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Oil, Gas & Energy Law Intelligence

Covid-19, Climate Change and the Role of Nuclear Power in the Transition to Renewable Energy Sources to Achieve Carbon Neutrality by 2050

by D.M. Ong

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Covid-19, Climate Change and the Role of Nuclear Power in the *Transition* to Renewable Energy Sources to Achieve Carbon Neutrality by 2050

By David M. Ong[∂]

Abstract

Two significant phenomena have arguably combined to herald a potentially opportune moment for the nuclear industry. These phenomena are first, the global, Covid-19 pandemic that may have at least in part been due to the second phenomenon, namely, the ongoing climate change crisis. While pre-dating the advent of the pandemic, the climate change crisis (or emergency) is increasingly seen as inextricably linked to the pandemic's arrival, both as a partial environmental cause for this species-jumping disease, as well as presenting an opportunity to re-set the global energy source mix. In light of these significant current events, this essay will examine the prospects for a revival of investment in the (civilian) nuclear power industry from a combination of scientific, economic, policy and legal perspectives. In doing so, it hopes to highlight the continuing viability of the nuclear industry in a post-Covid world, transitioning towards carbon neutrality.

Introduction

Two significant phenomena have arguably combined to herald a potentially opportune moment for the nuclear industry. These phenomena are first, the global, Covid-19 pandemic that may have at least in part been due to the second phenomenon, namely, the ongoing climate change crisis. While pre-dating the advent of the pandemic, the climate change crisis (or emergency, as it is now increasingly regarded) is increasingly seen as inextricably linked to the pandemic's arrival, both as a partial environmental cause for this species-jumping disease,[1] as well as presenting an opportunity to re-set the global energy source mix.[2] In light of these significant events, this article will examine the prospects for a revival of investment in the (civilian) nuclear power industry from a combination of scientific, economic, policy and legal perspectives. In doing so, it hopes to highlight the continuing viability of the nuclear industry in a post-Covid, carbon neutral world.

Background: Climate Change and Increasing Propensity for Pandemics

It is increasingly possible to see the global public health emergency caused by the Covid-19 pandemic as merely a harbinger for continuing human-induced, climate change-related, disruption on a global scale. Weakening ecosystem resilience due to changing weather patterns and natural habitat loss from land clearances have combined to bring humans ever closer to wildlife, enabling pathogens of the type held to be responsible for the present pandemic to jump from animals to humans. Prospects for such proximity-based, zoonotic transmission will tragically only improve given current climatic trends. The (hopefully) relatively short-term

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[1] See, for example, 'Forest loss raises chances for viruses to leap from animals to humans', by Catrin Einhorn, *New York Times (NYT)* newspaper, International Edition, 13 April, 2020 at 6.

[2] See, for example, 'The Covid-19 fight opens a climate opportunity', *Financial Times* (UK) newspaper leader, 16/17 May, 2020, at 8.

shock of the pandemic will very soon give way to a continuing series of medium to longer term climate change crises. Foremost among these climate change-related challenges is the possibility of more pandemics due to rising incidences of unexpected encounters between normally reticent wildlife and encroaching human populations. A further source of possible future strife lies in forced human migrations resulting from the growing propensity and severity of climate change-induced extreme weather events, both within and across national borders.[3] While the advent of the pandemic was not precisely forecast, and nor will future climate change-related extreme weather events, these phenomena have nevertheless been predicted, and are increasingly expected to occur by experts in the relevant fields.

In relation to the global public health emergency that Covid-19 has spawned across the world, the authoritative *Statement on the State of the Global Climate in 2019* by the World Meteorological Organization (WMO), [4] one of the two co-founders (alongside the UN Environment Programme - UNEP) of the Inter-governmental Panel on Climate Change (IPCC) notes that: 'Climate-related events already pose risks to society through impacts on health, food and water security as well as human security, livelihoods, economies, infrastructure and biodiversity. … Health effects include heat-related illness and death; injury and loss of life associated with severe storms and flooding; *occurrences of vector-borne and water-borne diseases*; exacerbation of cardiovascular and respiratory diseases through air pollution; and stress and mental trauma from displacement as well as loss of livelihoods and property.' [5] *(emphasis added)* While suspected climate change-related individual weather disasters pre-date the advent of the Covid-19 pandemic, the World Health Organization (WHO) has noted that: 'Changes in infectious disease transmission patterns are a likely major consequence of climate change.'[6] Specifically, the loss of natural habitat (at least in part due to such global environmental change) is increasingly seen as inextricably linked to the 'species-jumping' nature of this affliction.[7] The most recent WMO Statement confirms the twin impacts of climate change and the Covid-19 pandemic upon a significant proportion of the global population: 'In 2020, over 50 million people were doubly hit – by climate-related disasters (floods, droughts and storms) and by the COVID-19 pandemic.'[8]

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[3] For example, the results of a recent survey 'indicate that climatic conditions, by affecting drought severity and the likelihood of armed conflict, played a significant role as an explanatory factor for asylum seeking in the period 2011–2015', especially for countries that were affected by the Arab Spring. See: Guy J. Abel, Michael Brottrager, Jesus Crespo Cuaresmac, Raya Muttarak, 'Climate, conflict and forced migration', *Global Environmental Change*, Vol.54 (2019) 239–249, at 239 & 240.

[4] See: *WMO Statement on the State of the Global Climate in 2019*, WMO-No.1248 (2020), published: 10 March, 2020. 44pp. Accessible at: https://public.wmo.int/en/media/press-release/multi-agency-report-highlights-increasing-signs-and-impacts-of-climate-change

[5] *Ibid.,* at 28.

[6] See: WHO, Chapter 6: Climate Change And Infectious Diseases, by J. A. Patz, A. K. Githeko, J. P. McCarty, S. Hussein, U. Confalonieri, N. de Wet, in *Climate Change and Human Health – Risk and Responses*, ed by Muttra A.J. McMichael, D.H. Campbell-Lendrum, C.F. Corvalán, K.L. Ebi, A. Githeko, J.D. Scheraga and A. Woodward, WHO (2003) Full book available online at: https://www.who.int/globalchange/publications/cchhbook/en/
Quoted extract from Summary, 16-17, at 17. Accessible at:
https://www.who.int/globalchange/summary/en/index5.html

[7] See, for example, 'Forest loss raises chances for viruses to leap from animals to humans', by Catrin Einhorn, *New York Times (NYT)* newspaper, International Edition, 13 April, 2020 at 6.

[8] See: *WMO Statement on the State of the Global Climate in 2020*, WMO-No.1264 (2021) at 39, accessible at: https://library.wmo.int/doc_num.php?explnum_id=10618; citing the International Federation of Red Cross and Red Crescent Societies, accessible at: https://media.ifrc.org/ifrc/wp-content/uploads/2020/11/20201116_WorldDisasters_Full.pdf

Notwithstanding the growing scientific acceptance of links between climate change and increased propensity for pandemics like Covid-19, there is already sufficient evidence of the relationship between such climate change concerns and increasing occurrences of extreme weather activity across the world. Evidence of this latter phenomenon has long been charted, such that although the latest WMO Statement initially observes that: 'The risk of climate-related impacts depends on complex interactions between climate-related hazards and the vulnerability, exposure and adaptive capacity of human and natural systems. …'[9], It then goes on to state that:

'Climate-related events already pose risks to society through impacts on health, food and water security, as well as human security, livelihoods, economies, infrastructure and biodiversity. Climate change also has implications for ecosystem services. It can affect patterns of natural resource use, as well as the distribution of resources across regions and within countries. Climate change and individual climate-related events have significant environmental repercussions as well. Negative environmental effects include impacts to the land, such as droughts, wildfires in forest and peatland areas, land degradation, sand and dust storms, and desertification. Air pollution is linked to the use of fossil fuels. In freshwater systems, impacts include floods and water stress, and in marine systems, they include sea-level rise, ocean acidification, reduced levels of ocean oxygen, mangrove decay and coral bleaching. Many of these impacts are linked to biodiversity loss.'[10]

Indeed, climate change-induced impacts are increasingly being factored into the overall international financing costs of maintaining the infrastructure underpinning the global political economy. Going back to 1992, for example, the insurance industry had already recorded the fact that: 'The scope and frequency of loss incurred by natural catastrophes have experienced a drastic increase worldwide over the past decades.'[11] Moreover, the link between such extreme weather events and atmospheric greenhouse gas build-up is now also becoming clear, as is their combined connexion to forced human migration flows. The 2019 WMO Statement notes that: 'In addition to conflicts, insecurity, and economic slowdowns and downturns, *climate variability and extreme weather events* are among the key drivers of the recent rise in global hunger and one of the leading causes of severe (food security and *population displacement)* crises.'[12] *(emphasis added)*

