The Increasing Problem of Electric Power Consumption

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Introduction

The main variable I will be discussing in this paper is electric power consumption. I will mainly be analyzing the electric power consumption of the world as a whole, but will also look at smaller subsets of countries. In this case, electric power consumption is measured in kilowatt-hour per capita. The description of the dataset describes electric power consumption as the measure of "the production of power plants and combined heat and power plants less transmission, distribution, and transformation losses and own use by heat and power plants" (World Bank Group, 2014). This number is then divided by the population to arrive at kilowatt-hour per capita.

This measure is important because electric power is crucial to daily life. According to the Environmental Protection Agency, the electricity produced by power plants is used in a variety of ways. This includes but is not limited to heating, lighting, electronics, refrigeration, and manufacturing. There are also many different fuel sources for electricity. Some of those sources are gas, coal, and solar. Despite the benefits of electricity production and consumption, there are also costs associated. Burning fossil fuels in order to power power plants leads to air pollution. This air pollution can harm both humans and the environment. Acquiring these fossil fuels is also costly. Drilling and extracting can negatively affect the soil and water in the area (Environmental Protection Agency, 2024).

Electric power consumption is a variable of interest because many people reap the benefits of electricity. However, consuming electricity can also harm the planet we live on. It is important to monitor the amount we consume to avoid overconsumption. It is also important not to deplete our resources.

Data Source

This data is taken from the World Bank Group DataBank. Specifically, it is from the World Development Indicators collection. This time-series data covers 43 years, spanning from 1971-2014. Data was collected annually. 217 countries and territories are covered in this data. However, there are some values missing from the dataset. Not all countries have numbers from every year. The data can be split up into subsections as well. You can select whatever countries or territories you want. You can sort by region as well. You can also look at other factors such as socioeconomic status, specifically income levels.

Data Analysis

The following figure, Figure 1, was obtained from the World Bank Group DataBank website:

