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The (Missing) Role of Nuclear Energy in the Sustainable Development Goals

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EN | Abstract:
Nuclear science and technology are used in many countries to help meet development objectives in areas including energy, human health, food production, water management and environmental protection. The focus of this paper will be on energy and specifically how nuclear energy fits into SDG 7 (Affordable and clean energy) and relates to SDG 13 (Climate action).

The Sustainable Development Goals (SDGs) were adopted by the United Nations in 2015 as a universal call to action to end poverty, protect the planet, and ensure that all people enjoy peace and prosperity by 2030.

Sustainable Development Goal 7, Affordable and clean energy, aims to "Ensure access to affordable, reliable, sustainable and modern energy for all", with a focus on developing countries.
This goal classes "renewable" technologies to be sustainable, while excluding nuclear energy. The term "renewable" usually includes unsustainable, high carbon biofuel. From a policy point of view, it is a problematic term. According to multiple scientific bodies, nuclear energy is clean, reliable and is needed to transition away from fossil fuels in order to combat climate change. No country in the world has been able to decarbonise its electricity sector without having either nuclear energy or - where available - substantial hydro or geothermal energy as part of the energy mix.

SDG 13, Climate action, focuses on lowering greenhouse gas emissions and adaptation to climate change. This goal does not mention nuclear energy. Significant research has shown that in the absence of suitable hydro or geothermal resources, decarbonisation aims are not achieved without nuclear energy. These issues will be discussed in this paper.

Objective: To assess whether nuclear energy should be included in SDGs 7 and 13, and consider the reasons for its current exclusion.

ES | Abstract:
La ciencia y la tecnología nucleares se utilizan en muchos países para ayudar a cumplir los objetivos de desarrollo en áreas como la energía, la salud humana, la producción de alimentos, la gestión del agua y la protección del medio ambiente. Este documento se centrará en la energía y, concretamente, en cómo la energía nuclear encaja en el ODS 7 (Energía asequible y limpia) y se relaciona con el ODS 13 (Acción por el clima).

Los Objetivos de Desarrollo Sostenible (ODS) fueron adoptados por las Naciones Unidas en 2015 como un llamamiento universal a la acción para acabar con la pobreza, proteger el planeta y garantizar que todas las personas disfruten de paz y prosperidad para 2030.

El Objetivo de Desarrollo Sostenible 7, Energía asequible y limpia, pretende "Garantizar el acceso a una energía asequible, fiable, sostenible y moderna para todos", centrándose en los países en desarrollo. Este objetivo clasifica las tecnologías "renovables" como sostenibles, pero excluye la energía nuclear. El término "renovable" suele incluir el biocombustible insostenible y con alto contenido de carbono. Desde el punto de vista político, es un término problemático. Según múltiples organismos científicos, la energía nuclear es limpia, fiable y es necesaria para la transición desde los combustibles fósiles para combatir el cambio climático. Ningún país del mundo ha sido capaz de descarbonizar su sector eléctrico sin disponer de energía nuclear o -cuando energía nuclear o, cuando está disponible, una cantidad considerable de energía hidroeléctrica o geotérmica como parte de la combinación energética.

El ODS 13, Acción por el Clima, se centra en la reducción de las emisiones de gases de efecto invernadero y en la adaptación al cambio climático. Este objetivo no menciona la energía nuclear. Una importante investigación ha demostrado que, en ausencia de recursos hidroeléctricos o geotérmicos adecuados, los objetivos de descarbonización no se alcanzan sin la energía nuclear. Estas cuestiones se debatirán en este documento.

Objetivo: Evaluar si la energía nuclear debería incluirse en los ODS 7 y 13, y considerar las razones de su actual exclusión.

Keywords: *Climate action, nuclear energy, renewable energy, sustainable development goals*
Palabras Clave: *Acción climática, energía nuclear, energías renovables, objetivos de desarrollo sostenible*

I. INTRODUCTION

Public perception of nuclear energy

The Intergovernmental Panel on Climate Change (IPCC) recognises that “the current deployment pace of nuclear energy is constrained by social acceptability in many countries due to concerns over risks of accidents and radioactive waste management.” (Bruckner et al, 2014)

The IPCC summarises: “Though comparative risk assessment shows health risks are low per unit of electricity production (Hirschberg et al, 2016), and land requirement is lower than that of other power sources (Cheng & Hammond, 2017), the political processes triggered by societal concerns depend on the country-specific means of managing the political debates around technological choices and their environmental impacts.” (Gregory et al, 1993)

The role of nuclear energy in establishing sustainable energy paths, (Bruggink & van der Zwaan, 2002) discusses the reasons for nuclear energy being a controversial issue for public policies on energy and the environment. It points to arguments that are often used by anti-nuclear groups and individuals, which are: radioactive waste, reactor accidents, nuclear weapons, and economic competitiveness.

The authors state that “Energy technologies ought to be considered in terms of their potential to contribute to goals of sustainability, including climate change prevention and supply security support. This implies a balanced judgement of their environmental, economic and social risks. Considering nuclear energy in terms of sustainability goals has so far been largely avoided, because many scientists and policymakers either exclude this option by definition or consider the nuclear issue outside their domain of competence, given the dominant role of public opinion.”

Debate is essential to informing public opinion. The misinformation and fear around nuclear energy means that public-led policy decisions are likely to exclude nuclear energy on the basis that it has many active voices against it, most notably NGOs like Greenpeace International (Eden, S., 2006) and Campaign for Nuclear Disarmament, (CND) who have protested both nuclear weapons and nuclear power together for many decades, conflating the different technologies when lobbying against them.

