Navigating the Nexus: Climate Change, Clean Energy, and Nuclear Nonproliferation

Review of existing literature within the NEXUS of Clean Energy, Nuclear Nonproliferation, and Climate Change in order to better understand the current status of the field.

FINAL UNDERGRADUATE RESEARCH REPORT

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1 Introduction

The global security implications of climate change is expected to result in unprecedented investments in alternative clean energy sources. Direct concerns of climate change include but are not limited to energy security, environmental migration, resource wars, and climate security [1]. Clean energy is a multifaceted issue, and it's not the case that the most environmentally friendly energy source will be the main technologies used in climate change mitigation strategies across the globe.

Energy determinants involve political, economic, and even social aspects for consideration. The most probable future scenario of climate change mitigation strategies includes nuclear energy in the zero-carbon energy mix. It's currently the worlds second largest source of zero-carbon base load energy, and It's potential to improve energy security, provide economic growth, and reduce global emissions is unprecedented.

In 2021 Congress passed the bipartisan Infrastructure Investment and Jobs Act. The bill allocates 2.5 billion for R&D in the next generation of advanced nuclear reactors. The small reactors (SMR's) are designed to lower construction cost and increase operational safety. The Department of Energy anticipates the demand for these advanced technologies will reach a trillion dollars in term of market opportunities, proving the nuclear industry as being indispensable. The nuclear industry is not limited to just the energy sector, there are applications of nuclear technology in medical treatments, radiation processing, and the desalination of water. This is all to say nuclear technology is likely here to stay, even taking into consideration the risk of nuclear proliferation of weapons. This is why it is increasingly important for global security purposes to strategically prepare and understand how the increased use and advancement of nuclear technologies can have adverse affects.

The aim of this literature review is to provide the existing literature studying the intersections of climate change, clean energy, and nuclear non-proliferation. The research provided in this review has proved to be very interdisciplinary. There's little research studying all intersections of these fields. It's for this reason the literature collection was separated into dyads, and overlaps were recorded.

1.1 Methodology

Initial literature collection methods relied heavily upon Google Scholar and Scopus followed by subsequent reference tracing of relevant publications found. Understanding the terminology of the academic field, coupled with the introduction of operators in the search query string, helped refine output sources significantly. A temporal method was introduced to isolate publications and maximize aggregate literature collection in five year intervals.

Other academic search engines including Scinapse, BASE, Semantic Scholar, Science.gov, The Lens, Scinapse, and Cambridge Core were also exhausted of relevant resources to the

research scope. The type of literature collected included journal articles, review articles, books, world organization reports, & conference reports.

Literature citations were stored using EndNote, a citation manager, with advantages in sorting and reviewing literature. Citations were stored with their respective PDF files in an online repository, that allowed for an isolated search query within my reference repository. This was especially useful while binning articles into sub-fields.

1.2 Leximancer: Machine Learning Content Analysis Program

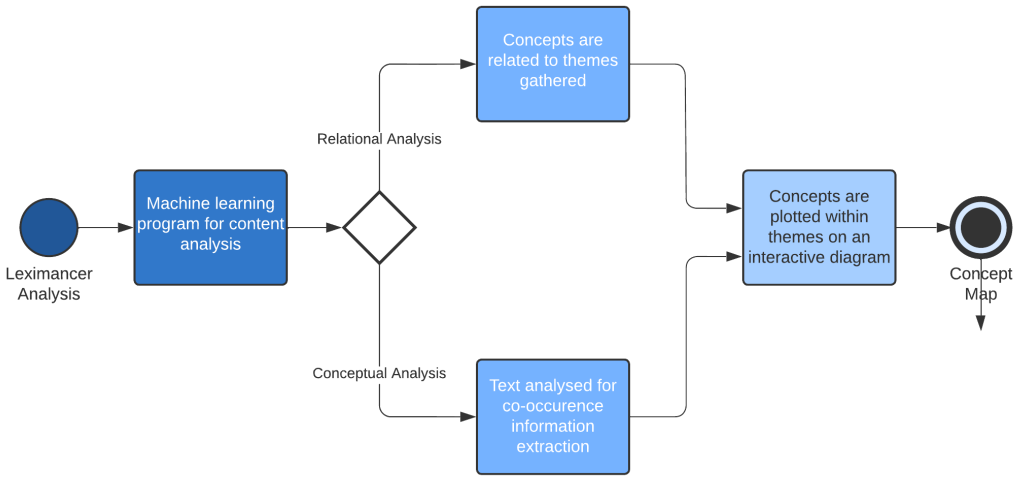

Figure 1: Leximancer Program Algorithm Flowchart [2]

Leximancer, a machine learning algorithm, produces a model for qualitative data analysis via two stages of co-occurrence information extraction, first a thematic analysis and second a relational analysis. The programs uses a method of transforming lexical co-occurrence information from natural language into semantic patterns. The algorithms themselves are statistically based, but the program runs with nonlinear dynamics and utilizes machine learning [3]. It's been cited in over 2000 journal articles, and is considered one of the leading content analysis programs for research purposes. The program automates text analyses from input documents into high-level learning concepts, producing key concepts and actionable insights.