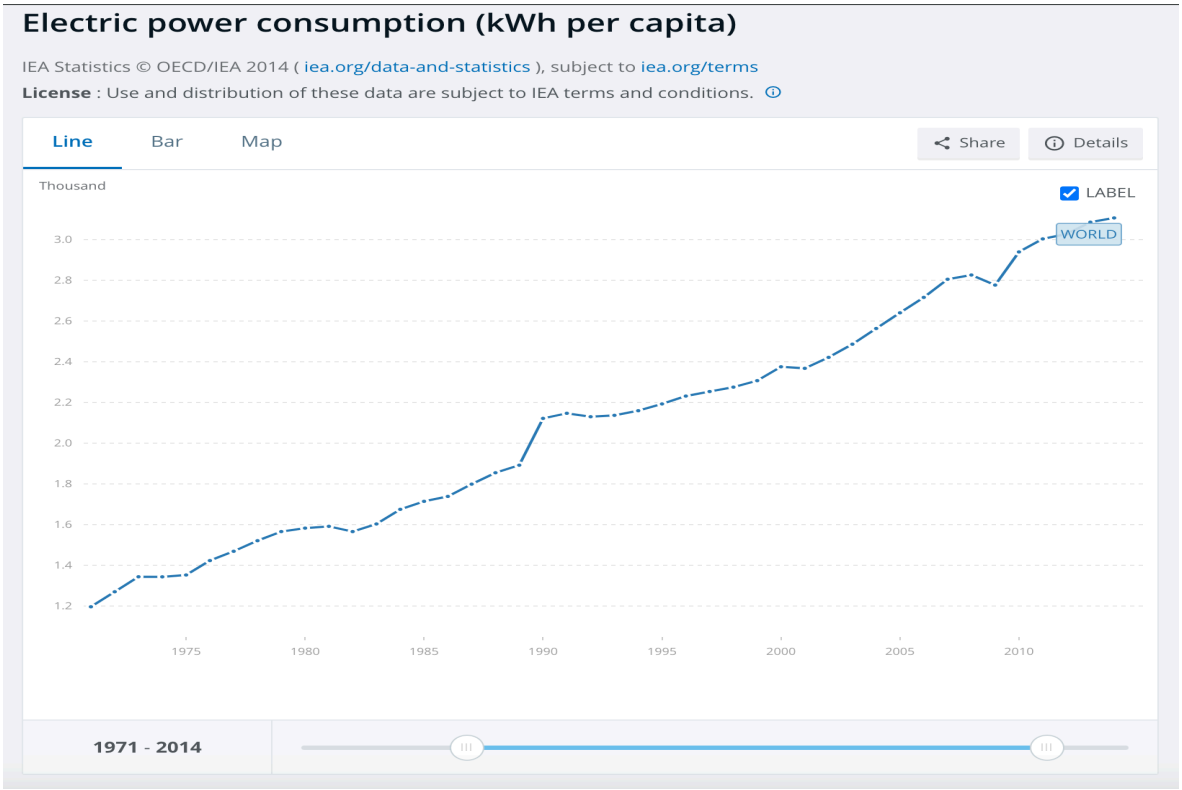

Figure 1 (World Bank Group, 2014)

Figure 1 depicts the world electric power consumption from 1971-2014. The overall trend appears to be linear. As time goes on, electric power consumption increases. This is true for almost every year. There are multiple relative maximums on the graph as well. Those are in 1991, 2000, 2008, and 2014. There are only five instances of electric power consumption decreasing. Those are from 1973-1974 (-1 kWh per capita), 1981-1982 (-25 kWh per capita), 1991-1992 (-17 kWh per capita), 2000-2001 (-8 kWh per capita). The largest decrease occurred from 2008-2009, with a change of 49 kWh per capita. Most of these decreases immediately

follow a peak on the graph. It is also interesting that most of these decreases are all right before or after the start of a new decade. It is also something to note that electric power consumption is never decreasing more than one year in a row. The lowest point on the graph is in 1971, the first year data was collected.

I was also interested in how smaller subsets of countries compared to one another. The following figure, Figure 2, is from the World Development Indicators website. It shows countries that are classified as having low income, with the majority of countries being located in Sub-Saharan Africa. Some of these countries in this income range include the Democratic People's Republic of Korea, Syrian Arab Republic, Mozambique, Sudan, Niger, Ethiopia, and Togo.

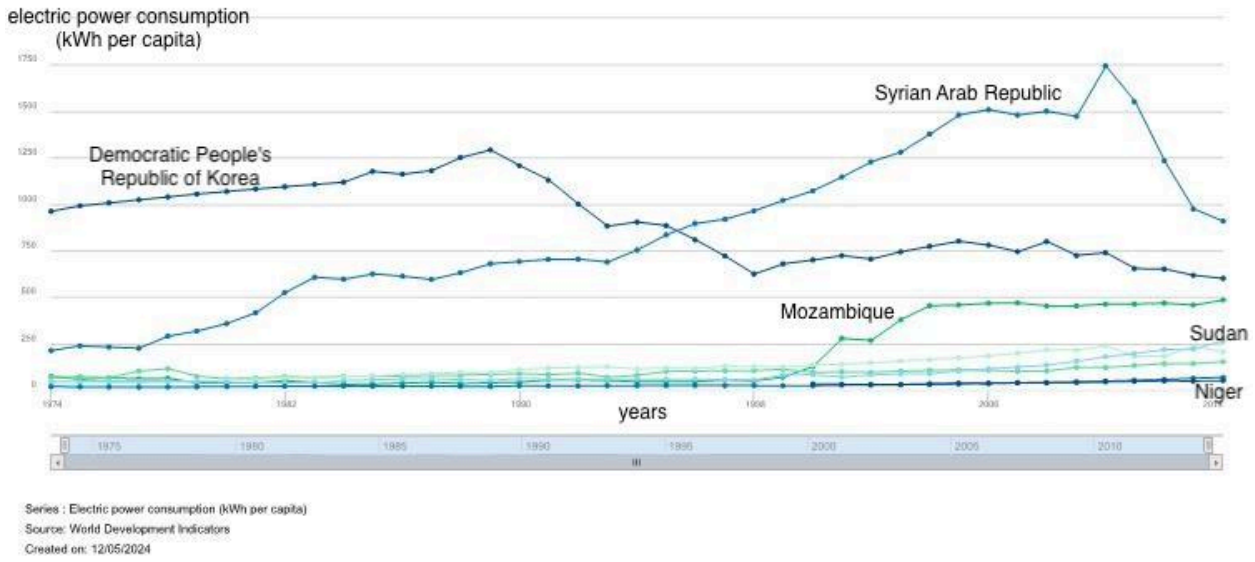

Figure 2 (World Bank Group, 2014)