Notwithstanding the immediate challenges wrought by Covid-19, the current pandemic affords us an opportunity to contemplate our responses to the even broader and deeper challenges raised by human-induced climate change. This reckoning in turn requires all manner of responses to be considered, including those that may appear at first sight to be far-fetched, or even unattainable. To mitigate and adapt to all these inevitable challenges requires contemplation of hard truths and even tougher solution choices. Acute awareness of this 'once-in-a-generation' opportunity to that bring about real change is growing among thought leaders, as well as major decision-makers in both government and the private sector. Writing in the *Financial Times* newspaper (UK), Mario Monti notes that: 'An ambitious agenda is needed for the post-Covid 'normal'[13], proposing the creation of an inter-governmental panel on health threats, as well as a sustained programme of investment in early warning systems so that future

[9] *Ibid.,* at 34.
[10] *Ibid.*
[11] Gerhard A. Bertz, 'Greenhouse Effects on Natural Catastrophes and Insurance', *The Geneva Papers on Risk and Insurance*, 17 (No.64, July, 1992) 386-92, at 387.
[12] See: 2019 WMO Statement (2020) *ibid.,* at 29.
[13] See: *Financial Times* newspaper (UK), 16 March, 2021.

emerging infections are identified and responded to as rapidly as possible. Similarly, Sonia Sodha, an *Observer* (UK) newspaper columnist opens a recent op-ed in *The Guardian* (UK) newspaper by stating that: 'We're living in a time of high stakes and urgency - risks need to be taken', and so, 'it's not enough now for science, to move in a stately fashion with great caution', labelling the politicisation of science around both the Covid-19 virus and its related vaccines as a period of 'post-normal science' which she describes as 'the kind of science that takes place in conditions of great uncertainty, where the values around science are in dispute, the stakes are high and decisions are urgent', and further denoting that: 'Covid science is post-normal science on steroids.'[14]

Covid-19 has also impacted heavily on the fossil fuel-based global economy. For example, at the height of the pandemic among Western nations, the authoritative Organization for the Oil Exporting Countries (OPEC) noted that: 'The world economy is forecast to face a recession in 2020, declining by 3.4%, following global economic growth of 2.9% in the previous year. Within the OECD, the US is forecast to contract by 5.2% in 2020, following growth of 2.3% in 2019. An even larger decline is expected in the Euro-zone, where economic activity is forecast to fall by 8.0% in 2020, compared to growth of 1.2% in 2019. Japan is forecast to contract by 5.1% in 2020, comparing to growth of 0.7% in 2019. China's 2020 GDP is forecast to grow by 1.3%, recovering from a sharp contraction in 1Q20, and following growth of 6.1% in 2019. India is forecast to decline by 0.2%, a sharp slowdown from already weakening growth of 5.3% in 2019. Brazil's economy is forecast to contract by 6.0% in 2020, following growth of 1.1% in 2019. Russia's economy is forecast to contract by 4.5% in 2020, after growth of 1.3% in 2019, not only due to COVID-19, but also because of the considerable decline in oil prices.'[15]

The Case for Nuclear Power as a *Transitional* Energy Source to Meet a 2050 Global Carbon Neutral Target

In the wake of an arguably new climate change norm coalescing around a net-zero carbon emissions target by 2050,[16] there has been unprecedented take-up of this new target and deadline across States/governments, international organizations, and nearly all industry sectors around the world.[17] Moreover, much like the impetus brought on by the Covid-19 public health emergency, the natural scientific, technology, and engineering disciplines are at the forefront

[14] See: Sonia Sodha, *The Guardian* newspaper (UK) 20 March 2021, accessible at: https://www.theguardian.com/commentisfree/2021/mar/20/were-living-in-a-time-of-high-stakes-and-scientific-risks-need-to-be-taken

[15] See: OPEC, Monthly Oil Market Report (MOMR) for May, 2020 (dated: 13 May, 2020) reporting on prospects for the 'World Economy', accessible at: https://www.opec.org/opec_web/en/publications/338.htm

[16] According to the World Resources Institute (WRI), '59 countries, representing 54% of global GHG emissions, have communicated net-zero emissions targets, including the world's two largest emitters – the United States and China.' See: WRI Webinar, *Net Zero Targets: Which Countries Have Them and How They Stack Up,* broadcast on 2 June, 2021. Accessible at: https://www.wri.org/events/2021/6/net-zero-targets-which-countries-have-them-and-how-they-stack

[17] According to the International Energy Agency (IEA), '(n)et-zero emissions pledges have been announced by national governments, subnational jurisdictions, coalitions and a large number of corporate entities … As of 23 April 2021, 44 countries and the European Union have pledged to meet a net-zero emissions target: in total they account for around 70% of global CO_2 emissions and GDP.' See: IEA, *Net Zero by 2050: A Roadmap for the Global Energy Sector,* at 32. Revised version, October 2021 (4th revision). Available at: https://www.iea.org/reports/net-zero-by-2050

of efforts to meet new target. Among the more welcome of these contemplated technology-based solutions to the climate change emergency/crisis must be the wholesale changeover to renewable energy sources from current greenhouse gas-spewing fossil-fuels. However, despite their ever-improving economic viability, the combined efforts of hydro, wind and solar power sources of energy are still at least a (human) generation away from the complete takeover of fossil-fuels. This means that although the net-zero carbon emissions goal by 2050 might be met, the complete removal of human-induced carbon emissions into the global atmosphere is still a long time coming. Above all, therefore, humankind presently needs 'stop-gap' measures to buy us time to effectuate the necessary changeover to total reliance on renewable energy sources. One such stop-gap measure is the possibility of relying on nuclear power as a *transitional* energy source in the passage of the global economy and society from its current fossil fuel base, to fully renewable energy sources. While this proposal will surely be controversial, there are at least a couple of reasons why the 'nuclear option' must be seriously considered as a transitional energy source on the pathway to full reliance on renewable energy.

First, nuclear power is a proven, non-carbon, alternative source of energy in the appropriate form (electricity) for our future use, especially in the switch to battery-driven cars. In the short term, this will hasten the attainment of net-zero carbon emissions and thereby assist in meeting current national government and corporate/ business target(s) of overall carbon neutrality by 2050. In the medium term, this transitional role for the nuclear industry will allow renewable energy sources time to completely takeover the world's energy supply, thus paving the way towards zero carbon emissions altogether. This non-carbon emissions future will in turn hopefully stave off the worse effects of human-induced climate change, especially that of forced human migrations which have the potential to cause widespread social disruption.

Second, once harnessed, nuclear energy is a stable, yet flexible source of power, unlike hydro, wind and solar forms of renewable energy, which are prey to extreme weather events. These extreme weather events are projected to grow in numbers and severity during our mounting climate change crisis. Transitioning to such renewables through the intervening reliance on nuclear power will provide a continuous, yet flexible source of power to ensure stability (through variety) within the overall energy source mix for society. At the very least, the nuclear industry should retain its current role within the varied energy mix that ensures the global economy is not beholden to any single source for its future energy needs.

Based on the above outlook, a convincing case can be made for the nuclear industry to take its rightful place as a *transitional* energy source, to complement the range of renewable energy sources gearing-up to supplement and eventually replace the *status quo* reliance on fossil fuel-based energy generation industries. Summarising the points elaborated above, there are at least three reasons for the (re-)consideration of nuclear power as an alternative, transitional source of climate change-friendly, 'renewable' energy. These are enumerated below, as follows:

First, the need to address the climate crisis/emergency risk through carbon emissions reductions, including reliance on the nuclear power generation sector taking its place alongside other renewable energy sources;

Second, and related to the above is the concurrent need to reduce the current dependence on fossil fuels as the main energy source for the world;

Third, and following on from the above two points is the further, corresponding need to provide a secure and stable yet flexible nuclear energy source for national and international grids during

the *transitional* phase from traditional, fossil fuel-based sources, to fully renewable ones such as that powered by solar, wind and waves.

The attributes of nuclear power listed above are succinctly summarised by Bill Gates in his recent book, *How to Avoid Climate Disaster,* in which his opening line on 'nuclear fission' is: 'Here's the one sentence case for nuclear power: It's the only carbon-free energy source that can reliably deliver power day and night, through every season, almost anywhere on earth, that has been proven to work on a large scale.'[18] Empirically, nuclear power's strengths lie mainly in the large, even huge, amounts of energy capable of being generated from comparatively very small amounts of raw source material, namely, uranium. As the *Energy Matters* website notes, '(t)he uranium fuel produced forms into ceramic pellets the size of a capsule but each one produces the same amount of energy as 675 litres of oil. … (Moreover) nuclear power plants do not release any CO2 emissions.' [19] Unlike other alternative energy sources, namely, renewables that are dependent on natural phenomena (sun, wind and waves) and thus subject to possible disruption, for example, due to extreme weather events;[20] whereas nuclear power is a secure and stable energy source. A further benefit of nuclear power generation lies in the fact that especially when replacing fossil fuel-based sources of electricity, it mainly substitutes for the most pernicious carbon-based fuel of them all, namely, coal.[21] It is also flexible in its delivery mode. Distribution-wise, nuclear energy benefits from its easy transformation into a stable source of electrical power, rendering it amenable for all manner of applications within industry, homes, and transportation. This trait also compares well as against other renewable energy sources that face perennial storage and distribution-on-demand obstacles. Depending on how geographically distant they are situated from their ultimate markets and/or consumption sites, electrical power produced from both renewable and nuclear energy sources may face storage capacity issues. Certain jurisdictions have responded to this energy market failure by requiring 'production-plus-storage' projects.[22] Furthermore, there is a continuing need to provide for a mixed bag of renewable energy sources, including nuclear power, to ensure that there is no over-reliance on any specific renewable (or indeed any other) energy sources, such that sudden and unexpected downturns from one source can be made-up by drawing from others. A growing number of governments, especially from developing economies, are actively considering adding nuclear power to their energy source mix for the above reasons.

