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Is It Possible to Fully Decarbonize the Global Supply of Energy by 2050? The Role of Energy Efficiency, Renewables and Nuclear Power

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Introduction

Many countries are beginning to take the need for a green industrial strategy more seriously, as the human effects of climate change become more apparent. The European summer heatwave of 2003 contributed to at least 70,000 deaths across the continent, and such extremes of heat in summer are expected to become more frequent by the 2040s. at the current rate of climate change. If no action is taken, it is predicted that we will see severe impacts at 3ºC of warming. For example, in the UK, a sea level rise of 0.83 metres would be predicted (1) , river flooding would cause twice as much economic damage and affect twice the number of people it does today (2), and by 2050, up to 7,000 people would die from the effects of heat, compared to around 2,000 at the present time (3). The WHO predicts that between 2030 and 2050, climate change is expected to cause approximately 250 000 additional deaths per year, from malnutrition, malaria, diarrhoea and heat stress. The direct damage costs to health (i.e. excluding costs in health-determining sectors such as agriculture and water and sanitation), is estimated to be between USD 2-4 billion/year by 2030 (4).

Given these findings, which will impact the most vulnerable of our populations, inaction would appear not to be an option for democracies that pride themselves on social justice. So how do we mitigate the effects of climate change, yet retain our industrialised societies?

The Role of Energy Efficiency

Energy efficiency can reduce green house gas (GHG) emissions, both directly from reducing fossil fuel consumption, but also indirectly from changes made to the way in which energy is generated. However, many of the methods used to increase efficiency require the public to make changes in the way that they use energy, for example switching from the use of gas boilers in homes, to electric boilers or installing heat pumps, or increasing insulation in homes. These changes will come at a cost to householders, and at a time of economic stress due to the recent pandemic, household budgets are likely to be under some considerable stress. Provision of government grants may be used to encourage individuals to make their lives more sustainable, but these rarely cover the full cost. It can be demonstrated that energy efficiency can make a difference – improvements in energy efficiency resulted in a 12% reduction of CO_2 emissions between 2000

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and 2017. Energy efficiency in the industrial sector can also be shown to be of value – for example, producing metals like steel, aluminium and copper from recycled scrap is 60-90% less energy intensive than production from metal ores (5).

The Role of Renewables

Most people would expect that the recent growth in renewables, primarily wind and solar power, has played and will continue to play a role in reducing GHG emissions. Whilst it is certainly true that solar and wind produce substantially less GHG in their life cycle than fossil fuels (5), the evidence from Germany's Energiewende policy suggests that this is not the whole story. This policy, at a cost of 160 billion Euros to consumers and government, has seen a very impressive effort to increase the production of electricity using wind power, which now generates 40% of the country's electricity. However, Germany's GHG emissions have not declined less rapidly than expected. This is due in part to the fact that both wind and solar are intermittent sources of energy, and with the German reluctance to use nuclear power, coal, oil and gas power stations have been required for the production of baseload electricity.

In addition, solar and wind are not a solution for all countries. Offshore wind is a valuable source for countries such as the UK, whereas in other areas such as Japan, it is even less of a realistic option. Much of the public focus has been on how to generate electricity in a more climate friendly manner, the reality is that the most difficult sectors of all to decarbonise are heavy industry and transport. In these areas cleaner energy sources are required – particularly hydrogen. Hydrogen generation requires provision of large amounts of reliable energy. Although renewables are favoured by the general public, they have inherent problems with regard to the amount of land required. A recent report (6) has estimated that to replace the UKs current oil consumption with hydrogen generated using offshore wind would require 120 km^2, or with solar PV 26,000 km^2. In contrast the amount of land required using advanced heat sources i.e. nuclear was considerably smaller i.e. 55 km^2. Energy density may be seen as being of particular importance for island nations.