An analysis by Wang & Kim (2018) found that “individuals’ acceptance of nuclear energy is based on individual beliefs and perceptions, but it is also influenced by the institutional and socio-cultural context which each country faces, as communities near to nuclear facilities also tend to exhibit the highest levels of support.”

SDG 7 recognises that renewables cannot work without a backup energy source. The goal states: “By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology.” The preference of fossil fuels over nuclear energy is cause of concern here.

SDG 7 outlines the clear need for “reliable” energy, while also focusing on renewable energies that require a baseload power source for lack of wind or sun. Baseload power generation is the minimum level of demand on an electrical grid over a span of time. Whether or not baseload generators will be needed in the future the subject of much debate, but baseload demand does currently exist and is likely to continue to exist. It may be that baseload demand will be satisfied naturally with baseload plants in the future, or satisfied with much trouble using intermittent sources plus currently unproven magnitudes of energy storage.

To illustrate this, in her book Shorting the Grid: The Hidden Fragility of Our Electric Grid (2020), Meredith Angwin takes a typical energy demand graph for the New England region of the U.S., which shows how widely demands on the grid vary over the day, then shows that there is a steady 10,000 megawatt (MW) demand, which goes up to 16 MW during the day and then falls back down to 10 MW. That 10 MW is baseload: it always has to be there.

The need for baseload power may be why SDG 7 outlines the need for "advanced and cleaner fossilfuel technology", but it gives no indication of how soon such technology might become available and how clean it will be. The absence of clean and currently-available nuclear energy is notable.

The problems with exclusion

Significant research has demonstrated that nuclear energy is needed to address climate change. Our World in Data (Richie, 2020) finds that nuclear energy is as safe and clean as renewable sources of energy. IPCC reports, particularly the landmark 2018 report, 1.5C Warming, find that nuclear energy is necessary to bring down global greenhouse gas emissions. The IPCC decarbonisation scenarios by Working Group III recognise four pathways to show the importance of studying different societal approaches. Pathway P3 is based on the continuation of technological and societal development and shows the most notable rise in nuclear generation (+501%) by 2050. The use of nuclear power increases in all four pathways, by between 59 and 106% by 2030 and by between 98 and 501% by 2050. (IPCC, 2018)

A paper by the United Nations Economic Commission for Europe in energy pathways (UNECE, 2019) demonstrates different scenarios for building nuclear power based on various IPCC scenarios for decarbonisation. It is problematic that this research has not informed the SDGs.

SDG 13, Climate action, highlights the need to address rising greenhouse gas emissions and to achieve carbon neutrality by 2050. Although SDG 13 does not mention specific energy sources, this goal is linked to SDG 7, and they work in tandem.

It is not uncommon for nuclear energy to be excluded from discussions of sustainability and development. The impact of campaign groups against nuclear is not to be underestimated (Jamison, 2015). For example, although a slight majority of Germans see a future role for nuclear energy in the power mix of the country according to a recent YouGov survey (2021), this has had no bearing on Germany's decision to completely phase-out nuclear power. The implications of this decision are now being seen.

II. RESEARCH ELABORATIONS

Germany as a case study

Germany once operated 17 nuclear reactors, which produced nearly a quarter of the country's electricity. The decision to phase out nuclear power was made after the Fukushima Daiichi power plant meltdown in 2011. The contribution of nuclear energy to Germany's electricity output has been cut from almost-25 percent to 11.3 percent (IAEA, 2022), and will be zero by the end of 2022.

When announcing the nuclear phase-out, then-Chancellor Angela Merkel pledged that this energy gap would be filled by renewables, but this has yet to be achieved: Germany's top power source in 2021 was coal, which provided 27 percent of the country's electricity. Wind ranked as second (DeStatis, 2021).

In 2019, Merkel explained to the World Economic Forum: "We will have phased out nuclear energy by 2022. We have a very difficult problem … We cannot do without baseload energy. Natural gas will therefore play a greater role for another few decades … It's perfectly clear that we'll continue to obtain natural gas from Russia." The fact that Germany currently relies on Russia for 49% of its gas supply (Statista, 2022) has been widely criticised due to Vladimir Putin's recent invasion of Ukraine and the resulting calls to cut ties with the Russian President.

Researchers Jarvis et al (2019) estimate that the consequence of Germany closing its nuclear power plants and burning coal instead led to local increases in particle pollution and sulphur dioxide that likely killed an additional 1,100 people per year from respiratory or cardiovascular illnesses. Their paper calculated costs of the nuclear phase-out and found that: "In aggregate, the phase-out led to an increase in CO2 emissions of 36.3 Mt per year. This corresponds to a 13% increase relative to the scenario without the nuclear phase-out. This increase in CO2 emissions was primarily attributable to an increase in emissions from hard coal plants of 25.8 Mt, with lignite and gas making up the remainder."

Is it possible to transition to 100% renewables with current technology?

Despite slowing action on climate change, Germany is often applauded for its target to achieve a 100% renewable energy grid. There has been much misinformation on powering a country with 100% renewable technology. The most notable papers claiming to show this, which have mostly been debunked, are by Mark Jacobson, and Benjamin Sovacool and Andrew Stirling.

In 2013 Jacobson et al published a paper titled Examining the feasibility of converting New York State's all-purpose energy infrastructure to one using wind, water, and sunlight, which claimed that the state of New York in the U.S. could run on 100% renewable energy. The study concluded that: "This plan may serve as a template for plans in other states and countries. Results here suggest that the implementation of plans such as this in countries worldwide should reduce global warming, air, soil, and water pollution, and energy insecurity". The paper was criticised in Energy Policy for insufficient analysis (Gilbraith, 2013) "to demonstrate the technical, economic, and social feasibility of their proposed strategy", but gained much media attention.

