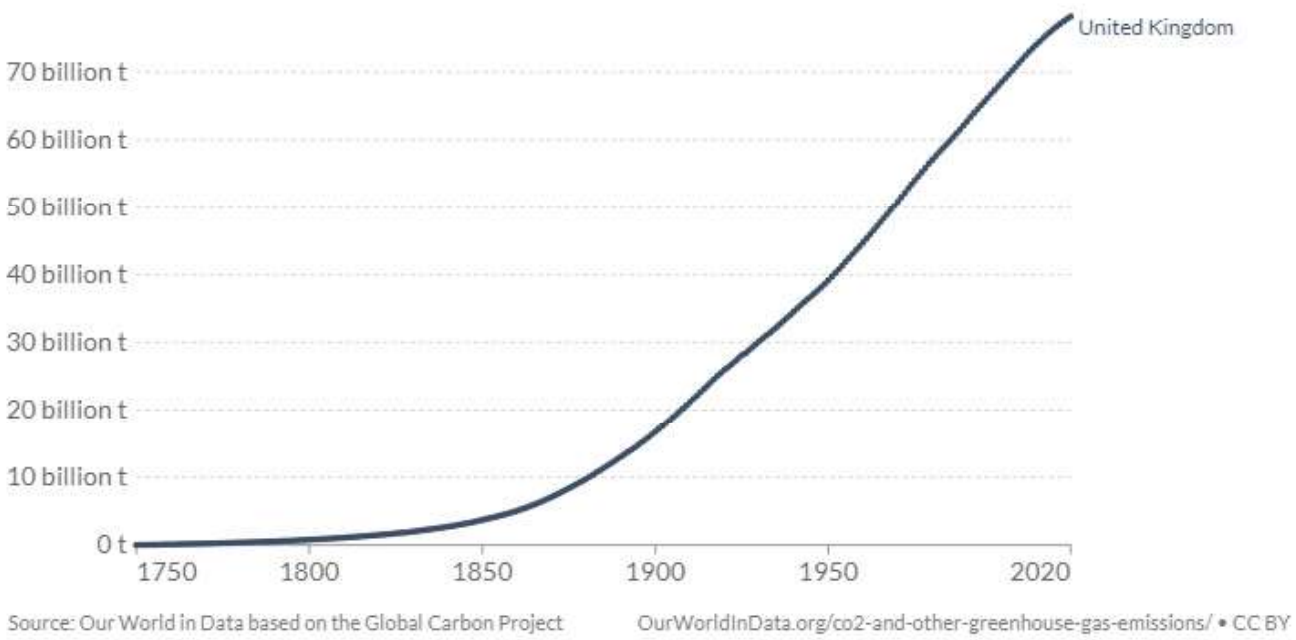


Figure 2. Cumulative carbon dioxide emission in the UK since 1750 (Source: Global Carbon Project 2021)

Among the GHGs, carbon dioxide accounts for three-quarters of the warming impact of emissions. It is the most persistent GHG, with a significant proportion of carbon emitted today remaining in the atmosphere for a century. The analysis of the interaction of carbon emissions and temperature rise over the century demonstrates that the pace of global warming is approximately proportional to the amount of carbon dioxide in the atmosphere. Such calculations mean we can estimate our carbon budget. The size of the carbon budget depends on (a) the temperature outcome and (b) the degree of uncertainty.