Leximancer not only develops the concept map shown in figure 2 it also provides an alternative means to perform text analyses in an automated and systematic way using the semantic network developed by the program, and acts as a sort of guide for your concept map. We can think of the concept map as the surface level literature analysis that can only be deeply interrupted using the semantic network.

1.2.1 Insights

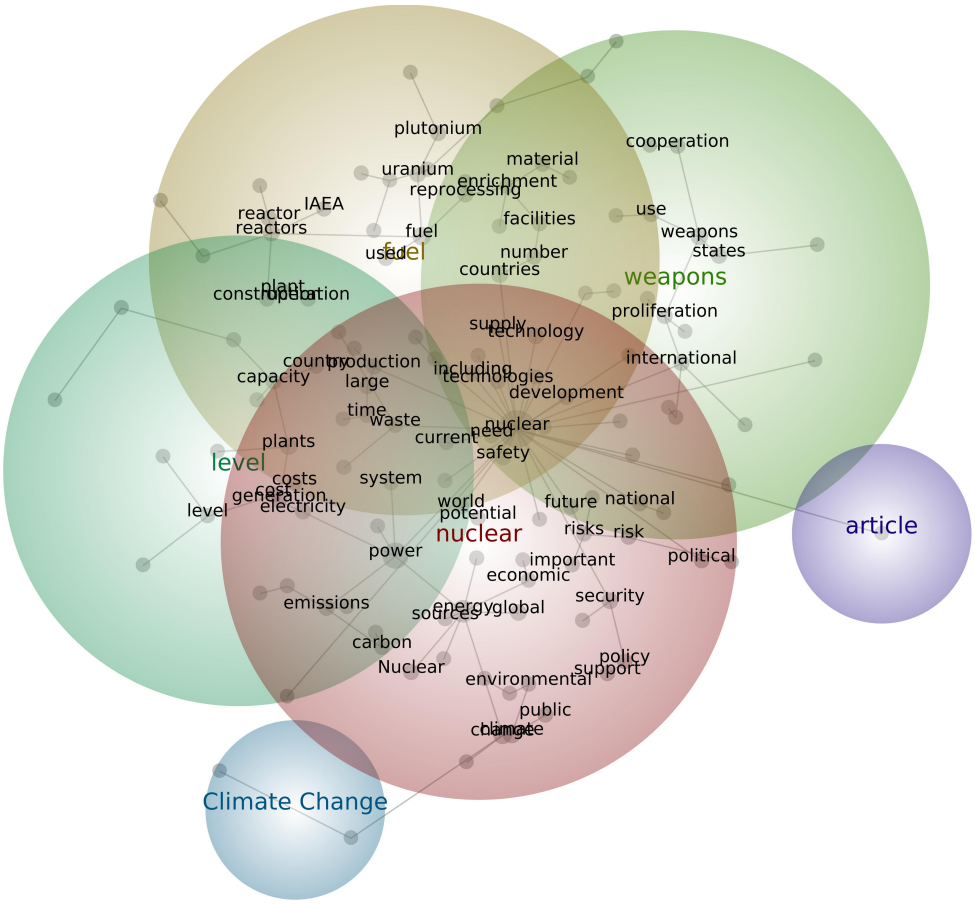

Figure 2: Qualitative Data Analysis Model of the NEXUS [2]

The literature collected was ran through Leximancer to develop this concept map. Initial insights were interrupted directly from the concept map depicted in figure 2 above. You can see the main theme was nuclear with intersections in the weapons and energy themes. It's interesting to point out that Energy Policy is inter-sectional with weapons and energy, and this most likely speaks to the copious amounts of literature that spoke to the affects of energy security and nuclear energy generation and the risks for regional conflict or proliferation of nuclear weapons. This provides information on how relevant energy policy is specifically in the study of clean energy and proliferation, as the link bridging these fields is provided through the energy policy theme.