The Role of Nuclear Energy

Whilst both energy efficiency and renewables offer small steps towards the solution to climate change, nuclear could potentially offer a step change in climate change mitigation. The ideal energy source is one that requires smaller amounts of land in order to generate substantial amounts of consistent energy, that could be used both to generate power for a variety of purposes, domestic and industrial, including generation of hydrogen. Nuclear power has the potential to meet all of these criteria, but lacks the general societal acceptance of renewables. In addition, more flexibility will be required of nuclear power. It should no longer be seen in terms of generating only baseload electricity.

There is no doubt that future nuclear power systems will be required to work with an energy system that includes intermittent energy produced by renewables. Any developments in nuclear power would therefore need an inbuilt flexibility to supply energy to the grid when renewables were off line, but in the interests of using energy efficiency, to be able to supply power for other uses when the need for electricity generation was met by the use of renewables.

Heating and transport are the largest energy users and these two areas may be particularly difficult to decarbonise using electricity. Nuclear reactors produce heat on a vast scale – a typical nuclear power station produces heat that is equivalent to the output of a 100,000 domestic gas boilers. A recent report from the Royal Society (7) points out that there are two key issues that impact the utility of nuclear at present: it is most economic when run at high output, and 65% of the energy produced is lost as waste heat. In the past, some of this heat has been used to heat co-localised infrastructure, for example the UK's first nuclear plant, Calder Hall, supplied building heat for Calder Hall itself and nearby Sellafield. The Agesta reactor in Sweden supplied heat to Farsta, a suburb of Stockholm, and the Chinese have recently built a pilot nuclear reactor to heat districts in the colder northern regions of the country. Heat from nuclear reactors has also been used to power co-localised industry – for example the Wylfa power station in North Wales was used to provide power for an aluminium smelter.

Low temperature heat generated from conventional nuclear reactors could be used therefore to heat homes in the local area, which would increase energy efficiency. However, the high temperature heat generated from the newer Generation IV reactors would be better suited to drive hydrogen production, which in turn could be used to decarbonise the "difficult to reach" transport sectors such as aviation, heavy-duty vehicles and shipping.

Barriers to Capitalising on Nuclear's Potential to Decarbonise

There are a number of barriers that need to be overcome in order for nuclear to realise its potential as a major player in decarbonisation strategies. Firstly, it needs to be accepted by the general public as a safe, secure and economic method of producing energy. Improving its energy efficiency, and using the currently wasted heat it produces will potentially increase its economic viability. The move to using small modular reactors may reduce some of the public concern regarding having a very large infrastructure project built in their back yard. However, co-localising of a nuclear power plant with an industrial process plant may prove challenging from both a public and planning perspective. Such developments would provide stable employment of a skilled workforce for decades – in the case of nuclear maybe two or three generations, which is a bonus for community cohesion.

There is no doubt that reaching our climate goals will be challenging, but there is an ethical intergeneration obligation on us to do so. Energy efficiency, renewables and nuclear power all have a role in meeting this obligation. We do have the tools necessary to do this, but the question is do we have the political will and sense of societal responsibility to take some difficult decisions, before it is too late?

〈References〉

1: Figure based on RCP4.5 projection for London from the UKCP18 Marine Projections. Projections for RCP6.0 (a 3°C scenario) are very similar and not reported for this reason in UKCP18 (see UKCP18 Overview Report, and Chapter 13, IPCC Fifth Assessment Report, Working Group 1). https:// www.metoffice.gov.uk/pub/data/weather/uk/ukcp18/ science-reports /UKCP18-Overview-report.pdf

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Writer's Profile

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Prof. Gerry Thomas is Professor of Molecular Pathology at Imperial College London and the Director of the Chernobyl Tissue Bank (CTB). The CTB was established in 1998 to facilitate research, in cooperation with Belarussian, Ukrainian and Russian scientists, into the biological mechanism that are involved in development of thyroid cancer following a nuclear power plant accident. Since the Fukushima accident in 2011, she has been engaged in public communication of the real health risks of energy production, including exposure to low doses of radiation from nuclear accidents.