Jacobson later published a "landmark" study (2017) claiming that a full transition of all sectors of 139 countries in the world to wind, water, and solar power by 2050 is possible (Jacobson et al, 2015). The study excludes nuclear energy at the outset, stating: "While some suggest that energy options aside from WWS [wind, water, solar], such as nuclear power, coal with carbon capture and sequestration (coal-CCS), biofuels, and bioenergy, can play major roles in solving these problems, all four of those technologies may represent opportunity costs in terms of carbon and health-affecting air-pollution emissions."

Jacobson's reference to nuclear power as air-polluting and raising carbon emissions is false. Nuclear energy does not contribute to air pollution, and replacing fossil fuels with nuclear energy decreases carbon emissions. A report by The World Health Organisation (WHO) estimates that there are around 4.2 million premature deaths per year from particulate pollution arising from the combustion of fossil fuels (2021). In the report Nuclear Power in a Clean Energy System (2019), International Energy Agency (IEA) states: "Nuclear power and hydropower form the backbone of low-carbon electricity generation. Together, they provide three-quarters of global low-carbon generation. Over the past 50 years, the use of nuclear power has reduced CO_2 emissions by over 60 gigatonnes – nearly two years' worth of global energy-related emissions."

Aspects of Jacobson's analysis were debunked by 21 researchers in a peer-reviewed paper published in Proceedings of the National Academy of Sciences (PNAS) (Clack et al, 2017) on the cost-effectiveness and feasibility of a full transition to wind, water, and solar, stating that the study's outcomes are "not supported by adequate and realistic analysis and do not provide a reliable guide to whether and at what cost such a transition might be achieved. In contrast, the weight of the evidence suggests that a broad portfolio of energy options will help facilitate an affordable transition to a nearzero emission energy system".

In retaliation, Jacobson attempted to sue the National Academy of Sciences and the lead author of the critical paper for $10 million on grounds of defamation (Hiltzik, 2018). Jacobson later withdrew his claim, just prior to the final judgement.

In addition, researchers Sovacool, Stirling et al (2020) published a paper claiming that "larger-scale national nuclear attachments do not tend to associate with significantly lower carbon emissions while renewables do." Researchers Jenkins et al (2022) analysed Sovacool's paper and, based on the same dataset, concluded that: "nuclear power and renewable energy are both associated with lower per capita CO2 emissions with effects of similar magnitude and statistical significance. We further demonstrate through sensitivity analysis that this association is robust to potential omitted variables. Our empirical analysis thus confirms that nuclear power and renewable electricity alike can contribute to decarbonization and climate mitigation objectives".

The aforementioned papers, despite being debunked, remain accessible online, and continue to receive widespread media coverage and celebrity endorsement, which may explain why these narratives remain dominant in the public domain and continue to impact policy on clean energy. Jacobson also released a book (2020) titled 100% Clean, Renewable Energy and Storage for Everything on the same topic.

This research promoting 100%-renewables pathways has impacted policy decisions around the world. In the US, New York closed Indian Point nuclear power plant for political reasons and after decades of lobbying from environmental groups (Hu, 2002). Three natural gas-fired power plants have been introduced to provide baseload power supply for New York City, which Indian Point had previously provided (EIA, 2021).

In the U.S., the state of California decommissioned three of its four nuclear plants and is planning to close its remaining power plant. Diablo Canyon nuclear power plant is still producing around 9 percent of California's electricity, but if Diablo Canyon is shut down, the energy gap will almost certainly require burning more gas. Gas already provides 37 percent of California's electricity.

Life-saving nuclear technology

Nuclear power and hydroelectricity have the lowest median life cycle greenhouse gas emissions of electricity generating technologies (UNECE, 2021).

In their paper Prevented Mortality and Greenhouse Gas Emissions from Historical and Projected Nuclear Power (2013), researchers Pushker Kharecha and James Hansen found that "Because nuclear power is an abundant, low-carbon source of base-load power, it could make a large contribution to mitigation of global climate change and air pollution." The researchers calculated that global nuclear power has "prevented an average of 1.84 million air pollution-related deaths and 64 gigatonnes of CO2-equivalent (GtCO2-eq) greenhouse gas (GHG) emissions that would have resulted from fossil fuel burning. On the basis of global projection data that take into account the effects of the Fukushima accident, we find that nuclear power could additionally prevent an average of 420,000–7.04 million deaths and

80–240 $GtCO_2$-eq emissions due to fossil fuels by midcentury, depending on which fuel it replaces. By contrast, we assess that large-scale expansion of unconstrained natural gas use would not mitigate the climate problem and would cause far more deaths than expansion of nuclear power."

The importance of terminology

1. "Reliable" energy sources

SDG 7 lists the need for "reliable" energy, so the exclusion of nuclear energy here is again notable. Low carbon technologies differ in the way they generate electricity (relating to their dispatchability versus variability). Renewable technologies such as wind and solar panels have a variable output, which means that the quantity of power generated cannot be forecast precisely. On the other hand, "all thermal power plants (using nuclear, biomass or fossil fuel) are fully dispatchable and their output can be adapted to the system's needs" (IAEA, 2020).

The cited research shows that solar and wind power should not be included under the term "reliable", since they provide intermittent energy. This intermittency factor is presumably why SDG 7 also outlines the need for "advanced and cleaner" fossil fuels, for baseload needs.