Moving below the surface the size of the sub-level concepts speaks to their relevance in the literature. The main concepts seen being nuclear, energy, climate change, global security, weapons, and safety. This is supportive of the literature collected and reviewed

in the annotated bibliography as there are issues concerning nuclear technology risks of proliferation and climate change affects on the NPT. There are also relevant issues of safety related to nuclear accidents and radiation form nuclear waste that harmful to the environment.

Moving deeper into the synopsis review developed by Leximancer their are name like concepts with the most relevant being listed as the IAEA, United States, Russia, and China. Using Leximancer you can trace in what context these names were used. This speaks to the literature collected reviewing the nuclear technologies market, and the key role Russia will play in it. As well as the existing literature as to what the US has to lose if Russia is to continue to dominate the nuclear technologies market, as verified through Leximancer's tracing.

The world-like concepts that Leximancer provided established key words like nuclear, power, energy, countries, fuel, reactors, and technology. The relevance of fuel is in the context of the fuel process of nuclear power generation and the risks of proliferation it entails. Leximancer mapped fuel to be linked closely with the IAEA, Russia, and the United States. The IAEA is the responsible for current regulations on fuel reprocessing and enrichment to ensure the safeguard of the NPT are in place, and the IAEA will be pivotal in determining the security of states nuclear programs in the future. Russia has been known to exercise control of states with energy dependence, and their are risks for similar energy dependence given Russia's position in the nuclear fuel and reactor market.

2 Overview

The nexus of climate change, clean energy, and nuclear nonproliferation lacks any lengthy texts that explicitly addresses the intersections of these topics. This next section will represent book length texts that study some intersections of the three topics of interest. Literature in this section includes, excerpts from books, world organization reports, government reports, and review articles. The connection between the topics of interest seems to always be nuclear energy, and complications of such nuclear technologies. The literature in this section suggests nuclear energy will be included in the zero-carbon emissions energy mix. It discusses the possible success and risk of proliferation of the civilian nuclear industry. As well as the national security implications of the nuclear technologies market. The first text positions nuclear energy as a link to climate change and nuclear proliferation separately, but fails to draw a direct correlation. This book was selected because it was determined nuclear energy was an important link in the clean energy, climate change, and nuclear proliferation nexus.

Sovacool, B. K. *The National Politics of Nuclear Power: Economics, Security, and Governance*: 2012. [4]

This book is built on a theory of nuclear socio-political economy highlighting necessary factors needed to introduce nuclear energy into the global energy mix. The framework built is used as a predictive tool to evaluate contemporary nuclear power trends. It's topics covering the implication of nuclear energy as

a renewable energy source and global security, as well as how climate change impacts the nuclear power industry trajectory.

Weinberg, A. ***The nuclear connection: A reassessment of nuclear power and nuclear proliferation*****: 1985. [5]**

This book presents papers on nuclear power. Topics considered include prospects for commercial nuclear power and proliferation, the front end of the fuel cycle, the back end of the fuel cycle, national policy issues, non-proliferation policy, safeguards, controls, and sanctions. Emphasis on nuclear energy affecting both future outcomes of climate change mitigation and nuclear nonproliferation.

Scheffran, Jürgen. ***The Climate-Nuclear Nexus: Exploring the linkages between climate change and nuclear threats*****: World Future Council. 2015. [6]**

This report aims to make a contribution to the discussion on how both the prevailing climate and nuclear proliferation threats may interact with each other. Despite an increased understanding of the climate and nuclear threat and a growing urgency for action on both fronts, little attention has been given to how they may interact with each other. This report attempts to draw these potential links including conflicts as a result of climate change that main result in nuclear weapons deterrence tactics. How climate change induced natural disasters can pose dangers to nuclear installations, and lastly how inter-generational effects are a link between nuclear proliferation and climate change given nuclear testing and climate change effects.

Bunn, Matthew. ***Nuclear disarmament, nuclear energy, and climate change: Exploring the linkages*****: Strategic Studies Quarterly. 2019 [7]**

This book analyses nuclear power trends in relation to climate change. The book studies the implications of the large scale use of nuclear energy that would be needed for climate change mitigation and to meet global energy demands. The need for a global system for verification, control, and security for weapons-usable nuclear materials. So, going back to this idea of a multilateral uranium enrichment facility, or post-fuel cycle international depository.

