Board Buddies: A Modern Method of Recreation to Circumvent Screen Time

Impact of Nuclear Fusion Technologies on the Global South

A Thesis Prospectus
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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Introduction

The technical project on which I have been working on throughout the semester for the Electrical & Computer Engineering Department is Board Buddies, an interactive and physical version of the famous board game Othello. During the COVID-19 pandemic, many people were forced to maintain their relationships digitally — parents, siblings, couples, friends, etc. were not able to physically interact with each other and thus resorted to digital versions of their favorite activities. Many would play their favorite games or interact with each other on a screen, the abuse of which can lead to mental health issues. As a result, we developed Board Buddies as a pair of physical game boards which can remotely play games with each other over long distances. The boards communicate over Wi-Fi and use push button actuation for the tiles.

The STS research project I chose was investigating the potential impact of nuclear fusion on the Global South's economy. While many other components of an economy are crucial to its health, energy is a well-documented and generally-applicable corollary for most currently "developed" nations. Energy is incredibly important to a nation's development, particularly in its early stages; considering the environmental impact of retrieving energy from polluting sources, we need to replace our current harmful energy sources with clean and reliable ones. Therein lies a question of what negative externalities are produced alongside such a massive economic boom, and whether they can be completely circumvented with cleaner sources. A renewable energy source is to be considered, one which may have major upfront costs but saves money in the long term. Enter nuclear fusion reactors: nuclear fusion has been heralded for many decades as the "golden egg" of energy production, being able to produce virtually unlimited clean energy while using inputs such as seawater and producing only traces of nuclear waste relative to its sister technology, nuclear fission (The Economist, 2022).

Technical Project: Board Buddies

The overall purpose of the Board Buddies project was to develop a method for people to be able to play board games with loved ones without either close contact or any sort of screen time. The project was developed so users can play recreational games, namely Othello, over long distances without any turn lag, as well as not spend too much time in front of a digital version of the game. Physically interacting with the boards also involves people with the game more than using extensions of computers, i.e. keyboards or computer mice.

Board Buddies consists of two physical game boards built using wood and 3D printed acrylonitrile butadiene styrene (ABS). The boards communicate with each other over Wi-Fi using a Raspberry Pi Pico W communicating with an MSP430 microcontroller with the commonly-used universal asynchronous receiver-transmitter (UART) serial communication protocol. A full printed circuit board (PCB) was designed for each game board to house the microcontroller, Raspberry Pi, and other components such as a liquid crystal display (LCD) and power supply.

Ultimately, the user interface of the Board Buddies system is incredibly polished. Tactile

push buttons are used to simulate tiles being pressed, and each of the sixty-four tiles is also equipped with a light emitting diode (LED) to flash colors that represent the game state. There is virtually no turn lag, and the LCD displays the current turn, errors for invalid moves, and a final game-winning or -losing message.

STS Project: Nuclear Fusion in the Global South

Overview

As consumer demand skyrocketed throughout the 20th century during the Second Industrial Revolution, the United States saw a rise in primary energy production from 9.1 quads (quadrillion British thermal units) in 1900 to 97.7 quads in 2000, corresponding to a 973.6% increase in primary energy production over a century (US Energy Information Administration, 2009). Although the United States stands as a large contributor to the world's energy economy, other countries have substantially risen in energy production as well – in 1900, the world consumed approximately 41.39 quads in 1900, which rose to 418.82 quads in 2020, an overwhelming 911.9% increase in world energy production across the globe (Ritchie et al., 2022). Considering this trend of progressively increasing energy production, the correlation between energy and economic prosperity becomes more obvious. Global gross domestic product (GDP) per capita has also been rising steadily over the centuries. There lies an exponential relation between annual energy use per capita (kWh per person) versus GDP per capita for nearly every country which is documented (Our World in Data, n.d.), indicating an incredibly strong link between general energy usage and economic stimulation. A rapid increase in per capita waste and pollution has also historically accompanied the rapid boom in economic and energy prosperity (US Energy Information Administration, 2009).

How can we predict the impact of a massively consequential development such as successful nuclear fusion reactors? This is a difficult problem; not only are economics chaotic and notoriously difficult to predict, but social groups and their responses to technological trends are entirely unpredictable. However, we can draw a broad comparison between the Global North's transition to fossil fuels in the 20th century to a hypothetical transition for the Global South to nuclear power in the 21st or 22nd century. While much of this lies on speculation, multiple key sources from scientists, political activists, and economists will be considered to extrapolate what kind of impact nuclear might have in the future.

The Global Divide: A Brief Introduction

The term "Global South" is used to describe a group of countries with similar socioeconomic and political characteristics. It is often used to represent regions within Latin America, South and Southeast Asia, Africa, and some of Oceania. Countries within the Global South have historically been grouped into more abrasive terminology, such as "Third World" or "Periphery", mostly to denote that these countries have an overall lower income or a

marginalizing culture and political landscape. The other side of these countries is the "Global North", often associated with more positive terms like "developed" or "First World" countries.