The International Energy Agency (IEA) has shown that reducing nuclear power from its current generation will make hitting climate goals "drastically harder and more costly." The Intergovernmental Panel on Climate Change (IPCC) includes nuclear energy in its decarbonisation scenarios, notably the four chosen to illustrate the challenge of achieving 1.5C by 2100 (IPCC, 2018), while multiple IPCC reports outline the devastating impacts of climate change if global greenhouse gas emissions are not reduced. The International Atomic Energy Agency (IAEA) has also published research into the role of nuclear energy in climate mitigation and adaptation contexts.

This data, versus decisions made in the name of climate action, highlights that key factors relating to energy generation do not appear to be common knowledge by policymakers.

2. "Renewables"

The reasoning behind the term "renewables" is tenuous, and SDG 7 is a prime example of this. At present "renewables" includes biomass, which involves burning wood pellets, sometimes sourced from the logging of whole trees from old-growth forests, to generate electricity. UK government research has shown that greenhouse gas emissions per unit of electricity generated from biomass can be higher than those from fossil fuels, depending on factors such as the type of biomass burnt and where it comes from. In addition to greenhouse gas emissions, biofuel also causes particulate air pollution, which the WHO (2021) estimates kills 3.8 million people per year via indoor cooking. Expanding biofuel for power will contribute to air pollution related deaths.

3. Modern

The use of the term "modern" in SDG 7, referring to the need for deployment of modern technologies, is also tenuous, since solar panels have existed since 1883 (Chu & Taranzano, 2020) and wind farms since 1887 (Shahan, 2014). Some old nuclear power plants may now need to be retired or extended, usually after having provided clean energy for a minimum of 40 years, but the energy extracted from the atomic nucleus is the most recent physics discovery in terms of energy conversion. Nuclear fission is therefore arguably the most modern energy technology. The argument in SDG 7 for "modern" technology may be that nuclear hasn't improved over time: but even if that was true, why would it need to be improved when data shows that it works well already?

Climate change mitigation

Climate change mitigation is essential and also currently achievable. In a report titled Climate change and nuclear power (2020), the IAEA found that energy accounts for most emissions, with electricity driving growth. The production and use of energy represent the largest source of emissions, accounting for around two thirds of total emissions in recent years. Roughly half of total energy emissions are produced directly by the use of fossil fuels in industry, transport and buildings, with emissions from transport having increased significantly (2.5-fold) since 1970.

The IPCC decarbonisation scenarios by Working Group III (1.5C Warming, 2018) show the need for significant amounts of new nuclear power. The IAEA report The Potential Role of Nuclear Energy in National Climate Change Mitigation Strategies (2020) demonstrates a wide array of possibilities for policymakers on deploying nuclear energy to address climate change.

Land use

An often-ignored factor is how much space different power generation methods require. Nuclear power stations have a minimal land footprint, which is important for areas with little land available. The report Land Requirements for Carbon-Free Technologies (2021) compared the land area that electricity generation facilities would require to produce the same amount of electricity as a 1,000- megawatt nuclear power plant in a year, and found that a nuclear energy facility required the least space: around 1.3 square miles per 1,000 megawatts of installed capacity. As well, the report The potential land requirements and related land use change emissions of solar energy (2021) finds that "At the domestic level, solar energy is found to predominantly compete for land with cropland and managed forests, while on a global scale, 27 to 54% of the land required for solar energy is found to indirectly displace unmanaged forests, predominantly outside the region where the solar energy is consumed". The use of land, management of forests and displacement of cropland should be key concerns for SDG 15 (Life on land) and others.

III. DISCUSSION

Should SDG 13, Climate action, include nuclear energy?

Just as nuclear energy has been shut down and banned by governments around the world, it has also likely been excluded from the SDGs because of misinformation and fear. Papers advocating for a 100% renewable future have been found to lack details and feasibility, but continue to dominate the narrative on nuclear power.

Germany provides an excellent case study of what happens when people respond to this fear. Germany is taking a risk in attempting to create a 100% renewable energy future, and has so far made limited progress towards this goal (i.e. less than was intended), with a significant cost to people and the planet. Outcomes on climate impacts and poverty are being risked in favour of ideology or preference of some technologies over others.

During current events, as Russia continues its invasion of Ukraine, nuclear energy is now being reconsidered by some green groups and countries, as energy security and independence have become political focuses. Germany remains committed to its nuclear phase out, despite now recognising that filling the energy gap means building its first liquified natural gas (LNG) terminal, and keeping coal-fired power plants that are due to shut down on standby for emergencies (Sheahan et al, 2022).

Ignoring and excluding nuclear energy from policies has already had an impact on our rapidly warming world. Fear of nuclear power after the 2011 Fukushima Daiichi nuclear power plant meltdown led to some governments phasing out or banning nuclear power altogether, including Germany, Italy and Switzerland (EESI, 2011). However, the Daiichi meltdown caused at most only one death (Richie, 2020) and the plant withstood an earthquake and a tsunami. The world response, sometimes called ‘The Fukushima effect’, has had more significant consequences for nuclear energy development, despite fossil fuels being significantly more harmful to life on Earth.

Phase-outs of nuclear power, and bans on building new reactors, lead to increased emissions and deaths from air pollution. According to analysis by the US Energy Information Administration (2016), when a reactor shuts down, the lost electricity is replaced by burning more coal or gas, which are reliable as baseload power sources.

Nuclear energy saves lives. When nuclear power plants are replaced by fossil fuels or biofuels, this has calculable detrimental impacts on people and the planet. The debunked argument for excluding nuclear energy on the basis of 100% renewables has had significant impact on climate policies. According to business columnist Michael Hiltzik (2017):

"Jacobson was widely quoted in the scientific and law press. Climate activists including Sen. Bernie Sanders and actor Mark Ruffalo picked up on his vision. He boasted of having laid to rest all the usual doubts about wind, solar and water power."