Currently, industrial processes account for 32% of emissions. It includes different production processes, such as the production of manufactured goods. Emission from buildings, such as the use of energy for electricity and heat generation for buildings, accounts for 18% of emissions. 16% of current emissions emerge from transport, which comprises energy used by cars, heavy goods vehicles, shipping and the aviation industry. 11% of current emissions pour from energy generations, this involves the production and supply of energy, and 10% of current emissions emanate from food and agriculture.[5]

Challenges

When the amount of carbon added to the atmosphere is greater than the amount removed, the level of carbon dioxide in the atmosphere increases. To keep temperature rise below 1.5 degrees Celsius, we must reach the net zero - the balance where carbon emitted and taken out of the atmosphere are equal. The IPCC estimates[6] that for achieving a 1.5 degrees Celsius target, the net carbon dioxide emissions would have to be reduced by up to 50% by 2030 on 2010 levels and reach a net zero level by around 2050. For a 2-degree Celsius limit, net zero emissions need to be reached soon afterwards. In addition, it would also require the depletion of other GHGs emissions, such as methane and black carbon, that remain in the atmosphere for shorter periods.

The biggest hurdle is that this transition would require extensive emission reductions from all sectors of the economy. Even if emission reduction is possible, carbon dioxide removal (CDR) is also required

to reach net zero. In the power sector, further, development is needed for renewable energy storage and smart systems, carbon capture and storage (CCS) infrastructure and CDR methods. In the transport sector, increased efficiency and electrification of vehicles, the potential use of hydrogen fuel cells in vehicles, alternative fuels in aviation and shipping along with behavioural changes to reduce demand are desired. In agriculture, forestry and land use sectors, human diet change leading to reduced livestock numbers and associated methane emissions, increased soil carbon storage, afforestation, restoration of wetlands to store more carbon and decreased mineral nitrogen fertiliser use are essential. In the industrial sector, shift to low, zero or negative carbon emissions, for example, by using carbon-negative building materials (wood, carbonated aggregates), capturing carbon dioxide from cement manufacture, and usage of alternate heat sources such as hydrogen is required.

In residential and commercial buildings, improved insulation, utilisation of heat pumps and potential use of hydrogen to replace natural gas are preferred. In this aspect, one of the UK's biggest challenges is to decarbonise around 30 million existing buildings. Many of these are old, poorly insulated, and have carbon-based energy supplies. Even though renewable energy production has increased, there are some critical challenges, such as political barriers and the lack of policies and regulations for redeveloping existing buildings using renewable energy technologies.

Further, research and planning for the application of a suite of CDR methods are essential. In the waste sector, increased reuse and recycling, banning wastes containing biodegradable carbon from landfill and capturing methane gas are vital. Some important policies and strategies need to be adopted soon to implement the sector-wise decarbonisation process.

Net zero strategy in the UK has recently faced a legal challenge. On 18 July 2022, High Court ruled following a judicial review brought by Client Earth, Friends of the Earth and the Good Law Project that the government's net zero strategy was unlawful.[7] It was ruled illegal in two ways: First, not enough information to know that supporting nuclear power stations through this strategy would enable carbon targets to be met. Second, it failed to offer sufficient details on how many individual policies would cut emissions. These are the obligations under the Climate Change Act 2008. The net zero strategy will remain a government policy, and it has not been quashed, but the court ruling has posed a new dimension and a difficult task for the government. It could be a learning curve for India as well. The general principle is that any decarbonisation strategy should have due regard to the obligation of the relevant climate change act. Currently, the Climate Change Committee found that only 39% of the emissions cut are backed by credible policies. The policy response is also necessary for other challenges, such as the climate change impacts outside the geographical boundary. It could negatively affect UK trade and food supply and increase migration due to displacement and conflict in severely affected regions.

We need to understand our carbon emission output. If we seek to predict the trajectory of the carbon emissions output, there are four main components which will drive it according to the Japanese economist Yoichi Kaya[8], derived from the earlier work expressed by Paul Ehrlich of Stanford and John Holdren of Harvard, respectively and also referred by William Nordhaus.[9] The four components are population, per capita income, watts of energy required to produce a pound of income (energy intensity) and the carbon intensity of the energy required to produce a watt. This formula can be adapted for the UK as below:

Carbon dioxide emissions= Population X (Pound/Person) X (Watts/Pound) X (Carbon/Watts)