Due to a number of events throughout history, it should be noted that the Global South has experienced a slew of bad outcomes such as hunger, low energy production, income inequality, impacts of colonialism, election tampering, political and economic freedom, and many more. Fortunately, in the 20th century, many Global South leaders became much more involved in international politics, including leaders from Saudi Arabia, China, and India. This trend has led to the potential of high economic growth and industrialization, evident after these countries became privy to various high density energy sources such as petroleum and coal. Given that these energy sources are cheap, widely available, and high in energy output, it is a logical solution for budding nations looking to boost economic growth quickly and make a mark in international markets. Indeed, these are the same energy sources used in the past by countries now considered to be "developed", such as the United States.

While it may seem natural to criticize countries for using fossil fuels, it should be noted the Global South has far less capital to invest in energy sources with such high upfront costs like solar, wind, or geothermal energy farms; it is also logically fallacious to diminish their accomplishments considering many of the hallmarks of the Global North were achieved using "dirty energy", just the same as Global South countries in the same economic stage now. The relevant social groups in this scenario are those impacted by such an economy, including the governments in each respective nation as well as the citizens who use that energy (Ritchie et al., 2022).

Many countries in the Global North, including the United States, Canada, and those in Western Europe, have benefited significantly from the use of fossil fuels such as coal, oil, and natural gas. These countries have experienced rapid economic growth and industrialization over the past century, largely fueled by the abundant and cheap energy provided by fossil fuels. This has led to the development of modern infrastructure, transportation systems, and advanced technologies, as well as the creation of millions of jobs and the generation of significant wealth.

However, the use of fossil fuels has also had negative consequences, both for the countries in the Global North and for the rest of the world. The extraction, transportation, and consumption of fossil fuels has caused significant environmental degradation, including air and water pollution, land destruction, and climate change. In addition, the reliance on fossil fuels has contributed to global inequality, as many countries in the Global South have been exploited for their natural resources and have suffered the negative environmental and social impacts of fossil fuel extraction, while receiving little of the economic benefits. Finally, the over-consumption of fossil fuels has led to resource depletion, and the world is facing the challenge of transitioning to more sustainable energy sources in the future (Mann, 2021).

The Next Industrial Revolution

A key text I will use is M.E. Mann's recent book on climate change, energy markets, and the Global North's impact on environmental psychology across the world. Fossil fuels, such as

coal, oil, and natural gas, played a major role in the Industrial Revolution of the 18th and 19th centuries, which led to the rapid economic development and industrialization of many countries in the Global North, including the United States, Canada, and those in Western Europe. The abundance and cheapness of these energy sources helped to power the development of modern infrastructure, transportation systems, and advanced technologies, as well as the creation of millions of jobs and the generation of significant wealth. However, the use of fossil fuels has also had negative consequences, including environmental degradation, climate change, and global inequality (Mann, 2021).

Nuclear power has the potential to provide a (sometimes) clean and potent source of energy that could help to spur an industrial revolution in countries in the Global South. Nuclear fission is the process of separating light atomic nuclei to release energy, and has the potential to be more sustainable than fossil fuels. If successfully commercialized, nuclear fission could provide a reliable and almost carbon-free source of electricity that could help to power economic development and industrialization in countries in the Global South (Sovacool et al., 2020).

On the other hand, nuclear fusion is a promising source of abundant energy that has the potential to revolutionize the way we power the world with clean, nearly limitless energy by instead *combining* light atomic nuclei to release energy. This makes it a particularly attractive option for countries in the Global South, which often face challenges related to energy access and sustainability. If successfully developed, nuclear fusion could provide a reliable and affordable source of energy for these countries, helping to drive economic development and improve quality of life. However, it is currently in its very early stages of development, and there are many technical and scientific challenges that need to be overcome before it can be used as a practical energy source. Despite these challenges, there is a great deal of hope and optimism about the potential of nuclear fusion, and many researchers and scientists are working to make it a reality (Turrell, 2021).

Methods and Roadmap

A general timeline I will use to research this project is spending the majority of the earlier stages developing a coherent argument using multiple sources as well as the key texts. A full outline for the project can be written and revised over time using these sources, and the main points will follow. This outline will be extensive as most of the research will be done prior to a full draft of the thesis. A few drafts of the prospectus itself will be developed to work out details and content issues, especially regarding economic details for specific countries.

During the outline process, I will consider counter-arguments for nuclear fusion; many groups have voiced concerns over nuclear fusion, including climate activists, politicians, and scientists who believe it may never come to fruition. These counter-arguments will be bridged with my research to develop a cohesive argument for developing nuclear fusion for social groups within the Global South while considering the opposing side.

I expect to need two reviews of the project. A quick review from Professor Earle at the beginning of the semester is important, after which a review after fleshing out a full outline would close it out.

Key Texts

The Sovacool Nature paper (Sovacool, 2020) discusses the massive carbon emission reduction possible by switching to a nuclear fission based power system. The purpose of citing this paper is to give a tangible, real-world piece of evidence that nuclear power has vastly more potential than fossil fuels. The analysis by Ali (Ali, 2020) is a comment on Sovacool's paper, where he gives a narrative to the subject as he discusses the push for more atomic energy research. Overall, the two work together as a single key text to develop a narrative concluding that nuclear fission power is not only powerful but clean, and nuclear fusion power will do more than that.

