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A Historical Analysis of The Energy Sector on a Global Scale

Our access to energy is a central component in our lives that is often easy to overlook. In the past year, global energy markets have been notably impacted by conflicts in Eastern Europe and for many of us, the price of gas which is central to our daily lives has fluctuated all over the map. The Russia-Ukraine conflict has resulted in certain trade restrictions on Russia and forced many countries to obtain energy resources from other producers or perhaps invest more in the domestic production of energy. The situation has raised questions surrounding the globe's dependency on Russian natural resources and prompted conversations about what changes could make the economy less vulnerable to geopolitical events. An article from the International Energy Agency discusses the shift away from Russian exports of fossil fuels and discusses how this event has spurred efforts to restructure the energy sector (IEA, 2022). While it may be difficult to predict what may happen in the energy sector in the coming years, it is worth looking back at historical data to identify key players and examine trends to understand what shifts the industry has experienced in the past.

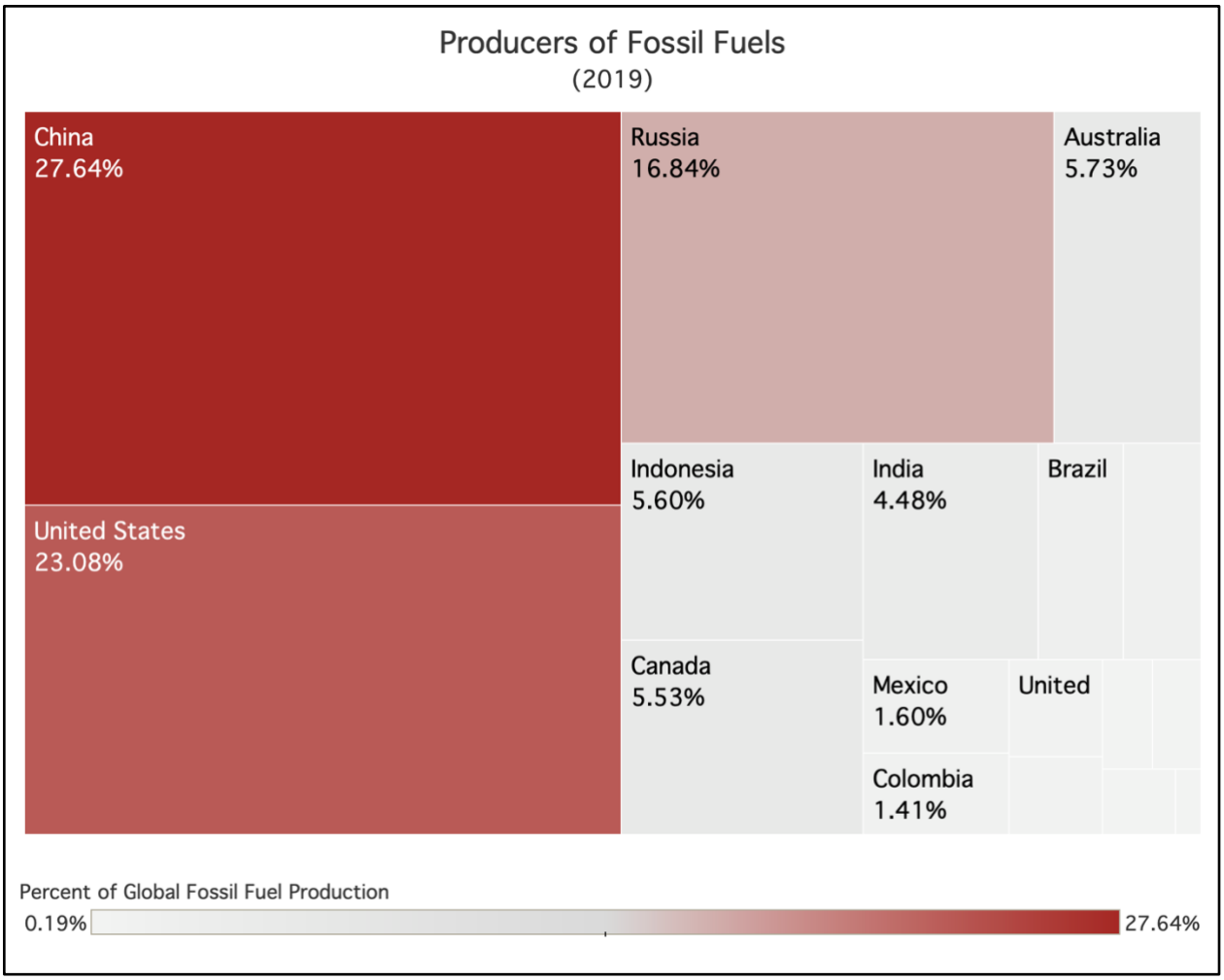
The energy sector is deeply rooted in the trading and utilization of fossil fuels. Resources like coal, natural gas, and oil have been the primary sources of energy for decades and few countries have taken the substantial initiative to shift away from these sources. An article from the Institute for Energy Economics and Financial Analysis

discusses how a shift to renewables on a large scale may be more tenable now that fossil fuel costs have been driven up and are highly volatile (Jaller-Makarewicz, A. M., n.d.). It is important to recognize the prevalence of fossil fuels and grasp how deeply we rely on their availability. To get a glimpse into energy trends before the changes we see post-pandemic and after the invasion of Ukraine, this study focuses on energy consumption data from 1989 to 2019. This allows us to capture a significant window of time in recent history and focus on reliably reported data available in more countries than a long-term analysis could provide.