The population might drive energy demand, which leads to carbon emissions. It is unwarranted to control population growth for the sake of climate change mitigation. Per capita income is a variable and is tough to manage because everybody wants to be rich. So, population and economic growth are working against our climate goals. The third term in the above equation is the amount of energy required to produce a pound of income, which is crucial and should move in the right direction. The amount of energy required to produce a pound of income in a service economy is much lower than in a heavy industry economy. The fourth term is the amount of carbon emitted to produce each watt of energy. The third and fourth terms are related to energy intensity and carbon intensity, which we shall have to manage. But the challenge here

is that the energy intensity of the economy and the carbon intensity of the energy mix needs to fall faster than the population and per capita income rise. It is a challenge for both UK and India. The International Energy Agency predicts that global energy-related carbon dioxide emissions will increase between now and 2040.[10] The above equation also suggests that the main driver of GHG emissions is economic growth. With no growth, temperatures would likely stay within 2.5 degrees Celsius by 2200.[11]

Technology for Decarbonisation

To decarbonise economies and overcome some of the challenges mentioned above, we require better technologies to achieve the goal. Bill Gates[12] put forward a list of technologies to achieve this goal, as follows: Hydrogen production without emitting carbon; Grid-scale electricity storage that can last a season; Electrofuels; Advanced biofuels; Zero carbon cement; Zero carbon steel; Plant and cell-based meat and dairy; Zero carbon fertiliser; Next generation nuclear fission; Nuclear fusion; Carbon capture, both direct and point capture; Underground electricity transmission; Zero carbon plastics; Geothermal energy; Pumped hydro; Thermal storage; Drought and flood tolerant food crops; Zero carbon alternatives to palm oil; Coolants that don't contain F-gases.

In UK, a review of options and costs for removing oil, coal and gas for electricity production has been carried out recently.[13] According to the UK-based Centre for Alternative Technology, if we swap fossil fuels for home solar panels, we need 49 million 3.5 kilowatts (kW) solar panel systems. The cost for it is 296 billion pounds. If we swap fossil fuels for wind turbines, we need around a total of 37000 offshore and onshore wind turbines and installing them would cost 72 billion pounds. If we swap fossil fuels for nuclear reactors, we need 14 nuclear plants, and its estimated cost is 77 billion pounds. These statistics are based on the UK's demand and existing supply of energy. The change in nuclear technology can reduce both the building cost and the waste problem of a nuclear plant. Lately, all nuclear power stations use the intense heat of an atomic reaction to create steam to drive a spinning turbine to generate electricity. The most common are pressurised water reactors (PWR). Recently, a new technology, molten salt reactor (MSR), has been unveiled. MSR has been built in Canada with a whopping cost of around 1.2 billion dollars, which is approximately five times cheaper than PWR. In this reactor, the radioactive elements, such as uranium or thorium, are held in a liquid sodium chloride solution. Molten salt also cools the core and transfers the heat into steam to drive turbines. Its great advantage is that it remains liquid at higher temperatures without pressurised containment and creates far less radioactive gas.

The technologies mentioned above that we need to meet net zero are not enough and require new policies so that we can demonstrate and deploy those inventions in the market as fast as possible.

The Implication of Decarbonisation for UK Policy

UK Climate Change Act 2008 has put in place legally binding emissions reduction targets and a framework for climate change mitigation and adaptation. Under the Act, the Committee on Climate Change was charged with advising on targets and carbon budgets and monitoring progress.

The UK's domestic emissions have decreased by about 40% from 1990, mainly due to a reduction in emissions from power generation. At the same time, Gross Domestic Product has grown by around 70%, and emissions arising from its consumption of goods and services, including those associated with imports, remain significantly higher than the 1990 level.