Finally, it is important to note that switching to nuclear energy will represent an eminently verifiable power source to meet the new, 2050 carbon-free target. This is a further significant quality of nuclear power at a time when doubt has been cast on both the measurement and verification of the actual carbon capture figures initially touted as being saved through various carbon sequestration technologies. Overall, therefore a case can be made for nuclear energy to be re-classified as a reliable *transitional* energy source to be invested in, alongside the whole gamut of renewable energy sources, all of which can ultimately designed to verifiably meet the new zero carbon emissions target by 2050.

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[18] Bill Gates, *How to Avoid Climate Disaster,* Alfred A. Knopf (2021) at 84.
[19] According to the *Energy Matters* website, accessible at:
https://www.energymatters.com.au/components/nuclear-energy/
[20] Volcanic eruptions for example, can spew ash into the sky that obscures sunlight that the solar energy industry relies on, whereas wind can change both direction and pace when it is most needed.
[21] See: 'Briefing: Covid and the climate,' *The Economist* (UK) magazine, 23 May 2020, 14-16.
[22] See: 'Battery Packs lend fresh energy to US renewable generation push', *Financial Times* (UK) newspaper, Tuesday 18 February, 2020 at 18.

Continuing Challenges (& Opportunities) for Nuclear Industry Investment

On the other hand, the viability of nuclear power within this spectrum of different renewable energy sources continues to face at least three significant challenges: First and foremost, the nuclear power generation segment of this industry has to allay and then overcome continuing safety and environmental concerns stemming from very well-known accidents and incidents involving nuclear power plants that have now entered folklore.[23] Among the most notorious civilian nuclear disasters, the following three incidents stand out: 3-Mile Island, Chernobyl, and Fukushima. However, as the World Nuclear Association has pointed out about each of these accidents, respectively: **'**One was contained without harm to anyone, the next involved an intense fire without provision for containment, and the third severely tested the containment, allowing some release of radioactivity.' Moreover, according to the Association, '(t)hese are the only major accidents to have occurred in over 17,000 cumulative reactor-years of commercial nuclear power operation in 33 countries.'[24] Recently, on the eve of the tenth anniversary of the last of these three incidents in March 2011, at the Fukushima-Daichi nuclear facility on the eastern seaboard of the main Japanese island of Honshu, an official report by the UN's Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) has held that: 'No adverse health effects among Fukushima residents have been documented that could have been directly attributed to radioactive exposure from the accident.'[25] Moreover, the latest findings supported a 2013 report on the health impact of the radiation released after three reactors suffered meltdown at

Aside from safety and security risks associated with nuclear power generation, the task of ensuring similarly safe and environmentally secure disposal of spent nuclear fuel also needs to addressed. As *Energy Matters* notes, 'Nuclear energy is highly efficient but also has highly toxic waste as a byproduct.'[26] Nevertheless, in the face of a mounting climate change crisis, it is notable that commentators are beginning to re-assess their previous opposition to the nuclear fuel option. Writing in the *New Yorker* magazine before Covid-19 took over the media universe, Kormann observes that as climate change worsens *(sic)* it may be time to reconsider whether nuclear power is worth the risk?[27] She notes that Steven Pinker, the world-famous Harvard University psychology professor, Joshua S. Goldstein, an international relations professor at American University, and Staffan Qvist, a Swedish nuclear engineer, published an

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[23] This perception of the high risk of nuclear industry safety breaches, coupled with conspiratorial elements involving deep State cover-ups and the like, with disastrous results for all concerned, has entered into the realms of popular culture as well. For example, in the form of nuclear industry-based movie/film thrillers such as *The China Syndrome* (1979) starring Jane Fonda, and *Silkwood* (1983) starring Meryl Streep.

[24] World Nuclear Association, Home / Information Library / Safety and Security / Safety of Plants / Safety of Nuclear Power Reactors *(*Updated June 2019*)*. Accessible at:
https://www.world-nuclear.org/information-library/safety-and-security/safety-of-plants/safety-of-nuclear-power-reactors.aspx

[25] See: Justin McCurry, 'Residents health not damaged by Fukushima radiation – UN', *The Guardian* newspaper (UK) Thursday 11 March, 2021 at 30, citing UNSCEAR report on "Levels and effects of radiation exposure due to the accident at the Fukushima Daiichi Nuclear Power Station: Implications of information published since the UNSCEAR 2013 Report', accessible at:
https://www.theguardian.com/environment/2021/mar/10/fukushima-meltdown-did-not-damage-health-un-japan
2020 & 2013 UNSCEAR reports as well as associated Press Releases and other materials, accessible at: http://www.unscear.org/unscear/en/fukushima.html

[26] See: *Energy Matters* website, *ibid.*

[27] Carolyn Kormann, 'Is Nuclear Power Worth the Risk? The Fukushima disaster sparked a worldwide phaseout of nuclear reactors. As climate change worsens, it may be time to reconsider', *New Yorker* magazine, 22 December, 2019. Accessible at:
https://www.newyorker.com/news/dispatch/is-nuclear-power-worth-the-risk

Op-Ed column in the *New York Times* newspaper, headlined, 'Nuclear Power Can Save the World', arguing that the only way to supply the growing global demand for electricity without fossil fuels is through a mix of renewable energy *and* nuclear power—not just with what we currently have but through a build-up of safer, advanced nuclear plants.

Second, the nuclear industry has to convince investors, consumers, and regulators alike of the stability and continuity of both its raw materials base and total energy output. While the raw material for the nuclear power generation industry, namely, uranium ore is technically a non-renewable resource, its prospective supplies are high. With regard to the longevity of nuclear power industry, the Nuclear Energy Association notes that: 'The world's present measured resources of uranium (5.7 Mt) in the cost category less than three times present spot prices and used only in conventional reactors, are enough to last for about 90 years.'[28] The advent of small, modular nuclear reactors (SMRs) that are able to efficiently generate proportionately greater amounts of power through better technology will enhance the time scale for transition to completely renewable energy sources.[29] On the other hand, a recent meta-analytical study of SMRs has found that very little research so far take on a whole SMR programme (and its financing), rather than 'single project/plant/site' studies. Furthermore, there is a gap in knowledge about the cost-benefit analysis of the 'modular construction' and SMR operating and decommissioning costs.[30]

Third, the nuclear power distribution sector of this industry has to ensure that it can secure infrastructure compatibility with the national and possibly even international power grid(s) drawing electricity from different renewable energy sources to make good on its stable supply and flexible, on-demand qualities. On this point, the advent of new, so-called 'small modular reactors' (SMRs) that are designed to be individual locality-specific, or even installation-based, power providers may reduce the need for national/international grid connexions to channel the huge amounts of electric power generated by traditionally larger nuclear reactors to their individual users. While SMR technology itself is arguably proven, there are continuing technical issues that are currently preventing its full roll-out for civilian use.

Reverting to the safety and environmental issues posed by the global nuclear industry, it may be noted that the relative maturity of this industry does allow a further argument in its favour to be made. This argument builds on the fact that with nuclear power, we are dealing with relatively well-known risks, as opposed to the still uncertain but apparently increasing risks of runaway climate change causing more extreme weather events all around the world. Thus, it can be argued that we have reached a 'tipping point' whereby the known risks of reverting to nuclear power as a relatively safe and secure energy source now *outweigh* the unknown but clearly mounting risks posed by continuing to release carbon emissions into the atmosphere. While such climate change-related risks to human civilization are currently unquantifiable, the overall magnitude of their expected impacts as modelled by climate scientists easily meets the threshold(s) of 'serious or irreversible' damage that would necessitate the application of the precautionary principle or approach to carbon-emitting activities deemed to be contributing to these negative climate change-related impacts.

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[28] World Nuclear Association, 'Uranium Supply' section. Accessible at: https://world-nuclear.org/information-library/nuclear-fuel-cycle/uranium-resources/supply-of-uranium.aspx

[29] See, for example, Bahman Zohuri, Patrick McDaniel, *Advance Smaller Modular Reactors: An Innovative Approach to Nuclear Power*, Springer (2019)

[30] See: B. Mignacca and G. Locatelli, 'Economics and finance of Small Modular Reactors: A systematic review and research agenda', *Renewable and Sustainable Energy Reviews,* Vol.118 (February, 2020)

In other words, it is submitted here that any comparative risk assessment between the currently un-measurable but potentially serious or irreversible risks of negative climate change-related impacts and the correspondingly safety and security risks posed by a well-regulated civilian nuclear industry will tilt in favour of the latter. Simply put, there is now more certainty of serious or irreversible climate change-related events occurring than the correspondingly more well-known and therefore calculable safety and security risks presented by the nuclear industry. Nuclear safety and environmental concerns are simply outweighed by sheer existential threat to global human civilization(s) presented by human-induced climate change-related extreme weather events. Such a risk assessment should at least be considered and, if deemed feasible, then undertaken before any final decision is made to dismiss the nuclear power option from any future energy source mix.