In order to be evidence-based and effective, SDG 13 must include all forms of clean energy. Clean, reliable energy is needed for developed nations to decarbonise, and for developing countries to meet their growing energy needs. Some have already made commitments to new nuclear energy, for example China and India. Nuclear energy is the fifth-largest source of electricity for India (IBEF, 2021) and the country aims to increase its atomic power contribution from 3.2% to 5% by 2031. China has committed to building 150 new nuclear reactors over 15 years, as well as expanding wind and solar power (Van Boom, 2021). The difference between countries where anti-nuclear ideology has not been dominant, and where they have, is notable here.

An IEA report found that in 2019, the number of people without electricity access dropped to 770 million, a record low in recent years. Countries that wish to develop or expand nuclear fleets should be permitted and supported to do so. Equally, if we are to accept the scientific assessment and consensus that nuclear energy is sustainable then its contribution to SDG 13 is crucial.

Should SDG 7, Affordable and clean energy, include nuclear energy?

Just as the research shows that it is necessary to address climate change, there is misinformation regarding the cost of nuclear energy. It is possible that SDG 7 excludes nuclear power on the basis of "affordability". While renewable technologies have become cheaper over time, nuclear energy has not become cheaper in most parts of the world. However, the current model for assessing cost, the 'levelized costs of energy' (LCOE), is outdated and ignores several crucial factors.

LCOE does not take into account costs and benefits at an energy system level, such as price reductions due to low-carbon generation and higher system costs when extra interconnection, storage or backup power is needed due to the variable output of renewable sources.

Variables that aren't considered by the LCOE are:

- Cost of land use
- Costs when storage or backup power is needed due to the variable output of renewable sources
- Cost to consumer
- Dispatchability, the ability of a generating system to come online, go offline, or ramp up or down, quickly as demand swings
- Indirect costs of generation, which can include environmental externalities or grid upgrades requirements

Intermittent power sources, such as wind and solar, may incur extra costs associated with needing to have storage or backup generation available.

Wind and solar power costs are much cheaper than nuclear on a LCOE basis, and that's likely to continue to be the case even if nuclear gets cheaper, because solar and wind are cheap. Adding this cheap low-carbon generation to the grid will lower power sector emissions, because at any particular time if the cheapest way to generate electricity is the lowest-carbon, that's what will be used, lowering emissions at that time.

Decarbonising the grid requires meeting demand at all times, but if there is little sunlight and wind available then even cheap renewable generation isn't useful. Baseload capacity, which has to be ready to deploy when needed, can be much more expensive than the intermittent supply, because it's being used for a different purpose.

For example, the capacity factor of solar in U.K. and German latitudes is around 11 percent. That means that although large installed capacity numbers get announced, the solar is only integrated with large gaps by including fossil fuel) backup (Statista, 2021). Offshore wind in the UK fares better, at around 40% capacity factor, but it still supplies less energy than its fossil fuel baseload partner.

Various schemes involving storage, trans-continental interconnections and/or demand management have been proposed to address this problem. Adding grid development to wind and solar deployment brings up the cost dramatically. Offshore wind connection costs have been estimated at €7 billion, which brings the total cost to €32 billion (Spaes, 2019).

However, the argument is not being made here in order to exclude renewables from the SDGs, but to illustrate the many factors involved in calculating cost, and to demonstrate that the exclusion of nuclear energy from SDG 7 on the basis of cost is misplaced.

The cost of not building new nuclear

In their research into the consequences of Germany closing its nuclear power plants, Jarvis et al (2019) find that: "Valuing carbon emissions at a social cost of carbon of $50/tCO2, the phase-out results in estimated climate change damages of $1.8 billion."

Kikstra et al (2021) have calculated the "social cost of carbon" (SCCO2), which assesses the economic cost of greenhouse gas emissions to society. Expressed in US dollars per tonne of carbon dioxide, estimates currently vary greatly between $10 to $1,000. The study finds that economic damage could be over $3,000 per tonne of CO2. Study co-author Dr Chris Brierley says: "Burning CO2 has a cost to society, even if it is not directly to our wallets. Each person's emissions could quite well result in a cost to humanity of over $1,300 per year, rising to over $15,000 once the impacts of climate change on economic growth are included." (UCL, 2021)

Putting aside financial cost, there is a case to be made for protecting the one known habitable planet in the universe.

Climate scientist Kerry Emanuel has stated that "Every time we close a nuclear plant and replace it with fossil fuels we condemn people to premature death. And conversely when we replace coal with nuclear, we save many lives." (Clark, 2020)

In a letter written to The Guardian newspaper (2015), climate scientists James Hansen, Kerry Emanuel, Ken Caldeira and Tom Wigley write: "To solve the climate problem, policy must be based on facts and not on prejudice. The climate system cares about greenhouse gas emissions – not about whether energy comes from renewable power or abundant nuclear power. Some have argued that it is feasible to meet all of our energy needs with renewables. The 100% renewable scenarios downplay or ignore the intermittency issue by making unrealistic technical assumptions, and can contain high levels of biomass and hydroelectric power at the expense of true sustainability. Large amounts of nuclear power would make it much easier for solar and wind to close the energy gap."

They conclude, "The climate issue is too important for us to delude ourselves with wishful thinking. Throwing tools such as nuclear out of the box constrains humanity's options and makes climate mitigation more likely to fail. We urge an all-of-the-above approach that includes increased investment in renewables combined with an accelerated deployment of new nuclear reactors."