The paper by Cardozo (Cardozo, 2019) clearly outlines the current state of nuclear fusion energy. The paper extends its analysis from current science and economics to what is expected in the future, as well as how we can accelerate the technology to that scale as fast as possible. I will use this paper as a key text to develop a foundational understanding of how fusion will impact economics, then extrapolate to the Global South.

Mann's book (Mann, 2021) is an example of a climate scientist giving the current state of climate change, the effects of capitalism on the global economy, the Global North's impact on the Global South through environmental racism and psychology, and what we can do to combat the beast of climate change. I will use this source as a key text to analyze both the Global Divide and how energy is in the mix in the context of economics.

Turrell's book (Turrell, 2021) is a very recent publication which outlines the trajectory, current state, and future potential of nuclear fusion as a technology. It outlines the possible effects on climate change, energy markets, and global economics as a consequence of nuclear fusion's development. This source is a key text, and it will help me develop my arguments for nuclear fusion's future potential.

Bibliography

Ali, Saleem H. (2020, November 14). Nuclear Nemesis: will climate change revitalize atomic energy? Springer Nature Sustainability Community. https://sustainabilitycommunity.springernature.com/posts/nuclear-nemesis-will-climate-change-revitalize-atomic-energy

Ali's article and Sovacool's paper work together as a single key text to develop a narrative concluding that nuclear fission power is not only powerful but clean, and nuclear fusion power will do more than that. This is half of one key text.

Cardozo, N. J. L. (2019). Economic aspects of the deployment of fusion energy: the valley of death and the innovation cycle. Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 377(2141), 20170444. https://doi.org/10.1098/rsta.2017.0444

This paper clearly outlines the current state of nuclear fusion energy. It extends from current science and economics to what is expected in the future, as well as how we can accelerate the technology to that scale as fast as possible. I will use this paper as a key text to develop a foundational understanding of how fusion will impact economics, then extrapolate to the Global South.

Mann, M. E. (2021). The New Climate War: The Fight to Take Back Our Planet (1st ed.). Publicaffairs, Hatchette Book Group.

Outlines the current state of climate change, the effects of capitalism on the global economy, the Global North's impact on the Global South through environmental racism and psychology, and what we can do to combat the beast of climate change.

Nast, C. (2021, October 1). Can nuclear fusion put the brakes on climate change? The New Yorker. https://www.newyorker.com/magazine/2021/10/11/can-nuclear-fusion-put-the-brakes-on-climate-change

This article is written as an opinion piece on how climate change could be positively impacted by the use of nuclear fusion. While much of the article is speculation, some recent papers are also used to justify the use of fusion in the context of an energy crisis like we have now. I will use this piece of evidence in an effort to show the specific impact nuclear fusion would have on climate change.

Our World in Data. (n.d.). GDP per Capita vs. Energy Use. Our World in Data. Retrieved December 16, 2022, from https://ourworldindata.org/grapher/energy-use-per-capita-vs-gdp-per-capita?time=latest

Developed by Our World in Data Energy to give a visual representation of GDP per capita versus energy use of a nation.

Ritchie, H., Roser, M., & Rosado, P. (2022). Energy Production and Consumption. Our World in Data. https://ourworldindata.org/energy-production-consumption

Energy Production and Consumption written by Ritchie *et al*. lists an extensive number of datapoints regarding which countries produce and consume the most amount of energy, relatively speaking. They also outline the comparison between energy use per capita versus GDP per capita, so there are other metrics to explore. This is important when I will contrast the Global North and South in energy use.

Sovacool, B.K., Schmid, P., Stirling, A. et al. Differences in carbon emissions reduction between countries pursuing renewable electricity versus nuclear power. Nat Energy 5, 928–935 (2020). https://doi.org/10.1038/s41560-020-00696-3

The Sovacool Nature paper discusses the massive carbon emission reduction possible by switching to a nuclear fission based power system.

The Economist explains. (2022, February 9). *What is nuclear fusion?* The Economist. https://www.economist.com/the-economist-explains/2022/02/09/what-is-nuclear-fusion

The Economist runs a column called "The Economist Explains" which outlines basic concepts for advanced topics. This issue covered nuclear fusion; generally, I will use this citation to give a basic overview of nuclear fusion currently. The technology needs to receive a proper treatment in terms of where it is in development, and this article does that.

Turrell, A. (2021). The Star Builders: Nuclear Fusion and the Race to Power the Planet (1st ed.). Scribner.

Outlines the possible effects on climate change, energy markets, and global economics as a consequence of nuclear fusion's development.

US Energy Information Administration. (2009). History of Energy Consumption in the United States, 1775–2009. Eia.gov. https://www.eia.gov/todayinenergy/detail.php?id=10

This source is a dataset which shows, visually, the change over time of different countries in terms of energy consumption. I will use this as a supportive piece of evidence to outline how countries have, over time, drastically increased their energy consumption. This will emphasize how important it is to conduct an analysis on energy.