Finally, a further and significant role that nuclear power can play within the emerging range of renewable energy sources is in the *transition* phase to fully renewable, portable, and storable energy sources. This is especially pertinent with the advent of rechargeable, industrial capacity batteries. Indeed, it is the short to medium-term potential of the nuclear industry to ensure secure, and stable yet flexible energy supplies during the crucial *transitional* period between continuing reliance on fossil fuels, and their complete takeover by renewable energy sources that should be emphasised. More broadly, the nuclear energy option also enables business and society to cater for the *transition risk* arising from the transformation to a low, or even, zero carbon global economy.[31]

Finding a Place for Nuclear Power (& Financing It!) Within the Energy Source Mix in the Transition to a post-2050 Carbon Neutral World

Notwithstanding failure to achieve agreement at successive Framework Climate Change Convention (FCCC) Conferences of Parties (CoP) for a *global* carbon emissions reduction strategy since the 2015 Paris Agreement,[32] there is arguably a growing political consensus is coalescing around the target of ensuring the world is carbon neutral by 2050.[33] Carbon neutrality in this context means no *net* carbon emissions from human activities, based on 1990 levels. The Paris Agreement was ratified by the UK on 18 November 2016. The main goal of the Paris Agreement is provided in Article 2(1)(a): 'Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognizing that this would

[31] In his Letter to Clients, entitled: *Sustainability as BlackRock's New Standard for Investing*, Larry Fink summarises the energy transition risk in investing terms as: 'transition risk – namely, how the global transition to a low-carbon economy could affect a company's long-term profitability.' Accessible at: https://www.blackrock.com/uk/individual/blackrock-client-letter

[32] The Paris Agreement, which aims to enhance the implementation of the 1992 Framework Convention on Climate Change (FCCC) (see Article 2(1) of Paris) was adopted by 196 Parties at the 21st Conference of Parties (COP) to the FCCC, in Paris, on 12 December 2015 and entered into force on 4 November 2016.

[33] For example, the aim of the European Union's 'strategic long-term vision' for *A Clean Planet for All:* 'The aim of this long-term strategy is to confirm Europe's commitment to lead in global climate action and to present a vision that can lead to achieving *net-zero greenhouse gas emissions by 2050* through a socially-fair transition in a cost-efficient manner', which nevertheless 'does not intend to launch new policies, nor does the European Commission intend to revise 2030 targets.' *(emphasis added)* See; COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE EUROPEAN COUNCIL, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE, THE COMMITTEE OF THE REGIONS AND THE EUROPEAN INVESTMENT BANK, *A Clean Planet for all: A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy*, Brussels, COM(2018) 773 final, 28.11.2018. 25pp, at 3.
Accessible at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52018DC0773&from=EN

significantly reduce the risks and impacts of climate change; …' It aims to achieve this goal through the successful attainment (of progressively more ambitious) individual nationally determined contributions (NDCs) by each Party, as required under Article 4(2) & (3). *All* parties to the Paris Agreement are therefore required to prepare and communicate, and then undertake and maintain successive Nationally Determined Contributions (NDCs).[34] However, Article 4(4) is the only provision of this Agreement that specifically mentions *'emission reduction targets'*, as follows: 'Developed country Parties should continue taking the lead by undertaking *economy-wide absolute emission reduction targets.* Developing country Parties should continue enhancing their mitigation efforts, and are encouraged to move over time towards *economy-wide emission reduction or limitation targets* in the light of different national circumstances.' *(emphasis added)*

The UK is apparently leading the world on the latter, emission reduction target exercise.[35] It is also showing good progress in meeting these targets.[36] On the other hand, the same report states that: 'In order to meet (the pre-Brexit EU's) climate goals towards 2030, the UK's CO2 emissions will need to fall another 31% from 2019, compared with the 29% achieved over the past decade. Emissions would need to fall even faster if the targets are raised in line with net-zero by 2050. In contrast, (UK) government projections suggest CO2 emissions will only fall by a further 10% by 2030.'[37] Moreover, the UK is (still) historically the fifth largest CO2 producer in the world as a whole, as can be seen from the following ranking list of countries with the largest cumulative CO2 emissions since 1750 (as of the start of 2019):

1) US – 397 Giga-tonnes of Carbon Dioxide (GtCO2); 2) (China) CN – 214 GtCO2; 3) fmr USSR – 180 GtCO2; 4) (Germany) DE – 90 GtCO2; ***5) UK – 77 GtCO2;*** 6) (Japan) JP – 58 GtCO2; 7) (Italy?) IN – 51 GtCO2; 8) (France) FR – 37 GtCO2; 9) (Canada) CA – 32 GtCO2; 10) (Poland) PL – 2 GtCO2.[38] ***(emphasis added)***

The emergence of this zero-carbon emissions target is a direct consequence of the climate change crisis or emergency that is perceived to be upon us. Despite the dwindling debate over any lingering uncertainty around the scientific consensus on the human impacts on climate change, the fact that there is now a discernible *risk* of irreversible damage from carbon-emitting activities is accepted even by the most financially probative entities within the global economy.[39] Even before its recent elevation to the status of a global climate change *crisis,* or even that of a climate *emergency*, this climate change *risk* scenario was already giving impetus

[34] See Articles 3 & 4 of the Paris Agreement.
[35] See: 'UK becomes first major economy to pass net zero emissions law: New target will require the UK to bring all greenhouse gas emissions to net zero by 2050, Department for Business, Energy & Industrial Strategy and The Rt Hon Chris Skidmore MP, published 27 June 2019. Accessible at: https://www.gov.uk/government/news/uk-becomes-first-major-economy-to-pass-net-zero-emissions-law
[36] Simon Evans, 'Analysis: UK's carbon emissions have fallen 29% over the past decade', *Carbon Brief* report, 3 Mar 20. Accessible at: https://www.carbonbrief.org/analysis-uks-co2-emissions-have-fallen-29-per-cent-over-the-past-decade
[37] *Ibid.,* citing, *inter alia*, the UK Government's own 2018 'projections of greenhouse gas emissions and energy demand from 2018 to 2035', accessible at: https://www.gov.uk/government/publications/updated-energy-and-emissions-projections-2018
[38] See: Carbon Brief's Twitter feed: 'Animation: The countries with the largest cumulative CO2 emissions since 1750', accessible at: https://twitter.com/CarbonBrief/status/1120715988532629506
[39] As Larry Fink, the leader of BlackRock – the world's largest private investment management fund, states in his latest (2021) Letter to CEOs entitled: *A fundamental reshaping of finance*: 'Climate change has become a defining factor in companies' long-term prospects. … The evidence on climate risk is compelling investors to reassess core assumptions about modern finance.' Accessible at: https://www.blackrock.com/corporate/investor-relations/larry-fink-ceo-letter

to the need for a widening range of alternative sources of power generation that either do not contribute, or contribute less, to global carbon emissions. The most carbon-intensive fossil fuel industries, such as coal and oil, are currently facing wholesale withdrawal of investment and/or the prospect of punitive carbon taxation. Even as between oil and gas supplies, an emphasis on the latter, less carbon-rich fuel of natural gas is beginning to prevail.