To ignore the words of leading climate scientists and the robust research on nuclear energy is no different than ignoring the scientific consensus that climate change is anthropogenic. This article makes the case for including nuclear energy in SDGs 7, which will also contribute to SDG 13, and help to achieve the overall aims of the SDGs.

IV. RECOMMENDATIONS

Updated SDGs should:

- Recognise nuclear energy as clean, reliable, and necessary for baseload in both established and emerging economies
- Include nuclear energy in SDG 7, with a view to working in tandem with goals 13 and 15
- Remove vague terminology from SDG 7, including the term “modern”
- Consider replacing the term “renewables” with specific power generations methods, in order to differentiate between wind, solar, biofuels, etc

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REFERENCES

➔ *Ambient (outdoor) air quality and health*. (2021, September 22). Who.int; World Health Organization: WHO. https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health

➔ Angwin, M. (2020). *Shorting the grid : the hidden fragility of our electric grid*. Carnot Communications.

➔ Boom, D. V. (2021). *What the US could learn from China’s nuclear power expansion*. CNET. https://www.cnet.com/science/why-the-us-should-learn-from-chinas-nuclear-power-expansion/

➔ Bruckner, T. et al. (2014). *Energy Systems*. Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.

➔ Bruggink, J. J. C., & van der Zwaan, B. C. C. (2002). The role of nuclear energy in establishing sustainable energy paths. *International Journal of Global Energy Issues (IJGEI)*, *18*(2/3/4). inderscience. http://www.inderscience.com/info/inarticle.php?artid=958

➔ Buchholz, K. (2022a, February 24). *Infographic: Which European Countries Depend on Russian Gas?* Statista Infographics. https://www.statista.com/chart/26768/dependence-on-russian-gas-by-european-country/

➔ Buchholz, K. (2022b, February 24). *Infographic: Which European Countries Depend on Russian Gas?* Statista Infographics. https://www.statista.com/chart/26768/dependence-on-russian-gas-by-european-country/

- *California - State Energy Profile Analysis - U.S. Energy Information Administration (EIA)*. (2021). Eia.gov. https://www.eia.gov/state/analysis.php?sid=CA
- *Chapter 4 — Global Warming of 1.5 °C*. (2018). Ipcc.ch; Intergovernmental Panel on Climate Change (IPCC). https://www.ipcc.ch/sr15/chapter/chapter-4/
- Cheng, V. K. M., & Hammond, G. P. (2017). Life-cycle energy densities and land-take requirements of various power generators: A UK perspective. *Journal of the Energy Institute*, *90*(2), 201–213. https://doi.org/10.1016/j.joei.2016.02.003
- Chu, E., & Taranzano, L. (2019, April 22). *A Brief History of Solar Panels*. Smithsonian; Smithsonian.com. https://www.smithsonianmag.com/sponsored/brief-history-solar-panels-180972006/
- Clack, C. T. M., Qvist, S. A., Apt, J., Bazilian, M., Brandt, A. R., Caldeira, K., Davis, S. J., Diakov, V., Handschy, M. A., Hines, P. D. H., Jaramillo, P., Kammen, D. M., Long, J. C. S., Morgan, M. G., Reed, A., Sivaram, V., Sweeney, J., Tynan, G. R., Victor, D. G., & Weyant, J. P. (2017). Evaluation of a proposal for reliable low-cost grid power with 100% wind, water, and solar. *Proceedings of the National Academy of Sciences*, *114*(26), 6722–6727. https://doi.org/10.1073/pnas.1610381114
- Clark, N. (2020, July 23). *Is nuclear power a problem or a solution?* Aljazeera. https://www.aljazeera.com/features/2020/7/23/is-nuclear-power-a-problem-or-a-solution
- Clifford, C. (2021, December 21). *U.S. can get to 100% clean energy with wind, water, solar and zero nuclear, Stanford professor says*. CNBC. https://www.cnbc.com/2021/12/21/us-can-get-to-100percent-clean-energy-without-nuclear-power-stanford-professor-says.html
- Eden, S. (2004). Greenpeace. *New Political Economy*, *9*(4), 595–610. https://doi.org/10.1080/1356346042000311191
- *Electricity production in the 1st half of 2021: coal most important energy source*. (2021). Federal Statistical Office; Statistisches Bundesamt (Destatis). https://www.destatis.de/EN/Press/2021/09/PE21_429_43312.html
- Fares, R. (2015, March 11). *Renewable Energy Intermittency Explained: Challenges, Solutions, and Opportunities*. Scientific American Blog Network. https://blogs.scientificamerican.com/plugged-in/renewable-energy-intermittency-explained-challenges-solutions-and-opportunities/
- Ford, J. (2022, March 17). *Bloomberg - Are you a robot?* Www.bloomberg.com. https://www.bloomberg.com/opinion/articles/2022-03-17/ukraine-invasion-challenges-the-anti-nuclear-dogma-of-european-greens
- *Fort Calhoun becomes fifth U.S. nuclear plant to retire in past five years*. (2016). Www.eia.gov. https://www.eia.gov/todayinenergy/detail.php?id=28572
- Gilbraith, N., Jaramillo, P., Tong, F., & Faria, F. (2013). Comments on Jacobson et al.'s proposal for a wind, water, and solar energy future for New York State. *Energy Policy*, *60*, 68–69. https://doi.org/10.1016/j.enpol.2013.05.006