Kroenig, Matthew. ***Exporting the Bomb Technology Transfer and the Spread of Nuclear Weapons*****: Cornell Studies in Security Affairs. 2010 [8]**

Discusses topics of nuclear proliferation, defense strategy, and international security. Focused on the nuclear weapons arsenal of states, and how every country having one has received substantial help from advanced nuclear states in acquiring their arsenal. This text finds that state decisions to provide sensitive nuclear assistance are the result of a coherent, strategic logic. This presents implications for nuclear proliferation in relation to the nuclear energy market. If economic drivers are not what's causing this transfer of nuclear weapons then the implication of the nuclear energy market in contributing to proliferating are minimised.

3 Journals

The Nexus of nuclear nonproliferation, climate change, and clean energy has not been heavily studied or reviewed in academic journals. To better understand and thoroughly study these interconnections it was best to break apart the research topics into dyads, and study the relationship of these topics in this manner. This produced a significant amount of literature in journals including but not limited to Energies, Energy Policy, Daedalus, Progress in Nuclear Energy, Journal of Global Security Studies, Foreign Affairs, Energies Strategy Reviews, Science & Global Security, and The Journal of Risk. Followed by research within organizational repositories such as the IAEA, NEA, OCED, and INIS that produced

relevant reports. There was limited literature in journals that covered the intersection of all interested topics. It should also be noted that the highest number of publications recorded were from the journal of Energy Policy. Considering the journals scope and aims and nature of the methods used to collect relevant literature this was not surprising.

Progress in Nuclear Energy. 1977 -

An international peer-review journal concerning research topics of nuclear science and related aspects of economics, fuel management, operational safety, and environmental issues.

Energy Policy. 1973 -

Publishes peer-reviewed research on energy policy and supply at a regional, national, and local level. Topics of interest include environmental regulation, energy supply, governmental intervention, energy security, & technological innovation and diffusion. All papers explicitly address policy surrounding energy supply or use.

International Journal of Global Energy Issues. 1990 -

Source of information on topics concerning energy resources, energy-economic systems, international energy policy issues, technological innovations, and new energy sources. Specifically of interest are the publications concerning nuclear energy technology, safety, and waste concerns.

Energy Strategy Reviews. 2019 -

Publishes literature relevant to strategic decision-making of society's energy needs. Energy strategy planning as well as implementation with a focus on quantitative studies that advance the use of energy systems modelling tools.

Energies. 2008 -

A peer-reviewed and open access journal of scientific research, technological development, engineering, and studies related to policy and management.

Daedalus. 1955 -

Explores the frontiers of knowledge and issues that are considered of great public importance. Source of publications are the intellectual capacity of the American Academy of Arts and Sciences.

Journal of Strategic Studies. 1978 -

The aims and scope of the journal of strategic studies is a multidisciplinary approach to the study of war. Consists of review essays, special issues & sections. Recent editions have focused on Chinese defense innovation, sea power in the Asia-Pacific region, and peacekeeping in Africa.

4 Nuclear Energy at the intersection of Climate Change Mitigation & Clean Energy Technologies

It's important to understand if nuclear energy is a viable means of clean energy generation to determine risks of nuclear proliferation in relation to climate change. This section will focus on nuclear technologies particularly whether or not nuclear energy can fulfill it's role as a source of clean energy and used in the fight against climate change. There's multiple arguments as to why nuclear energy will be included in

the clean energy mix as a climate change mitigation strategy.

Duffey, Romney. *Sustainable futures using nuclear energy*: Progress in Nuclear Energy. 2005. [9]

Importantly links the role of nuclear energy in the hydrogen economy. The dual use of nuclear power presents another reason as to why nuclear technologies will continue to develop and be implemented. These technologies still present risks of proliferation of weapons usable material that need addressing.

Borges Silverio, Leticia. *An analysis of development and research on spent nuclear fuel reprocessing*: Energy Policy. 2011. [10]

The article emphasizes the need for management of spent-fuel. It reviews existing and potential technologies for fuel processing in order to be more sustainable, and promote nonproliferation as nuclear energy is developed as a clean energy source.

Kim, Son. *The Challenges and Potential of Nuclear Energy for Addressing Climate Change*: Pacific Northwest National Lab. 2007 [11]

This report investigates the value of nuclear energy in addressing climate change, and the reports the potential challenges associated with rapid and large-scale expansion of nuclear energy in response to climate change. The results of this report indicate that the value of the nuclear technology option for addressing climate change is denominated in trillions of dollars. Challenges of nuclear energy are included as global capacity for nuclear construction, proliferation, waste disposal, and uranium availability.

Lovins, Amory. *US nuclear power: Status, prospects, and climate implications*: The Electricity Journal. 2022 [12]

US case study to review existing nuclear technologies and potential mitigation affects on climate change mitigation. Takes an economics approach to potential of nuclear energy as a clean energy strategy.