Unfortunately, exceptions to this overall trend still abound, especially among the major, rapidly industrializing economies. For example, a recent issue of *The Economist* journal highlights 'a glut of new coal-fired power stations'[40] that expanded generating capacity in China by 37 Gigawatts (GW) last year, more than the amount by which it grew globally. Citing the Global Energy Monitor a non-profit organization, a *Financial Times* newspaper lead editorial also notes that China 'constructed more than three times as much new coal power capacity as all other countries combined.'[41] On the other hand, the same editorial also noted China's pledge in September, 2020 to become carbon-neutral by 2060, setting a goal for non-fossil fuels to reach 20% of her energy source mix by 2025, up from 15% in 2020, and citing Premier Li Keqiang's announcement that a plan to ensure Chinese carbon output peaked by 2030 would be completed by 2021. The same newspaper then followed-up this editorial less than a week later by reporting a drop in forward market prices for iron ore due to concern that China is working on new policy measures to restrain blast furnace-based steel production to hit this 2030 peak carbon emissions target, before achieving climate neutrality by 2060.[42] Moreover, there is evidence that China is even reining-in her overseas investment in fossil fuel-based projects. In a further news item just a couple of days following this editorial, the *Financial Times* reported that: 'China has told Bangladesh it will not fund coal mines and polluting power plants, as Beijing took steps towards fulfilling its promises of sustainable Belt and Road investment.'[43]

However, within this general movement away from traditional fossil-based energy industries towards well-known renewable energy sources such as solar, wind and tidal, the nuclear power sector arguably occupies a Cinderella role. This is despite the continuing significance of the nuclear industry, especially in relation to the production of electricity, as a recent speech by Rafael Mariano Grossi, the Director-General of the International Atomic Energy Agency (IAEA) noted succinctly, '(t)he 442 nuclear power reactors operating in 32 countries today provide more than 392 gigawatts of installed capacity, supplying over 10% of the world's electricity and around a third of all low-carbon electricity. There are 53 reactors under construction in 19 countries, which are expected to provide 56 gigawatts of additional capacity.'[44]

Several countries, such as the UK, Japan and Canada have also recently unveiled various renewable energy/ low-carbon energy policy-related strategies and plans. For example, Boris Johnson, the current UK premier has outlined a 'ten point plan for a green industrial

[40] See: 'Coal-fired power: Brown elephants', *The Economist* (UK) magazine (China section) 23 May 2020, at 47.
[41] See: 'China is falling short on its climate pledge: The world's biggest carbon emitter needs to take more rapid action', *Financial Times* (UK) newspaper, 10 March, 2021 at 22.
[42] See; Neil Hume, 'Iron ore retreats from 10-year highs on prospects of China steel pollution curbs', *Financial Times*, 16 March 2021, at 13.
[43] See: Christian Shepherd, 'China shuns Bangladesh on coal mine funding', *Financial Times*, 12 March, 2021 at 6.
[44] See: IAEA Director General's Introductory Statement to the Board of Governors, Vienna, 18 November, 2020 Accessible at: https://www.iaea.org/iaea-director-generals-introductory-statement-to-the-board-of-governors-18-november-2020

revolution'[45] which pledges, *inter alia,* to invest in renewable energy sources, such as *Advancing Offshore Wind (Point 1)* and *Driving the Growth of Low Carbon Hydrogen (Point 2),* as well as carbon emissions reduction technologies in transportation modes, such as through *Accelerating the Shift to Zero Emission Vehicles (Point 4),* and *Jet Zero and Green Ships (Point 6)*, as well as *Investing in Carbon Capture Usage and Storage (CCS) (Point 8)* also known as Carbon Sequestration. While support for nuclear power's potential as a viable low-carbon and *transitional* energy source is recognised within this ten-point plan under *Point 3: Delivering New and Advanced Nuclear Power*, a continuing and significant omission is the lack of any mention of conventional (fission) nuclear industry investment as worthy of financial support under *Point 10: Green Finance and Innovation.* Instead, such 'green finance' is confined to the development of so-called 'advanced modular reactors' and to commercialise (nuclear) fusion energy technology.[46]

Indeed, the much needed stable and continuing policy and legal framework for future investment in the UK nuclear industry is arguably still non-forthcoming. Thus, even when the (then) British prime minister, Theresa May unveiled the UK's energy strategy to meet its self-imposed target of net zero carbon emissions by 2050,[47] the nuclear industry was not prominently highlighted in this new strategy, despite its obvious utility value in assisting the UK to achieve carbon neutrality. For example, the term: 'nuclear' was only mentioned twice in the text of this 275-page Strategy, even though it reported that: 'We are already meeting some of our energy and economic needs with low-carbon technologies. Half of UK electricity generation in 2017 was from low-carbon sources, including renewables and *nuclear.* This low-carbon electricity generation helps lower emissions in other sectors where electricity is consumed (e.g. in buildings and industry).'[48] (*emphasis added*) Further on, the Strategy proposes that: 'Renewable generation could be four times today's levels, requiring a sustained and increased build out between now and 2050, complemented by firm low-carbon power options such as *nuclear* power and CCS (applied to biomass or gas-fired plants).'[49] (*emphasis added*) Significantly, when this Strategy came to the all-important section '5. Delivering a net-zero target in the UK', the crucial role of the nuclear industry is un-mentioned, and neither does the subsequent sub-section on '(c) Recommendations for policy in specific areas' specifically provide for nuclear power in this context.

The EU Commission has also contrived not to include even a single mention of the nuclear industry in its Communication on the so-called 'European Green Deal'.[50] Indeed, several EU governments (Austria and Germany, for example) are trying to prevail on others, namely, the

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[45] See: UK Government, Department for Business, Energy, Industrial Strategy (BEIS) Policy paper, full title: *The ten point plan for a green industrial revolution: Building back better, supporting green jobs, and accelerating our path to net zero*, 18 November, 2020. Accessible at:
https://www.gov.uk/government/publications/the-ten-point-plan-for-a-green-industrial-revolution

[46] *Ibid.*

[47] See: *Net Zero: The UK's contribution to stopping global warming*, Committee on Climate Change, UK Government, May 2019. 275pp. Accessible at: https://www.theccc.org.uk/wp-content/uploads/2019/05/Net-Zero-The-UKs-contribution-to-stopping-global-warming.pdf

[48] *Ibid.,* at 138.

[49] *Ibid*., at 145.

[50] Full title: 'A European Green Deal: Striving to be the first climate-neutral continent', see: COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE EUROPEAN COUNCIL, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS, Brussels, 11.12.2019 COM(2019) 640 final. Accessible at:
https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

Visegrad Group of countries,[51] to exclude reliance on nuclear power as an alternative to other renewable energy sources in order to meet the zero carbon emissions target envisaged by the EU's Green Deal.[52] Within this overall 'European Green Deal'[53], the EU is working, through its Action Plan on Financing Sustainable Growth,[54] on a common language and a clear definition of what is 'sustainable' finance. This exercise calls for the creation of a common classification system for sustainable economic activities, or an 'EU taxonomy', which the EU is hoping to establish through its so-called 'Taxonomic Regulation'.[55] Whether the nuclear industry falls within this overall taxonomic category for investment purposes remains uncertain. In this regard: 'In 2020, the Commission launched in-depth work to assess whether or not to include nuclear energy in the EU taxonomy of environmentally sustainable activities.'[56]

According to the EU Commission, as a first step, the Technical Expert Group on Sustainable Finance (TEG) was tasked with advising the Commission on the technical screening criteria for the climate change mitigation and adaptation objectives, but the TEG did not provide a conclusive recommendation on nuclear energy and indicated that a further assessment of the 'do no significant harm' aspects of nuclear energy was necessary. In its assessment of nuclear energy as part of its review on energy generation activities, the TEG concluded that nuclear energy has near to zero greenhouse gas emissions in the energy generation phase and can be a contributor to climate mitigation objectives.[57] While consideration of nuclear energy from a climate mitigation perspective was therefore warranted, the TEG ultimately could not reach a definite conclusion on potential significant harm to other environmental objectives, in particular considering the lack of operational permanent experience of high-level waste disposal sites. Therefore, nuclear energy was not included at this stage in the EU Taxonomy. Instead, the TEG recommended that more extensive technical work be undertaken on the 'do no significant harm' (DNSH) aspects of nuclear energy. During the summer of 2020, in agreement with the Directorate-Generals for Energy (DG ENER), for Environment (DG ENV), for Research and Innovation (DG RTD), for Climate Action (DG CLIMA) and the Secretariat-General of the European Commission, the Directorate-General for Financial Stability, Financial Services and Capital Markets Union (DG FISMA) requested JRC to carry out this 'more extensive technical work on the DNSH aspects of nuclear energy' as recommended by the TEG. Next, the in-house science and knowledge service of the Commission with extensive

[51] The Visegrad Group (also known as the "Visegrad Four" or simply "V4") are composed of four Central European countries, namely, Czech Republic, Hungary, Poland, and Slovakia. More information on this group of countries is available at: http://www.visegradgroup.eu/about

[52] See: 'Austria fails to turn neighbours against nuclear power', W*orld Nuclear News* report, 17 January 2020. Accessible at: https://world-nuclear-news.org/Articles/Austria-fails-to-turn-neighbours-against-nuclear-p

[53] See: The European Green Deal, *ibid.* Accessible at: https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

[54] Full title: Renewed sustainable finance strategy and implementation of the action plan on financing sustainable growth, accessible at: https://ec.europa.eu/info/publications/sustainable-finance-renewed-strategy_en

[55] Full title: Regulation (EU) 2020/852 (Taxonomy) on the establishment of a framework to facilitate sustainable investment. Accessible at: https://ec.europa.eu/info/law/sustainable-finance-taxonomy-regulation-eu-2020-852_en

[56] See: EU Commission website page on 'EU taxonomy for sustainable activities', under the sub-title: 'Assessment of nuclear energy'. Accessible at: https://ec.europa.eu/info/business-economy-euro/banking-and-finance/sustainable-finance/eu-taxonomy-sustainable-activities_en#regulation

[57] See: European Commission, JRC, Science for Policy report, 'Technical assessment of nuclear energy with respect to the 'do no significant harm' criteria of Regulation (EU) 2020/852 ('Taxonomy Regulation') by Abousahl, S., Carbol, P., Farrar, B., Gerbelova, H., Konings, R., Lubomirova, K., Martin Ramos, M., Matuzas, V., Nilsson, K., Peerani, P., Peinador Veira, M., Rondinella, V., Van Kalleveen, A., Van Winckel, S., Vegh, J., Wastin, F. (2021) EUR 30777 EN, at 2.

technical expertise on nuclear energy and technology, the Joint Research Centre (JRC) which aims to provide evidence-based scientific support to the European policy-making process, was invited to carry out such analysis and to draft a technical assessment report on the 'do no significant harm' (DNSH) aspects of nuclear energy, including aspects related to the long-term management of high-level radioactive waste and spent nuclear fuel, consistent with the specifications of Articles 17 and 19 of the Regulation (EU) 2020/852 ('Taxonomy Regulation').[58] This report was then reviewed by two sets of experts, namely, 1) the Group of Experts on radiation protection and waste management appointed by the Scientific and Technical Committee under Article 31 of the Euratom Treaty, as well as 2) the Scientific Committee on Health, Environmental and Emerging Risks (SCHEER) on environmental impacts,[59] which published their reports on 29 June and 30 June, 2021 respectively. Altogether, these three reports will be relied on to inform the Commission's final decision. These reports broadly agreed that nuclear energy does not risk significant harm to human health or to the environment.