When we want to understand the structure of an industry, it is important to identify who the key players are. In this case, it is crucial to identify which countries are the largest producers of energy, especially fossil fuels, and to what degree they are selling and exporting their resources. In this case, we will examine the most recent data available in the dataset in an attempt to obtain a current snapshot of the industry. The most reliable data in this respect was last available in 2019. In Figure 1 we see that three countries dominated the production of fossil fuels in 2019: China, the United States, and Russia. China alone comprises over a fourth of the production in that year and no countries outside of these top three produced above six percent of the global supply.

Figure 1.

Fossil Fuel Production in 2019 by Producing Countries

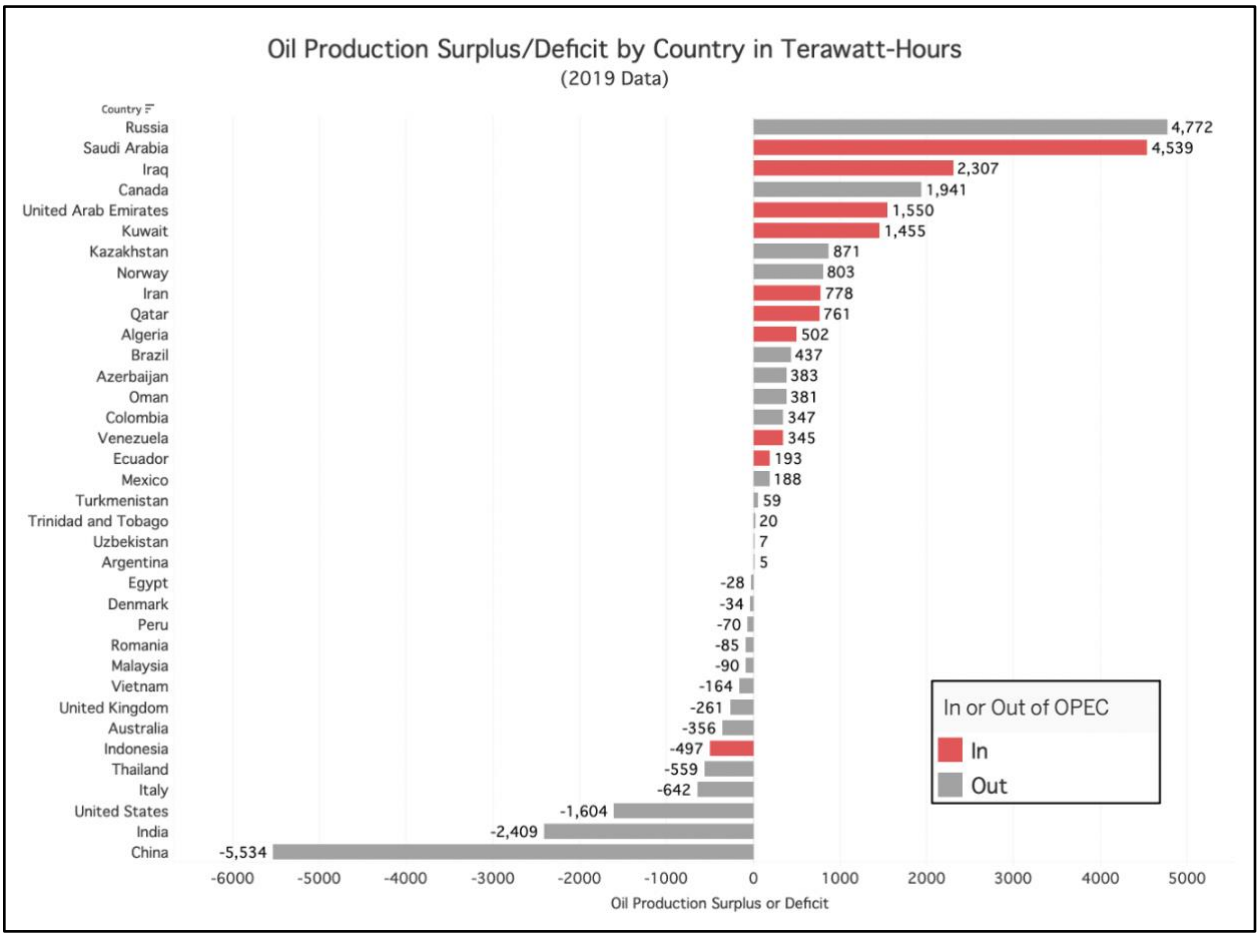


We've identified the top producers of fossil fuels, but it is important to note that this production is heavily dependent on the natural resources available to each country. It is surprising to see that no Organization of the Petroleum Exporting Countries (OPEC) appeared in this visualization. OPEC is effectively a trade organization specializing in the exports of crude oil primarily composed of countries in the Middle East, a region rich with oil (Organization of the Petroleum Exporting Countries, n.d.). The organization was

founded in 1960 and has been instrumental in influencing and stabilizing the global oil supply for decades and therefore is a notable group within the energy sector. To dive deeper into the separate segments of fossil fuels and investigate OPEC's role, we see the nominal differences between oil production and oil consumption in terawatt-hours for reporting countries in Figure 2.