Fabienne Gralla. *Energy transitions and national development indicators: A global review of nuclear energy production*: Renewable and Sustainable Energy Reviews. 2017. [13]

This study did not provide evidence that nuclear energy production can be seen as technological answer to global challenges like climate change or unequal energy distribution.

Kessides, Ioannis. *Nuclear Power and Sustainable Energy Policy: Promises and Perils*: The World Bank Research Observer. 2009. [14]

The author examines the challenges and opportunities of nuclear power in meeting the projected large absolute increase in energy demand, especially electricity, throughout the industrialized and developing world, while helping to mitigate the threat of climate change.

Marignac, Yves. *The nuclear option in front of climate change Associated risks, limitations and inhibition to alternatives*: 2015. [15]

This literature presents risks associated with nuclear energy these include: proliferation of weapons, risk of accident, accumulation of waste. The articles also examines how nuclear energy has limited efficiency on emissions reduction.

5 Nuclear Energy at the Intersection of Climate Change and National Security

This section focuses on the risks of regional and global security issues as a result of the nuclear technologies. States positioning in the nuclear market could create dependencies that could translate into national security concern. The concept of nuclear energy as a means for energy security of states. Also, the diffusion of nuclear technologies across the globe is associated with proliferation concerns. Whether nuclear weapons states create regional arms races and how civilian nuclear energy program can lead to weapons development.

Jewell, Jessica. ***The international technological nuclear cooperation landscape: A new dataset and network analysis*****: Energy Policy. 2019 [16]**

Distinguishes nuclear energy as not only a climate change mitigation strategy but also a strategy of national energy security through the pursuit of civil nuclear power programs. The articles studies the long-term interdependencies of states with nuclear technology suppliers, and develops a new database of nuclear cooperation agreements. Findings conclude Russia dominates international technological nuclear cooperation. Concludes with nuclear power having the potential to both carbonize the global energy market, but may introduce new patterns of dependence on nuclear suppliers.

Pradhan, P. K. ***The quest for nuclear energy in West Asia: Energy security or strategic necessity*****: Strategic Analysis. 2010 [17]**

Case study for nuclear energy interests in West Asia. Raises concerns of alternative motives, and whether militarization is the ultimate goal of their nuclear programs. Brings into question the issue of regional security arms races similar to the Gulf Cooperation Council and Saudi Arabia nuclear programs which were deemed to be in the name of countering the Iranian nuclear program.

Meserve, Richard A. ***The global nuclear safety regime*****: Daedalus. 2009 [18]**

Another overview of nuclear energy as a climate change mitigation strategy, but zones in on the need of nuclear safety regime due to proliferating risks of the nuclear technologies market.

6 Nuclear Technologies & the Nuclear Non-Proliferation Regime

Nuclear energy technologies have been prominently known to carry risks of proliferation along with them. In this section we'll review existing technologies and risks, as well as possible institutional arrangements to minimize these proliferation risks.

Lehtveer, Mariliis. ***Nuclear power as a climate mitigation strategy – technology and proliferation risk*****: Journal of Risk Research. 2014. [19]**

Analyses nuclear energy as a climate change mitigation technology, and the important implication for the risk of nuclear proliferation. These implications analysed include uranium enrichment development and reprocessing of spent fuel. Further implications for proliferation arise from the acknowledgement that if nuclear power is to contribute to climate change mitigation alternative fissile material production methods and global diffusion of nuclear technologies is needed. This in turn entails that states with weaker institutional capacity could develop nuclear programs and create a risk for nuclear terrorism, accident or theft.

Goldston, Robert. ***Climate Change, Nuclear Power, and Nuclear Proliferation: Magnitude Matters*****: Science & Global Security. 2011. [20]**

This article discusses nuclear energy technologies as a necessity to the zero-carbon energy mix, and related risks to nuclear proliferation provided certain nuclear technology developments. This is a technical article, but affirms the need for institutional arrangements that can limit the proliferation of nuclear weapons.

Grape, Sophie. ***New perspectives on nuclear power—Generation IV nuclear energy systems to strengthen nuclear non-proliferation and support nuclear disarmament*:Energy Policy. 2014. [21]**

Adding to the literature of meeting climate change goals while securing safe supplies of energy. Also strengthening nuclear nonproliferation while also aiding in the process of reducing stockpiles of nuclear weapons material.

Goldston, Robert. ***Climate Change, Nuclear Proliferation and Fusion Energy*: Princeton Plasma Physics Laboratory. 2010 [22]**

The premise of this article is to assess different clean energy technologies from carbon sequestration to fusion and fast-spectrum fission reactors. The proliferation risks of the nuclear technologies is weighed, and further asserts the concerns for future nuclear technology development.