In the meantime, on 21 April 2021, the European Commission formally adopted and published the final version of the so-called Taxonomy 'Delegated Act' (DA) along with its two Annexes, containing the technical screening criteria for climate change adaptation and mitigation under the Taxonomy Regulation, with this DA being formally adopted by the Commission on 4 June, 2021.[60] The European Parliament and the EU's Council of Ministers then have four months (which can be extended by an additional two months) to say whether they object to the DA.[61] If the DA survives this scrutiny process, the climate technical screening criteria set out in that DA will then apply from 1 January 2022. However, within the new EU 'Sustainable Finance' package of measures,[62] nuclear energy is currently side-lined pending a further evaluation of the Taxonomy's 'Do No Significant Harm (DNSH)' credentials. This is despite both individual EU Member States,[63] as well as the industry itself lobbying for nuclear power to be explicitly and positively included in designated 'Delegated Acts' under this Taxonomy for Sustainable Financing within the relevant EU instruments.[64] Unfortunately, because of continuing tension on the status of both nuclear power and natural gas in the debate as to whether these energy sources can be included within the proposed Taxonomy, the EU has currently suspended a final decision on this important issue. Thus, in June 2021, the European Commission adopted a Taxonomy Delegated Act which does not cover nuclear energy or natural gas. Instead, the Commission announced that these controversial energy sources would be covered in a complementary Delegated Act**,** with potential additional legislation for gas activities that contribute to reducing greenhouse gas emissions but which do not meet the Taxonomy's technical screening criteria.

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[58] *Ibid.,* see: Abstract.
[59] *Ibid.,* at 2-3.
[60] Accessible at: https://ec.europa.eu/info/law/sustainable-finance-taxonomy-reg
[61] Neither the European Parliament nor the Ministerial Council have the power to amend the DA – they must either approve or reject it, on qualified majority voting rules, so no one single Member State can veto the DA on its own.
[62] See: EU European Commission, 'Sustainable Finance' webpage at: https://ec.europa.eu/info/business-economy-euro/banking-and-finance/sustainable-finance_en
[63] See: Message: 7 EU leaders urge support for nuclear, 25 March 2021, *World Nuclear News* report, accessible at: https://www.world-nuclear-news.org/Articles/Message-Nuclear-is-green-energy,-say-7-EU-leaders
[64] See: 'Nuclear can bring balance to climate debate, says EC official', World Nuclear News report of a High-Level Workshop on the Outlook for Nuclear Power in Clean Energy Transition, organised by the International Energy Agency (IEA) and the International Atomic Energy Agency on 2 March, 2021. *World Nuclear News*, 8 March 2021. Accessible at: https://www.world-nuclear-news.org/Articles/Nuclear-can-bring-balance-to-climate-debate-says-E

Notwithstanding the above debate, both within the EU, and between the EU and its Member States, it is submitted here that serious consideration should be made for this Taxonomy Regulation (and its associated Delegated Acts) to ultimately include investment within the nuclear industry as qualifying for 'sustainable finance' status, due to its (above-mentioned) qualities as a stable yet flexible, low carbon-emitting energy source. This is especially the case, when compared to weather-dependent renewable energy sources like wind and solar. Neither will renewables fulfil our total energy requirements for at least another generation or even two. With most governments and industry now targeting zero carbon emissions by 2050, nuclear retains its position as both a transitional energy source to full reliance on renewables, as well as an alternative, back-up power source, should renewables succumb to adverse weather events. Indeed, the need for nuclear power to be seen to be on the right/correct side of the energy finance-climate change risk equation was emphasised recently by Stephen Vaughan, vice chair of Energy & Power at Rothschild & Co**,** when he stated that: 'Such a project (to include nuclear financing within 'sustainable' financing vehicles) cannot afford to face any impediments, which means the taxonomy and the environmental, social and corporate (ESG) reference points need to be positive.'[65] Specifically, these taxonomies must back investment in nuclear power. More generally, he noted that: 'We want the biggest institutions to come and play and commit, and the formal requirements need to be fulfilled. But there is an additional, more subtle, requirement that is not just about taxonomy. There needs to be a broader context of political support that investors are going to believe is durable. There needs to be a clear declaration, and made with political consensus, that nuclear is essential to the country's net-zero goal and climate ambition. And that really cannot be equivocal. So it's about ESG classification, but it's also about the reputational issues that the investors will consider.'[66]

Enlarging on this 'reputational risk' perspective, Vaughan observes that: 'Investors look at a project, not only in terms of meeting regulatory requirements, but from a much broader set of stakeholder perspectives. They are worried about what their ultimate investors think, what their pensioners think (if it's a pension fund) or their savers. They're worried about what their employees and their customers think. It's against that backdrop that they need to see a clear consensus. These are going to be big, high-profile investments that investors do not want to be controversial. Those investments will in some cases be deployed for decades, sometimes in quite illiquid conditions, and so investors will extrapolate and ask themselves, "Well, is this going be something I'm having to defend and to justify?" It must meet the relevant commercial criteria, but they need to know that it's going to be reputationally supportive. And that clearly requires the taxonomy to be in place and to be supportive, but it also needs a wider consensus, and a wider political declaration, that the nuclear project is a fundamental part of society's objectives to hit the climate targets.'[67]

Elsewhere, on the private finance/investor asset management front, successive media reports indicate a sea-change in the financial asset management industry towards factoring in climate change risk for their products. For example, in his 2021 Letter to Clients, the chief of BlackRock – a financial asset management company that reportedly has $2 trillion in funds, has reiterated the 'risk-reward' relationship that switching to more sustainable investments such as renewable energy sources entails for investors, observing that: 'We know that climate

[65] See: Remarks attributed to Stephen Vaughan made at the World Nuclear Association's *Strategic eForum on Sustainable Finance*, 'New nuclear needs positive taxonomies, says Rothschild & Co executive', 19 March 2021, reported on World Nuclear News (WNN) website page, accessible at: https://www.world-nuclear-news.org/Articles/New-nuclear-needs-positive-taxonomies-says-Rothsch
[66] *Ibid.*
[67] *Ibid.*

risk is investment risk. But we also believe the climate transition presents a historic investment opportunity.'[68] Notably this shift in emphasis also includes threats by such financial asset managers to divest from fossil-fuel industries.[69] However, disengagement from previously profitable investments in carbon-based assets brings with it a new challenge for the financial asset management business, namely, what constitutes a viable yet sustainable and climate change-risk averse investment for such private finance vehicles to divert their assets to? It is submitted here that the nuclear industry must now become a viable option within the progressive realignment of investment destinations for such private asset management firms, as well as publicly-held sovereign wealth funds.

This holistic approach to future nuclear industry investment, combining private finance sources with public/government backing, has been highlighted more generally by Mark Carney, former Bank of England Governor & co-Chair of the Financial Stability Board (FSB) Task Force on Climate Change,[70] and now serves as the UN special envoy on Climate Action & Finance, who concludes a recent a recent op-ed in the *Financial Times* newspaper by stating that: 'Finally, the world needs to rapidly expand blended finance, which combines public and private capital, to maximise impact. With proper structuring, billions of dollars of risk capacity at multilateral development banks, such as the World Bank and African Development Bank (*sic),* can support trillions of dollars of private investment in emerging and developing economies. With momentum growing for the core of the private financial sector to commit to net zero carbon emissions, now is the time for the G20 to ensure that all development finance institutions are fully Paris Agreement-aligned.'[71]

The looming prospect of increasingly negative climate change impacts therefore presents the global nuclear industry with both *challenges*, as well as *opportunities*. On the one hand, if climate change is seen as a catalyst, *enabling* the promotion of *renewable* energy sources, but without the inclusion of nuclear power within this energy source mix, then nuclear's status as a *sunset industry* may well be confirmed. On the other hand, should climate change policy and law recognise the intermediate requirement to rapidly *transition* from carbon-based through low carbon energy sources such as nuclear power, prior to full reliance on renewable energy sources, then nuclear energy can continue to play a role (perhaps even an enhanced one) in this *transitional* phase. This will first confirm nuclear's place as a mature technology within global low/non-carbon energy source mix of the (near) future, as well as building a platform for it to possibly even become a *sunrise industry*, especially if/when small modular reactors (SMRs) come on stream.