This graph is vastly different from the one of the whole world, Figure 1. The minimum point of all countries was 17.2 kWh per capita in Ethiopia in 1974. This is way below the world average. There are also many countries where there is such a small increase in electric power

consumption that the line graph appears constant. Thi trend describes countries such as Ethiopia, Sudan, Togo, and Senegal. There are also cases of countries in which electric power consumption decreases over a multi-year span. The Democratic People's Republic of Korea's consumption dropped from 1291.6 kWh per capita in 1989 to 624.1 kWh per capita in 1998. After making constant increases since 1974, the Syrian Arab Republic also dropped from 1744 kWh per capita in 2010 to 908.5 in 2014. It is possible that the electric power consumption by the Syrian Arab Republic is still dropping considering the data stops in 2014.

Figure 3, pictured below, is also from the World Development Indicators website. However, this figure depicts countries with middle income exclusively, which is then divided between lower middle income and higher middle income.

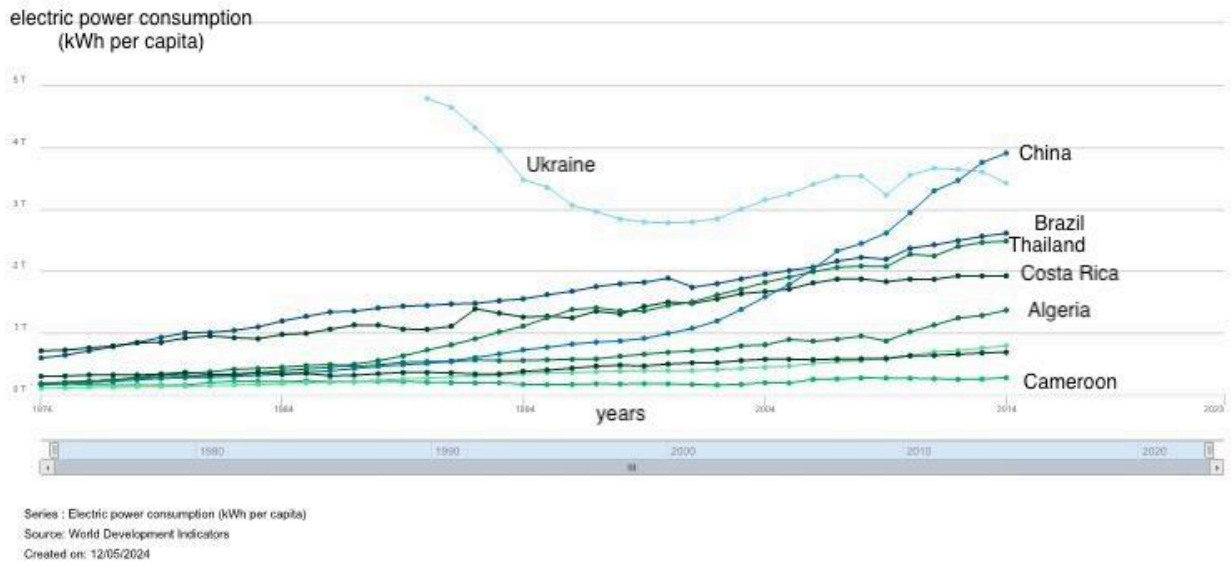

Figure 3 (World Bank Group, 2014)

The trends of these countries are closer to matching the trends of the world as a whole. Some countries included in this range are Ukraine, China, Brazil, Thailand, Costa Rica, Algeria, and Cameroon. The electric power consumption for these countries is increasing faster than the

low income countries, but not as fast as the world. China in particular had a rapid rise from 2000-2014, increasing their electric power consumption by 2912.4 kWh per capita. The case of Ukraine is something interesting as well. The shape of Ukraine's consumption is convex, which is something I have not seen in other countries. The maximum value for Ukraine is 4,787.5 kWh per capita, and it was actually during the first year data was collected for the country in 1990. Electric power consumption then drops until 2000. Consumption then starts to increase again before becoming relatively constant.