- Gregory, R., Lichtenstein, S., & Slovic, P. (1993). Valuing environmental resources: A constructive approach. *Journal of Risk and Uncertainty*, *7*(2), 177–197. https://doi.org/10.1007/bf01065813
- Hiltzik, M. (2018, February 23). *Column: A Stanford professor drops his ridiculous defamation lawsuit against his scientific critics*. Los Angeles Times. https://www.latimes.com/business/hiltzik/la-fi-hiltzik-jacobson-lawsuit-20180223-story.html
- Hirschberg, S., Bauer, C., Burgherr, P., Cazzoli, E., Heck, T., Spada, M., & Treyer, K. (2016). Health effects of technologies for power generation: Contributions from normal operation, severe accidents and terrorist threat. *Reliability Engineering & System Safety*, *145*, 373–387. https://doi.org/10.1016/j.ress.2015.09.013
- Hu, W. (2002, April 24). Post-9/11, Opposition to Indian Point Plant Grows. *The New York Times*. https://www.nytimes.com/2002/04/24/nyregion/post-9-11-opposition-to-indian-point-plant-grows.html
- IEA. (2019, May). *Nuclear Power in a Clean Energy System – Analysis*. IEA; International Energy Agency (IEA). https://www.iea.org/reports/nuclear-power-in-a-clean-energy-system
- *India's Nuclear Energy Boom | IBEF*. (2021, December). Www.ibef.org; India Brand Equity Foundation. https://www.ibef.org/blogs/india-s-nuclear-energy-boom#:~:text=Nuclear%20energy%20is%20the%20fifth
- *International Reactions to the Fukushima Nuclear Disaster: Summer Update | Article | EESI*. (2011). Www.eesi.org; Environmental and Energy Study Institute (EESI). https://www.eesi.org/articles/view/international-reactions-to-the-fukushima-nuclear-disaster-summer-update
- Jacobson, M. et al. (2013). *Examining the feasibility of converting New York State's all-purpose energy infrastructure to one using wind, water, and sunlight,.* Citeseerx.ist.psu.edu; Energy Policy. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.367.1949&rep=rep1&type=pdf
- Jacobson, M. et al. (2017). 100% Clean and Renewable Wind, Water, and Sunlight All-Sector Energy Roadmaps for 139 Countries of the World. In *stanford.edu*. https://web.stanford.edu/group/efmh/jacobson/Articles/I/CountriesWWS.pdf
- Jamison, A. (2015, January 1). *Science and Social Movements* (J. D. Wright, Ed.). ScienceDirect; Elsevier. https://www.sciencedirect.com/science/article/pii/B9780080970868850229
- Jarvis, S., Deschenes, O., & Jha, A. (2019, December 19). *The Private and External Costs of Germany's Nuclear Phase-Out*. National Bureau of Economic Research Working Paper Series. https://www.nber.org/papers/w26598

- Johnson, S. (2021, April 30). *New York's Indian Point nuclear power plant closes after 59 years of operation - Today in Energy - U.S. Energy Information Administration (EIA)*. Www.eia.gov. https://www.eia.gov/todayinenergy/detail.php?id=47776
- Kharecha, P. A., & Hansen, J. E. (2013). Prevented Mortality and Greenhouse Gas Emissions from Historical and Projected Nuclear Power. *Environmental Science & Technology*, *47*(9), 4889–4895. https://doi.org/10.1021/es3051197
- Kikstra, J. S., Waidelich, P., Rising, J., Yumashev, D., Hope, C., & Brierley, C. M. (2021). The social cost of carbon dioxide under climate-economy feedbacks and temperature variability. *Environmental Research Letters*, *16*(9), 094037. https://doi.org/10.1088/1748-9326/ac1d0b
- *Knapp die Hälfte der Deutschen ist grundsätzlich offen für Atomenergie*. (2021). YouGov: What the World Thinks. https://yougov.de/news/2021/12/08/knapp-die-halfte-der-deutschen-ist-grundsatzlich-o/
- *Life Cycle Assessment of Electricity Generation Options UNITED NATIONS ECONOMIC COMMISSION FOR EUROPE*. (2021). United Nations Economic Commission for Europe (UNECE). https://unece.org/sites/default/files/2021-10/LCA-2.pdf
- *Life cycle impacts of biomass electricity in 2020*. (2014). GOV.UK; Department of Energy & Climate Change. https://www.gov.uk/government/publications/life-cycle-impacts-of-biomass-electricity-in-2020
- *PRIS - Country Details*. (2022). Pris.iaea.org; International Atomic Energy Agency (IAEA). https://pris.iaea.org/PRIS/CountryStatistics/CountryDetails.aspx?current=DE
- *Public opposition to nuclear energy production*. (2011). Our World in Data. https://ourworldindata.org/grapher/public-opposition-to-nuclear-energy-production
- Reuters. (2022, March 8). Germany vetoes nuclear power extension, aims for LNG terminal in 2024. *Reuters*. https://www.reuters.com/world/europe/german-ministries-say-cannot-recommend-extending-nuclear-plants-lifetime-2022-03-08/
- Ritchie, H. (2020, February 10). *What Are the Safest Sources of energy?* Our World in Data. https://ourworldindata.org/safest-sources-of-energy
- Sep 20, P. par J. S. |, & Grid, 2019 |. (2019, September 20). *RTE estime à 7 mds€ le raccordement de l'offshore marin d'ici à 2035*. Énergies de La Mer. https://www.energiesdelamer.eu/2019/09/20/rte-estime-a-7-milliards-d-euros-le-raccordement-de-l-offshore-marin-d-ici-a-2025/
- Shahan, Z. (2014, November 21). *History of Wind Turbines*. Renewable Energy World. https://www.renewableenergyworld.com/storage/history-of-wind-turbines/#gref
- Sovacool, B. K., Schmid, P., Stirling, A., Walter, G., & MacKerron, G. (2020). Differences in carbon emissions reduction between countries pursuing renewable electricity versus nuclear power. *Nature Energy*, *5*(11), 928–935. https://doi.org/10.1038/s41560-020-00696-3