However, nuclear's role in the *transition* to a low/non-carbon energy source mix is far from confirmed. For example, in an op-ed column for the *Financial Times* (UK) newspaper, the Executive Director of the International Energy Agency (IEA) Fatih Birol announced a 'comprehensive road map for the entire energy sector to reach net zero by 2050' to come in May, 2021 without mentioning the nuclear's place within this proposed road map. Thus, despite nuclear power's relevance on the energy transition stage of the global climate change

[68] See: *Larry Fink's 2021 Letter to CEOs*, accessible at: https://www.blackrock.com/corporate/investor-relations/larry-fink-ceo-letter

[69] See, for example, Attracta Mooney, 'Aviva vows to force action on climate', reporting that 'one of Britain's top asset managers (Aviva Investors, which manages £355bn) has warned that it will use the "ultimate sanction" and ditch stakes in 30 of the world's largest oil, gas, mining and utilities companies unless they do more to tackle climate change.' *Financial Times* newspaper (UK) 1 February, 2021 at 11.

[70] See: the FSB, Task Force on Climate-related Financial Disclosures website at: https://www.fsb-tcfd.org

[71] Mark Carney, 'A new dawn for globalisation', Financial Times Weekend: Life & Arts section, *Financial Times* newspaper (UK), 20-21 March, 2021, 1-2, at 2.

play, the ambivalence exhibited against this much maligned industry by governments, reflecting wider societal and environmental concerns, is set to continue. These contradictory national perspectives are encapsulated by the contrast in approaches between Canada and Japan, both of which have recently published official Government policy papers on their strategic energy plans for 2030/2050 with their net zero emissions/carbon neutrality target(s) very much to the fore. The Japanese government had previously committed, *inter alia*, to 'reduce emission of greenhouse gases (GHGs) by 26%' in 2030, when it comes to 'Nuclear Power', although it proposed to do this in an arguably contradictory manner, through 'lower dependency on nuclear power generation to the extent possible', yet at the same time, proceeding with the 'restart of nuclear power plants and continuous improvement of safety.'[72]

On the other hand, for Japan's target of reducing GHGs by 80% in 2050, nuclear power is retained as 'one of the options for decarbonisation', alongside the 'pursuit of safe reactors, development of back end technologies.'[73] However, Japan now frets about possible blackouts due to (imported) LNG shortages,[74] having decided post-Fukushima to reduce her dependence on nuclear power, from 25% before 2011 to 22-20% in 2030,[75] as outlined in the 5th edition of Japan's 'Basic Energy Plan', published on 25 December 2020, and now officially re-titled 'Green Growth Strategy Through Achieving Carbon Neutrality in 2050.'[76] This Japanese Green Growth Strategy appears to provide that nuclear power and thermal power will amount to 'about 30-40%' of Japan's electricity power growth needs by 2050, also 'presupposing CO2 recovery', through Carbon Capture & Storage (CCS) technologies.[77] A further target for Japanese nuclear power is the 'verification of the small module reactor technology through international cooperation by 2030;…'[78]

Canada on the other hand, is moving swiftly to ensure that government investment & facilitation of Small Modular Reactors (SMR) technology allows her to take the lead in the future of the nuclear industry, through her 2018 SMR Roadmap,[79] which has now been turned into an SMR Action Plan,[80] which like the Japanese Strategy was also published in December (12th), 2020. This Canadian commitment to SMR development extends to both its regulatory domain and finance aspect, with Canadian public bodies lining-up to confirm their willingness to ensure appropriate regulation is in place to facilitate this nascent sub-species of the nuclear industry. For example, in the 2018 Canadian Roadmap for (SMRs), of the 4 Pillars, *Pillar 2: Policy, Legislation, and Regulation* had the following Priority Recommendations:

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[72] See: Japan, 5th Strategic Energy Plan, accessible at: https://www.enecho.meti.go.jp/en/category/others/basic_plan/5th/pdf/strategic_energy_plan_outline.pdf
[73] *Ibid.*
[74] See: Robin Harding, Leo Lewis & David Sheppard, 'Fears of Japan blackouts as power prices hit record highs: Cold snap and low LNG supplies leave portions of electricity system with little capacity', *Financial Times* (UK) newspaper (UK) 12 January, 2021.
[75] See: EU-Japan Centre for Industrial Co-operation, News item: 'Japan's New Basic Energy Plan Until 2030 Approved', accessible at: https://www.eu-japan.eu/news/japans-new-basic-energy-plan-until-2030-approved
[76] See: Japan Government, Ministry of Economy, Trade & Industry (METI), "Green Growth Strategy Through Achieving Carbon Neutrality in 2050" Formulated', accessible at: https://www.meti.go.jp/english/press/2020/1225_001.html
[77] See: METI, 'Green Growth Strategy Through Achieving Carbon Neutrality in 2050', policy document, 67pp + 14 Diagrams, at 3. Accessible at: https://www.meti.go.jp/english/press/2020/pdf/1225_001b.pdf
[78] *Ibid.,* at 28.
[79] Canadian Small Modular Reactor Roadmap Steering Committee (2018) *A Call to Action: A Canadian Roadmap for Small Modular Reactors*. Ottawa, Ontario, Canada. Accessible at: https://smrroadmap.ca/wp-content/uploads/2018/11/SMRroadmap_EN_nov6_Web-1.pdf
[80] See: 'Canada's SMR Action Plan', published: 12 December, 2020. Accessible at: https://smractionplan.ca

'**Federal impact assessment.** The federal government should work to align the modernization of Canada's federal impact assessment process with other initiatives to develop and deploy SMRs.

Nuclear liability. The federal government should review liability regulations under the *Nuclear Liability and Compensation Act*, in order to ensure that nuclear liability limits for SMRs are aligned with the risks they pose, using a graded scale based on risk-informed criteria.'

The Action Plan that followed this Roadmap includes a Chapter contributed by the Federal Government of Canada (on 18 December, 2020) that, *inter alia,* makes the following statements of her Actions:

'The Government of Canada has accepted the spirit of the Roadmap recommendation (#1) on cost-sharing SMR projects, and has acknowledged the recommendation (#2) on risk-sharing for first-commercial projects

The Government of Canada understands the important role it has to play in advancing SMR technology in time for Canada to be a world leader and to provide a non-emitting alternative for jurisdictions that must phase out conventional coal-fired power plants by 2030.'[81]

To that end, in October 2020, the Canadian Government announced a $20 million investment through the Strategic Innovation Fund that will enable Terrestrial Energy Inc., an innovative Ontario company, to take a critical step toward commercializing its cutting-edge SMR technology, creating significant environmental and economic benefits for Canada.

Recommendations and Conclusion

Given the case being made for the rejuvenation of the civilian nuclear power-generation industry in this paper, what is the prognosis for this currently ailing patient? At least two separate but linked and long-term recommendations are proposed here: First, recognising the value of nuclear power as a viable and indeed necessary 'stop-gap' low-carbon power source in the *transition* period to complete changeover to renewables, thereby requiring a re-alignment of public and private financing towards supporting investment within the nuclear industry. Second, continuing, renewing and enhancing international institutional support for nuclear industry education and training in general, and nuclear law in particular, as the means to regulate ever safer and more secure supplies of nuclear energy, as well as ensure the environmentally-sound treatment and disposal of the admittedly toxic by-products of this industry.

Once public and private financing for nuclear industry investment as both a legitimate and justified low-carbon 'green' investment is confirmed, the focus should turn to the expansion and improvement nuclear industry *expertise,* and particularly, nuclear law, as the regulating framework for the safety and security of human society and the natural environment, as well as by extension, the public and private investment within the nuclear industry. Transparently robust regulation of this industry will help to allay both societal and investor concerns, hopefully to the benefit of both, as the public (re-)embrace of the civilian uses of the power of

[81] See: (Canadian) Federal support for SMRs, accessible at: https://smractionplan.ca/content/government-canada

the atom will assist in the transition to renewable energy sources that mitigate negative climate change impacts, while in turn creating a more stable investment climate for nuclear financing.