Milagros Álvarez-Verdugo. ***Will Climate Change Alter the NPT Political Balance? New Challenges for the Non-proliferation Regime*: European Journal of International Law. 2010. [21]**

Reviews how to limit the risk of proliferation within the fuel reprocessing and uranium enrichment processes. It focuses on the possibilities of implementing a multilateral system for uranium enrichment and nuclear fuel-recycling activities. It establishes the economic, political, and legal tensions that would have to be overcome to establish the international program.

Sivaram, Varun. ***The Geopolitical Implications of a Clean Energy Future from the Perspective of the United States*: The Geopolitics of Renewables. 2018. [23]**

This articles discusses the implications of clean energy in the United States and the geopolitics that will result from switching energy production away from fossil fuels. US national and global interest are at stake if the US is to cede market share in nuclear power to countries like Russia and China, that coud lead to increased threats from nuclear proliferation. In the face of the various negative potential implications of a clean energy future, the United States will have an opportunity to advance national and global interests by leading efforts to strengthen international institutions like the nonproliferation regime, confront climate change, and invest in clean energy innovation

7 Transnational Nuclear Technology Market and Non-proliferation

Throughout the literature collection there was a reoccurring theme of issues related to the ownership and marketing of nuclear technologies. Followed by the lack of oversight and reach by IAEA, or any IGO to properly monitor such markets and transactions. The international security implications of these activities will become increasingly important as climate change mitigation strategies are implemented and some of the promising capabilities of nuclear technologies are fully realized. The rise of Russia & China's presence in particular in the nuclear export market is of geopolitical concern. Lack of regulations and oversight by the state owned nuclear firms create a problematic international security issue involving risks of nuclear proliferation & nuclear terrorism via nuclear stockpile insecurity. Due to Russia's overwhelming presence in the nuclear industry market it will most likely do little to improve global nuclear security standards, and the US position and decline in the global market presence puts it at unfavorable odds of challenging them. If Russia & China are to continue their growth in the nuclear power industry, given the expected growth of the industry due to climate change mitigation polices, US security and

international influence could suffer due to these nuclear power market dynamics making this field of research increasingly important.

Russia has a history of using resource wealth as a foreign policy tool, the likelihood that Russia will weaponize it's position in the nuclear energy market and exploit dependency on energy dependent states is high. Specifically Russia's Build, Own, Operate model (BOO) creates dependency on importing countries for much of their energy needs with little to no transfer of technology. China operates under a similar business model under the Belt & Road initiative. This section will cover topics related tot these issues.

David Gattie. *Twenty-First- Century US Nuclear Power A National Security Imperative*: Strategic Studies Quarterly - Perspective. 2020 [24]

This perspective articles captures how important the civilian nuclear power enterprise could be to the strategic sector within the US national security industrial base, and a topic of foreign policy interest. Interrupt's how competing powers are leveraging civilian nuclear collaboration to meet geopolitical objectives.

Lengefeld, M. R. *Nuclear shadows: Weighing the environmental effects of militarism, capitalism, and modernization in a global context*: Human Ecology Review. 2013. [25]

This research considers the cross-national influence of both economic and military development on energy consumption and carbon emissions within the context of civilian and military nuclear development. The results of the study suggests that increased democratization and civilian nuclear energy use fail to afford sufficient value in efficiency to offset carbon-intensive energy use. The results also support the treadmills of production and destruction pointing to compelling evidence of the emergence of risk-transfer militarism.

Williams, R. H. *Diversion-resistance criteria for future nuclear power*: Energy Policy. 1990. [26]

This articles describes how the global civilian nuclear energy industry needs to develop diversion-resistant criteria in order for nuclear power to make a major contribution to global energy. A focus is put on the international safeguards, and their inadequacies to regulate the scale of nuclear power that is needed for states to achieve energy security and curtail climate change.

Department of Energy. *Nuclear proliferation and civilian nuclear power: report of the Nonproliferation Alternative Systems Assessment Program. Volume VII. International perspectives*: Technical Report. 1979. [27]

This report has components that assess the various alternatives for providing assurance of the fuel supply for nuclear energy. It discusses technical and institutional measures and alternatives for various components of once-through and closed fuel cycles. The components of the once-through fuel cycle assessed are enrichment services and spent-fuel management; the components of closed fuel cycles assessed are reprocessing and plutonium management and fast-breeder reactor (FBR) deployment. It discusses risks of proliferation of current nuclear energy technologies.