➔ *The Potential Role of Nuclear Energy in National Climate Change Mitigation Strategies*. (2021, November 2). Www.iaea.org; International Atomic Energy Agency (IAEA). https://www.iaea.org/publications/15001/the-potential-role-of-nuclear-energy-in-national-climate-change-mitigation-strategies
➔ *The Role of Nuclear Energy in Establishing Sustainable Development: Energy Pathways*. (2019). United Nations Economic Commission for Europe (UNECE) e. https://unece.org/fileadmin/DAM/energy/se/pp/CSE/2019/EnComm28_Sept.2019/26.Sept/King_Lee_Nuclear.pdf
➔ UCL. (2021, September 6). *Economic cost of climate change could be six times higher than previously thought*. UCL News. https://www.ucl.ac.uk/news/2021/sep/economic-cost-climate-change-could-be-six-times-higher-previously-thought
➔ *UK: load factor of solar PV 2010-2019*. (2021). Statista. https://www.statista.com/statistics/555697/solar-electricity-load-factor-uk/
➔ United Nations. (2015). *The 17 Goals*. United Nations. https://sdgs.un.org/goals
➔ United Nations. (2021a). *Goal 7 | Department of Economic and Social Affairs*. Sdgs.un.org; United Nations. https://sdgs.un.org/goals/goal7
➔ United Nations. (2021b). *Goal 13 | Department of Economic and Social Affairs*. Sdgs.un.org; United Nations. https://sdgs.un.org/goals/goal13
➔ van de Ven, D.-J., Capellan-Peréz, I., Arto, I., Cazcarro, I., de Castro, C., Patel, P., & Gonzalez-Eguino, M. (2021). The potential land requirements and related land use change emissions of solar energy. *Scientific Reports*, *11*(1), 2907. https://doi.org/10.1038/s41598-021-82042-5
➔ Wang, J., & Kim, S. (2018). Comparative Analysis of Public Attitudes toward Nuclear Power Energy across 27 European Countries by Applying the Multilevel Model. *Sustainability*, *10*(5), 1518. https://doi.org/10.3390/su10051518
➔ Wigley, J. H., Kerry Emanuel, Ken Caldeira and Tom. (2015, December 3). *Nuclear power paves the only viable path forward on climate change*. The Guardian. https://www.theguardian.com/environment/2015/dec/03/nuclear-power-paves-the-only-viable-path-forward-on-climate-change

PEER REVIEW COMMENTS FOR ARTICLE SUBMISSION 'THE (MISSING) ROLE OF NUCLEAR ENERGY IN THE SUSTAINABLE DEVELOPMENT GOALS'

Modern nuclear power has great potential to help humanity find a path to a stable, salubrious climate in a world in which our energy needs are met with little impact on the environment and nature. The greatest obstacle that must be overcome to achieve that potential is the disinformation about nuclear energy that has been spread for decades, often with financial support of the fossil fuel industry.

I find it exceedingly frustrating when people advocating sustainable development "chicken-out" when faced with the task of confronting the anti-nuke people who grew up in the second half of the 20th century when well-meaning people concerned about nuclear war cast peaceful use of nuclear energy in the same basket. That was easy and made them feel good, but we can't allow such shallow assessments to prevail. For the sake of young people and future generations, we need a stream of papers such as this one by Zion Lights to set the record straight.

Dr James E Hansen PhD

This is a well-written and well-informed article on one of the pivotal debates of our time. The arguments are delivered clearly and backed by appropriate and up-to-date references from the literature.

Biofuel is discussed appropriately from a carbon perspective, but the proximal health impacts from the particular air pollution is perhaps an even more urgent reason to reduce reliance on biofuel. Shifting terminology away from renewable and towards "clean, sustainable" would help avoid policy mistakes of the past where biofuel is inadvertently prioritized.

The cost comparison of nuclear vs. intermittent energy sources is appropriate. It actually understates the issues with the LCOE metric. The cost of electricity per kWh on its own does not consider the essential impact of the capacity factor. If you want to directly compare the system costs of powering a high-latitude area that requires 100 GWy of electricity per year between nuclear and wind or solar, the capacity factor is absolutely essential. To meet this demand, you would need to build about 112 GW of load-following nuclear capacity (90% CF) or about 910 GW of solar capacity (11% CF). Since solar is not firm like nuclear and cannot ramp up without the sun, continental-scale energy storage systems would also need to be purchased and built. Thus, the appropriate cost comparison should be between 112 GW of nuclear capacity vs. 910 GW of solar capacity plus a massive energy storage infrastructure.

Furthermore, the nuclear plants will last 60-80 years, while the solar capacity and energy storage will need to be rebuilt every 25 years. These points are completely washed out by the concept of LCOE.

Lastly, LCOE is an investors metric. It massively discount future costs 15 years out and beyond, as they don't matter to the current investors. However, the people of the world in 15 years and beyond should be considered.

All that aside, this paper is of good quality and brings key and essential points to the conversation. I recommend publishing it.

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- The ideas, concepts and conclusions set out in this research article do not represent an official position of the European Institute for Multidisciplinary Studies in Human Rights and Sciences - Knowmad Institut gemeinnützige UG (haftungsbeschränkt).
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