One way forward is for mandated international organizations with remits that encompass the promotion of nuclear energy, such as the International Atomic Energy Agency (IAEA)[82], the OECD's International Energy Association (IEA) and Nuclear Energy Agency (NEA), as well as transnational nuclear industry organizations such as the World Nuclear Association, to both continue, and initiate, campaign(s) promoting a wider and deeper discourse on the future role of the nuclear industry, given the gathering momentum towards a carbon neutral world by 2050. [83] There are signs that these international/inter-governmental and transnational organizations are beginning to pay heed to their important role(s) in this regard. For example, the IEA has recently announced that it will unveil what it says is 'the world's first comprehensive roadmap to net-zero emissions by 2050.'[84] More pertinently, the IAEA has recently announced a major international conference on the subject of Nuclear Law,[85] encompassing all aspects of this field of law, both in terms of what it draws from cognate and related subjects like Energy Law and Environmental Law but also highlighting the contributions that Nuclear Law has made to diverse areas of law such as worker health and safety standards for similarly hazardous industries, and the provision of (strict) liability and damages for personal injury/harm and property loss through inter-State established industry-wide compensation schemes.

Within such a nuclear industry promotion campaign, emphasis should be placed on ensuring that the academic and professional *education* on all aspects of the nuclear industry to ensure a growing cadre of nuclear industry practitioners is maintained and if possible, advanced. In this context, all aspects of the nuclear industry should be promoted, *i.e.* both its positive characteristics of being able to provide a carbon emissions-free, stable, yet flexible source of energy, but also including its potential risks, especially in respect of its negative safety, environmental and security perceptions and related concerns. These concerns can be addressed within broader, academic disciplines that are concerned with worker safety, environmental protection, and other issues raised for all types of major infrastructure project management, not just the nuclear industry.

Specifically, it is notable that there appears to be a dearth of *nuclear law*-related courses and modules within universities generally. Given the renewed significance of nuclear power to meet the 2050 carbon neutrality or zero carbon emissions target, mainstreaming Nuclear Law

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[82] For example, Article III of the Statute establishing the IAEA, entitled: 'Functions', which provides, *inter alia,* that: 'A. The Agency is authorized: …; 4. To encourage the exchange and training of scientists and experts in the field of peaceful uses of atomic energy; …'

[83] For example, see latest speech by the IAEA Director-General, 'IAEA's Grossi Calls for Nuclear Power for Net Zero Emissions as Climate 'Clock is Ticking', when speaking during a panel session at the IEA-COP26 Net Zero Summit, a virtual high-level dialogue hosted by the Paris-based International Energy Agency (IEA). Accessible at:https://www.iaea.org/newscenter/news/iaeas-grossi-calls-for-nuclear-power-for-net-zero-emissions-as-climate-clock-is-ticking

[84] See: Press Release from the IEA on 11 January 2021, entitled: 'IEA to produce world's first comprehensive roadmap to net-zero emissions by 2050', to be published as *The World's Roadmap to Net Zero by 2050* on 18 May, 2021. Accessible at: https://www.iea.org/news/iea-to-produce-world-s-first-comprehensive-roadmap-to-net-zero-emissions-by-2050

[85] IAEA Director General, Rafael Mariano Grossi announced the IAEA's first-ever International Conference on Nuclear Law during his opening statement at the meeting of the IAEA Board of Governors on 18 November 2020. More information on this conference, which will take place from 7–11 February 2022, at the IAEA headquarters in Vienna, Austria is accessible at the following IAEA webpage entitled: *First International Conference on Nuclear Law: The Global Debate.* Further information accessible at: https://www.iaea.org/events/icnl-2022

should arguably be a holistic exercise. In other words, a 'cradle-to-grave' approach to all aspects of the policy and legal framework governing the nuclear industry must necessarily involve consideration of its financing, licensing, planning, operational safety, and environmental aspects, including de-commissioning, as well as all aspects of taxation related to this industry.

Nuclear Law therefore faces at least two (2) sets of challenges, but also opportunities – as the great footballer, Johan Cruyff's trademark quote states: 'Elk nadeel, heb zijn voordeel', loosely translated from the Dutch language and para-phrased here as: 'Every challenge is also an opportunity'. These two sets of challenges & opportunities are as follows:

1) To *mainstream* knowledge of *Nuclear Law* within more well-known/popular legal fields, such as Public International Law, (International) Energy Law, (International) Investment Law, (International) Environmental Law, Industrial Health & Safety Law & even (International) Human Rights Law (in its environmental and public information/ consultation/ participation aspects). Such a pedagogically-oriented mainstreaming exercise will serve to situate Nuclear Law more securely within these other/broader fields/areas of law, without necessarily losing any of its specialist subject matter. In this initial/first part of the exercise, the scope of 'Nuclear Law' as a legal field/discipline can arguably be expanded through its inculcation within the range of low/non-carbon energy sources required to achieve net zero emissions/carbon neutrality, such that nuclear industry investment must now be included within the definition of 'green' investment to allow so-called 'green' financial instruments such as bonds & other sustainable investment vehicles to be utilised for new nuclear build, both for current, latest generation nuclear reactor projects, but especially for new/future Small Modular Reactor (SMR) technology. Here, a continuing challenge will be to ensure that financing for nuclear power-generation is classified as an 'environmentally sustainable investment' for the purposes of attracting funding from the considerable amounts of (public & private) sustainable investment vehicles that have established in recent times, as argued above.

2) Following this initial exercise, *i.e.,* the *mainstreaming* of Nuclear Law knowledge within more well-known fields of Law, we can then highlight Nuclear Law's contribution to *international 'best practice'* in the law(s) related to major infrastructure development project management, generally. In other words, how can 'nuclear law' as a body of *lex specialis*, inform the *lex generalis* such that the concepts, principles, rules, standards and techniques of nuclear law can be transplanted or otherwise act as a model, or utilised to inform other areas/fields/sub-disciplines of law. Nuclear law achieves this by being one of the most regulated industrial activities at the international-level of jurisdiction, with multilateral conventions ranging from early notification of, and assistance in the event of civilian nuclear industry accidents; safety of nuclear installations; safety of spent fuel management and safety of radioactive waste management; and civil liability for nuclear damage. Many of these Conventions have also not just entered into force but very soon after adoption and with large numbers of State parties.

A further aspect of the near-comprehensive international regulation of the global nuclear industry that is significant for other renewable energy sources and new technologies for reducing (or collecting) carbon emissions is the multi-layered 'concept-principle-obligation-rule-standard' normative framework that utilises both 'hard' and 'soft' law instruments to collectively create a near-seamless legal *regime* governing almost every aspect of the nuclear life-cycle, which can arguably be transferable to the regulation of other low/non-carbon emitting renewable energy technologies. Thus, 'nuclear law', as it has developed over the past

70 years, has real granularity and depth - depth in which one can find prompts, ideas and models for pretty much all of the current issues that confront us today in the energy law field - from the regulating of retiring classes of energy assets (including their licensing phase-out and waste legacy management) to legal solutions needed for the permitting of new technologies and activities where no legal frameworks exist - such as the licensing of SMR's (on the assumption of a rapid series of international fleet-based roll outs).[86] As a particular example, the deployment of carbon capture and storage/sequestration (CCS) technologies appears to be the sole means of facilitating continuing direct fossil fuel contributions to the global energy mix. Governments casting about for regulatory frameworks for such new technologies can draw from the decades-old industry safety standards and third-party liability systems within the nuclear sector to frame the legal conversations around these new technologies, as well as secure the general public's acceptance of their social licence to operate.

Within this overall context, an initiative to *mainstream* Nuclear Law learning within Masters-level law degree courses at universities around the world, most pertinently through the inclusion of a dedicated Nuclear Law section within existing Energy, Environmental and Natural Resources Law & Investment-focused LLM (or equivalent level) degrees, or even as a stand-alone module within related Masters-level degree courses, is arguably both apt and timely, and should reap the following benefits:

1) Education of a new generation of law students world-wide on both the opportunities and challenges arising from nuclear's current and future role in the energy *transition* phase towards low/non-carbon, and renewable, energy sources;
2) This new, global cohort of students can then play well-informed, advocacy roles for nuclear power within the energy transition policy/law decision-making process of their respective home countries;
3) Broadening the scope of nuclear law as a relevant subject of study to include the financing, licensing, building, operating, and eventually, decommissioning of both large and small (re: SMRs, for example) nuclear power/energy projects as a sub-specie of major infrastructure development generally, thus widening its appeal as an attractive field of legal practice;
4) Through continuing and further professional legal education/training short courses in both general and specialist areas of Nuclear Law, we can also stimulate future professional legal interest in deepening their knowledge base and sharpening their skills in this evolving field.

These benefits should therefore be the aim/objective of broad international support for higher academic education (or professional learning) institutions in all five continents to include a Nuclear Law section/module within their Masters-level provision.

In conclusion, 'investment' is the key word here – both within the nuclear *industry* itself, as well as in the education and training of nuclear *policy and legal experts*. Specifically, the packaging of 'nuclear energy' as a 'green' or sustainable type of investment within the relevant taxonomies being developed for such green/sustainable investment vehicles, is essential to ensure the viability of this key low-carbon emission energy source within the transition to fully

[86] I am indebted to Paul Bowden, currently Visiting Professor at Nottingham Law School, Nottingham Trent University, UK and former Senior Partner at Freshfields, for his input on this point.

renewable energy sources, but also as an insurance policy against the weather-dependent vulnerability of certain renewables, such as wind and solar.