Saltiel, David. *Strengthening the nuclear nonproliferation regime : focus on the civilian nuclear fuel cycle.*: Journal of Nuclear Materials Management. 2005. [28]

This articles stresses the importance of a international enrichment program to decrease risks of proliferation.

Yim, Man-Sung. *Nuclear nonproliferation and the future expansion of nuclear power*: Progress in Nuclear Energy. 2007. [29]

This paper examines the relationships between the future expansion of nuclear power and the prospect

for world nuclear nonproliferation in light of different technologies.

Nguyen, Viet Phuong. ***Nonproliferation and Security Implications of the Evolving Civil Nuclear Export Market*****: Sustainability. 2019. [30]**

In this paper, the evolution of the market was examined from both the supply and demand sides with issues including the more concentrated and uncertain market, the lack of full participation by emerging suppliers to the nonproliferation regime, and the lesser governance capabilities of the newcomers.

Yusof, Mohammad. ***The Nuclear Suppliers and Non-Proliferation: International Policy*****: Strategic Studies. 1986. [31]**

The book analyzes the policy options of the industrialized states who have to supply nuclear technology and material for peaceful purposes while maintaining non-proliferation goals.

Lovering, Jessica. ***Expert assessments of strategies to enhance global nuclear security*****: Energy Policy. 2020. [32]**

Here we briefly analyze the current international state of play, and then outline a set of specific strategies the U.S. might adopt on its own, or promote internationally, to retain its influence.

Lin, B. ***China's Belt & Road Initiative nuclear export: Implications for energy cooperation*****: Energy Policy. 2020. [33]**

Research regarding the BRI nuclear cooperation is scarce. Given that paucity, this article aims at providing a fuller understanding of the program and policy implications. Distinctive parts include the BRI's economics and new norms reflected to this nuclear cooperation, which draw a range of implications to the global nuclear future.

8 Nuclear Renaissance & Risks of Proliferation

This section will focus on literature that discusses risks associated with global implementation of nuclear energy during what's described as the nuclear renaissance.

Feiveson, Harold. ***Can Future Nuclear Power Be Made Proliferation Resistant?*****: Center for International & Security Studies. 2008. [34]**

Reviews implications of a global expansion of nuclear power and how it could be proliferation-resistant in the long term. International institutional arrangements to oversee nuclear power would have to be largely non-discriminatory and, most importantly, fuel cycle facilities such as reprocessing and uranium enrichment should be under multinational or international authority.

Kim, Philseo. ***Assessing proliferation uncertainty in civilian nuclear cooperation under new power dynamics of the international nuclear trade*****: Energy Policy. 2022. [35]**

This paper analyses bilateral cooperation of civil nuclear technologies, and discusses the risks of proliferation.

Bluth, Christoph. ***Civilian Nuclear Cooperation and the Proliferation of Nuclear Weapons*****: International Security. 2010. [36]**

This articles studies how civilian nuclear assistance overtime increases the likelihood that states will initiate nuclear weapons programs. Creating a causal connection between peaceful nuclear cooperation

and proliferation.

Socolow, Robert H. ***Balancing risks: nuclear energy & climate change*****: Daedalus. 2009. [37]**

The national security community is currently engaged, to an unprecedented degree, in seeking progress toward nuclear disarmament. A byproduct of this process could be different technology choices and innovations in the governance of nuclear power notably, a halt to spent fuel reprocessing to separate plutonium as well as multinational ownership and control of uranium enrichment facilities. These developments could begin to decouple nuclear power from nuclear weapons.

Benea, Ciprian-Beniamin. ***THE ATOM AND CIVILIZATION*****: Revista Română de Geografie Politică Year XIII. 2011. [38]**

This articles adds precedent to the need of nuclear disarmament before nuclear expansion.

Bevins, James E.*Alternate Nuclear Proliferation Pathways in the Age of Non-State Actors*: Transactions. 2017. [39]

This research aims to answer whether indigenous development of SNM is feasible given the current capabilities of non-state actors. Second, it aims to develop methods to screen which approaches should be further investigated to devise and enact general and non-state actor specific countermeasures.

Crozat, M. P. ***Nuclear Fuel Leasing, Recycling and proliferation: Modeling a Global View*****: Nuclear Technology. 2004. [40]**

A system dynamics model was created to simulate fuel cycle interactions between two separate nuclear entities, and this model was employed to investigate fuel leasing arrangements. The model was also adapted to evaluate proliferation and economic implications of an international leasing regime. For a nuclear growth scenario, an open fuel cycle results in extensive spent-fuel accumulation. For a closed fuel cycle, the leasing fuel cycle shows potential to reduce proliferation concern, especially if coupled with improved security and safeguard technology.