Finally, I wanted to see the electric power consumption of high income countries. Figure 4, pictured below, is from the World Bank Indicators website as well. It shows high income countries such as the United States of America, Canada, Finland, Japan, Austria, and Chile.

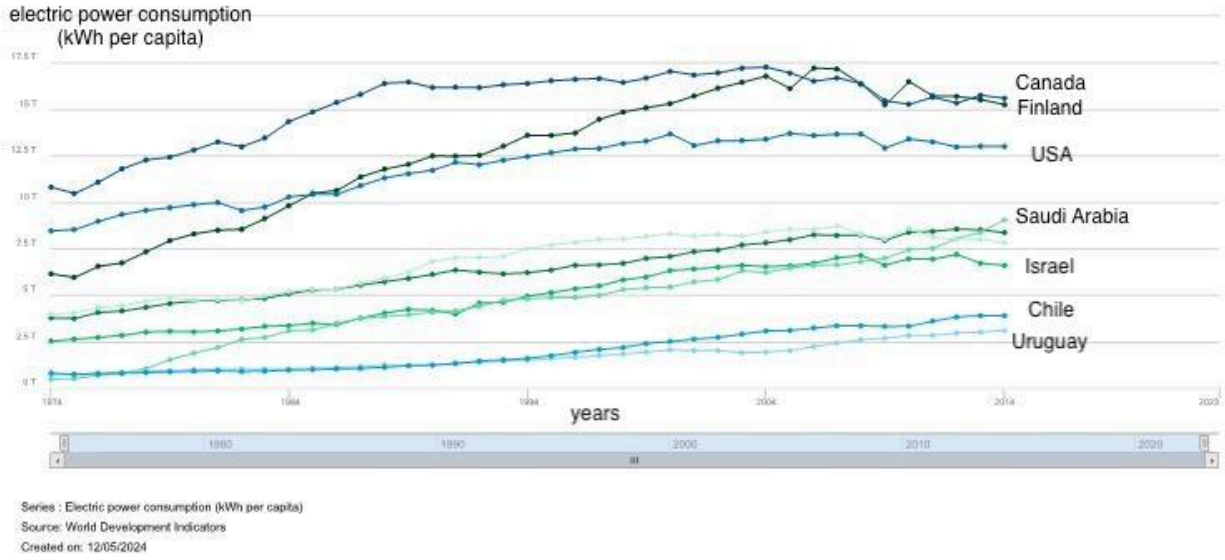

Figure 4 (World Bank Group, 2014)

This graph actually surprised me a little bit. I expected the slope of the lines to be much steeper than they actually are. The increase of electric power consumption is gradual instead of immediate. One possible explanation for this is the starting values for these countries. In 1974,

Finland, Canada, and the United States of America all had a kWh per capita of over 6,0000. This high starting point makes the increase seem not as large. It is interesting to note that Finland had the largest increase of these select countries. The country went from 6,140.2 kWh per capita in 1974 to 15,250 kWh per capita in 2014.

By taking a holistic view of low, middle, and high income countries, it is easy to see that the trends differ. The developing countries, those with low income, started with very low electric power consumption in 1974. The increase happens very slowly over time for most of the countries. On the other hand, the consumption of high income countries is much different. These developed nations start with a much higher electric power consumption than any other group. They had already been consuming a lot of electricity by 1974. These countries then have a very steady increase of consumption. After that, there are some countries where the consumption has started to level off. This is the case for countries like the United States of America, Canada, and Finland starting around 2004.

It is clear that the electric power consumption of the world as a whole is increasing rapidly. However, looking at countries separated by income tells a different story.

Economic Analysis

There are many reasons why the increasing electric power consumption is a potential problem. The main problem is that there are negative externalities associated with producing all of this electricity. According to the European Environment Agency, "it is nearly impossible to produce, transport, or consume energy without significant environmental impact." The agency then goes on to describe in detail why this is the case. They state that burning fossil fuels contributes to air pollution. Coal mining and the handling of oil can lead to water pollution. Mining can also produce solid waste that needs to be disposed of (European Environment Agency, 2017). As electric power consumption increases, as we have seen in the previous figures, so will all of these problems. Fossil fuels are nonrenewable resources. Once we use them up, they are gone forever. Additionally, burning these fossil fuels out harmful pollutants into the air. Not only could the problem of increasing electric power consumption be classified as an externality, but it could also be a tragedy of the commons problem. I will mainly be analyzing how to solve the externality problem.