The Committee on Climate Change's 2022 Progress Report[14] concluded that the UK is not on course to meet its five-year carbon budget after 2022, and progress on reducing emissions from transport, buildings and agriculture are chief concerns. The report suggests that 'The Net Zero Strategy contained warm words on many of the cross-cutting enablers of the transition, but there has been little concrete progress'. The report also added, 'There remains an urgent need for equivalent action to reduce demand for fossil fuels to reduce emissions and limit energy bills'.

However, the UK is demonstrating leadership in the technologies required to reduce emissions and remove carbon dioxide from the atmosphere and offers a range of strategic and commercial opportunities.

Such actions could stimulate sectors of the UK economy working on green growth, including wind and solar power, advanced batteries and energy storage, electric vehicles, hydrogen, carbon capture and storage, and CDR technologies. According to the Office for National Statistics, the low carbon and renewable energy sectors are growing about three times faster than the wider economy in recent times.

Decarbonisation of economies would further reduce risks, such as river and surface water flooding from heavy rainfall, coastal flooding and erosion from sea level rise; higher temperatures, including effects on well-being; water shortages; impacts on the natural environment such as further declines in native wildlife, decreased soil quality, reduced traditional fish stocks; spread of invasive pests and diseases.

At a recent COP26 meeting, the UK proposed five themes for climate change action. These are adaptation and resilience for societies against climate change; nature-based solutions to protect ecosystems; ending reliance on fossil fuels; transitioning to electric vehicles; increasing investment in sustainable infrastructure, and greening finance. However, implementation of such actions has policy implications and requires science diplomacy to see its fruition globally.

Science Diplomacy and Policy for Decarbonisation

More science is essential, but science alone is not enough to either guarantee alternative technology for decarbonisation or determine where unconventional local technology should be harnessed. The policymaking organisations must listen and be responsive to new science. Policymakers also need to ensure that, as policy evolves, they are adequately enforceable. When an environmental policy builds on careful science and rigorously analysed data and facts, it can be pursued without fear of upsetting interested parties or overturning prevailing wisdom. However, science diplomacy can lead to an innovative solution. Science diplomacy can focus on scientific solutions, expertise, resources and tools for an international effort to solve environmental problems.[15] It has been viewed that all three dimensions of science diplomacy[16]: science in diplomacy, diplomacy for science and science for diplomacy are vital for scientific, technological and global as well as national level policy response to climate change.

A balanced and rational climate change policy must focus on both aspects, what is known and what is unknown about climate change and its impacts. A balanced policy considers two types of possible errors when chosen under uncertainty. The first type of error is known as 'false negative'. This error means a government fails to regulate when, in fact, there is a risk of serious and irreversible harm. The second type of error is called a 'false positive'. This error means a government decides to regulate a risk that is not realised. When we adopt a policy for a decarbonised economy based on the precautionary principle, we primarily focus on the cost of a false negative. On the other hand, a policy based on false positive error is a decision to regulate that turns out to have been wrong, in the sense that the probability or magnitude of harm was smaller than believed. These need to be examined carefully during the policymaking process.

Conclusion

The UK government has accepted the Climate Change Committee report. It means that low-carbon investment must scale up to £50bn a year in the UK. It has been recognised that the energy supply companies, transport, and the Built Environment, as a whole, need radical change. Parallelly, the restoration of nature is also critical. We have forgotten nature's paramount role in climate change mitigation, resilience, and adaptation. Many examples demonstrate how natural habitats such as peat, woodland and seagrass can absorb massive amounts of carbon. So, nature can play a vital part in the decarbonisation process.

More than 90 years ago, Thomas Edison, the inventor of the light bulb, said to Henry Ford, the owner of Ford Motor Company and Harvey Firestone, the manufacturer of the tire, partially made from oil, 'I would put my money on the sun and solar energy. What a source of power. I hope we don't have to wait until oil and coal run out before we tackle that.[17] Edison's motivation for harnessing renewable energy is very pertinent today. Bringing this within the environmental policy framework and using science diplomacy as a tool for climate decision-making should be a norm now.

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