Goldschmidt, Pierre. ***Multilateral nuclear fuel supply guarantees & spent fuel management: what are the priorities?*****: Daedalus. 2010. [41]**

This paper reviews the idea of enrichment and reprocessing facilities being constructed and operated under multilateral arrangements. Such an approach is generally viewed as effective in ensuring safe and reliable access to nuclear fuel and services at competitive market prices while strengthening the nuclear nonproliferation regime by removing incentives for countries to develop indigenous fuel cycle capabilities.

9 Attitudinal Nexus of Nuclear & Climate Change

Regulations and safety measures put in place after nuclear accidents have made the development of nuclear plants more expensive. The public perception of the capability of peaceful use of nuclear technology has become increasingly important, and some studies have shown what seems to be an information gap between reality and perception of nuclear technology risks that can lead to desensitized government involvement in nuclear energy. This literature translates the issue of nuclear energy into being concerned with socio-economic factors, apart from proliferation factors. This section will cover literature that presents public perception as the correlation between clean energy, climate change, and nuclear nonproliferation.

Bickerstaff K. ***Reframing nuclear power in the UK energy debate: nuclear power, climate change mitigation and radioactive waste*****: Public Understanding of Science. 2008. [42]**

In this article a case study of the UK and the political debate around energy policy is studied, which reframes nuclear power as part of the solution to the need for low-carbon energy options.

Adam Corner. ***Nuclear power, climate change and energy security: Exploring British public attitudes*****: Energy Security. 2011. [43]**

This article suggests concerns about climate change and energy security will only increase acceptance of nuclear power under limited circumstances—specifically once other (preferred) options have been exhausted. In the end different framing of the issue alter the balance of support for nuclear power as well.

Doyle, Julie. ***Acclimatizing nuclear? Climate change, nuclear power and the reframing of risk in the UK news media*****: International Communication Gazette. 2011. [44]**

This article examines nuclear power policy in the UK and the role it would play in the generation of low carbon electricity. Reframing of new nuclear power as a means of tackling climate change signalled a dramatic U-turn on Labour's commitment to decommission all existing UK nuclear power stations by 2025. This article examines how the UK news media contributed to the reframing of nuclear power as low carbon, and the implications this has for public understanding of nuclear power and climate change.

B. Wang. ***Impact factors of public attitudes towards nuclear power development: a questionnaire survey in China*****: International Journal of Global Energy Issues. 2013. [45]**

This study investigates public attitudes towards nuclear power in China. The key point of this investigation is attitude analysis, which indicates that the attitudes towards nuclear power are complex and uncertain. It suggests that when regarding nuclear power as a response to climate change or energy security, the public will support nuclear power development conditionally.

J. Baron. ***Public opinion on nuclear energy and nuclear weapons: The attitudinal nexus in the United States*****: Energy Research & Social Science. 2020. [46]**

This study provide evidence of psychological linkage, and discusses how attitudes toward nuclear weapons may even drive those on nuclear energy.

Vainio, Annukka. ***Weighing the Risks of Nuclear Energy and Climate Change: Trust in Different Information Sources, Perceived Risks, and Willingness to Pay for Alternatives to Nuclear Power*****: Risk Analysis. 2017. [47]**

This article looks at how individual perceive nuclear energy in the context of climate change mitigation and how these perceptions are associated with trust in different risk information sources. It analyzes the interrelationships between trust, perceived risk of nuclear power, climate change concern, perception of nuclear energy as an acceptable way to mitigate climate change, and willingness to pay for alternatives to nuclear power.

Pampel, Fred. ***Support for Nuclear Energy in the Context of Climate Change: Evidence From the European Union*****: Organization & Environment. 2011. [48]**

This text also takes a public perception look at nuclear power support and future prospects. Finds that at the individual level, high socioeconomic status tends to increase support for nuclear energy. At the national level, the presence of operating nuclear power plants in a country leads to higher public support. Both these results more strongly support arguments focusing on the importance of familiarity with the technology than arguments focusing on postmaterialist values.

Kessides, Ioannis. ***The future of the nuclear industry reconsidered: Risks, uncertainties, and continued promise*****: Energy Policy. 2012.** [49]

In this article the historical cost escalation in nuclear power is analyzed, the impact of Fukushima is assessed, the new reactor technologies are examined, and the deployment of small modular reactors is assessed.

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