From a property rights perspective, some of the problems of increasing electric power consumption can be solved. However, this is not the case for the whole problem. The solution involves Renewable Energy Credits, or RECs. An article from the Harvard Law Review, titled "Renewable Energy Credits as Property," describes the use of these credits. The article defines RECs as "tradeable assets that allow a party to claim that it uses electricity produced from renewable resources" and "a tool to pursue policies that support decarbonization of the electric grid (Harvard Law Review, 2024)." RECs provide a way for people or companies to trade or own the right to electricity. This supports a more efficient way of electric power consumption. The problem of these Renewable Energy Credits is seen in their very name: they only work for

renewable resources. This is a problem because most electricity comes from burning fossil fuels. Despite this, RECs are beneficial in promoting clean energy production.

There are many different policies and types of policies that can be used to solve this problem. There are both command and control and incentive-based policies. We have discussed different command and control policies in class. Factories may be regulated to install smoke stack scrubbers in order to reduce emissions. However, this can be inefficient. Command and control policies are a one size fit all solution. Factories may know a better way to reduce these emissions, but cannot implement these solutions in order to comply with the policy put in place. Incentive-based policies are much more efficient. As the name suggests, these policies give the firm economic incentives to comply. This is not only good for the environment (in my case), but is also good for the economy.

An example of incentive-based policy in particular was put in place in Japan. These policies are called incentive-based demand response programs (IBDRPs). An article by Ladan Malehmirchegini and Hooman Farzaneh discussed these programs. The idea of these programs are for people to cut back on electric power consumption during high-use times in exchange for incentives from the provider. They found that the customers' "welfare is higher with more reduction in electricity from incentive incomes" (Malehmirchegini & Farzaneh, 2023). It is clear from this article that customers are more satisfied with using less electricity. Emissions will also be reduced in the process, since less electricity is being produced. A cost of these programs is that you will be using less electricity, and must substitute it with something else. The benefits are the incentive incomes you receive from reducing electric power consumption.

By looking at the trends in the data, it does seem like the policy is working. Japan has had relatively constant or even decreasing electric power consumption as recently as 2014.

Conclusion

Electric power consumption of the world has been increasing overall, although the income level of countries shows different rates of increasing. These results did not really surprise me that much. I think incentive-based policies currently work best to slow down this increase or even lead to a decrease. I think the reason for this is because money is the best incentive. Even if you care about the environment, you may not actually contribute to the solution unless there is an economic incentive to do so. In the future, I predict that electric power consumption will continue to rise before leveling off worldwide. Developing countries will rapidly increase their consumption before all countries' consumption becomes constant.

References

Environmental Protection Agency. (2014, October 21). *Electric Power Sector Basics*. EPA. https://www.epa.gov/power-sector/electric-power-sector-basics#howiselectricityused

European Environment Agency. (2017, February 14). *Environmental impact of energy*. European Environment Agency. https://www.eea.europa.eu/help/glossary/eea-glossary/environmental-impact-of-energy

Harvard Law Review. (2024, January 10). *Renewable energy credits as Property*. Harvard Law Review. https://harvardlawreview.org/print/vol-137/renewable-energy-credits-as-property/

Malehmirchegini , L., & Farzaneh, H. (2023, April 16). *Incentive-based demand response modeling in a day-ahead wholesale electricity market in Japan, considering the impact of customer satisfaction on social welfare and profitability*. Sustainable Energy, Grids and Networks. https://www.sciencedirect.com/science/article/abs/pii/S2352467723000528#:~:text=Incentive%2Dbased%20demand%20response%20programs,the%20service%20provider%20(SP).

World Bank Group. (2014). *Electric Power Consumption (kwh per capita)*. World Bank Open Data. https://data.worldbank.org/indicator/EG.USE.ELEC.KH.PC?end=2019&name_desc=false&start=1970&view=chart