Figure 2.

Oil Production Surpluses and Deficits for Countries in 2019



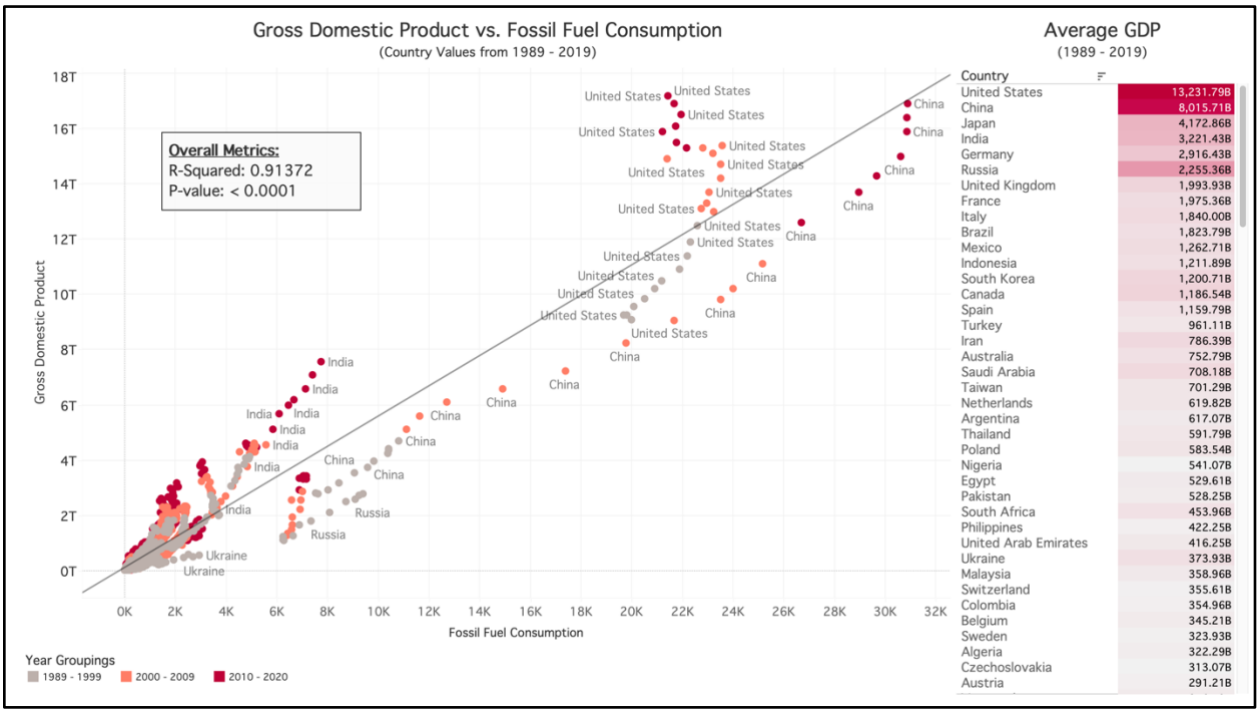
In this visualization, it is clear that OPEC has a larger role in the specific oil industry rather than fossil fuels as a whole. We see that 10 of the 16 OPEC countries appear in the

graph and are denoted in red. Interestingly enough, Indonesia is the sole OPEC country suffering an oil production deficit, whereas the rest of the organization's countries have sizable surpluses. Russia's position at the top of this list is notable as well. Although the country is the largest oil producer, followed closely by one of OPEC's core member states Saudi Arabia, the country is not involved in the world's most influential oil industry entity. We also see that China has a severe oil production deficit although the country is a leader in fossil fuel production.

It is well known that the harvesting and utilization of fossil fuels have adverse effects on the environment and result in pollutants lowering the quality of life for living creatures. One is left to wonder why there hasn't been a larger shift away from the use of these resources. A potential reason for the continuing prevalence of fossil fuels in the energy sector is the cheaper nature of these resources in comparison to cleaner energy solutions. That feature of fossil fuels seems to be subsiding as volatile markets are negatively impacting gas prices and electricity costs and renewable energy options are becoming cheaper by comparison according to an article from the Institute for Energy Economics and Financial Analysis (Jaller-Makarewicz, A. M., n.d.). However, in historical data, it appears that greater fossil fuel consumption is correlated with a higher gross domestic product, a measure that indicates the health of a country's economy. In Figure 3 we can see the relationship between these two metrics.

Figure 3.

- *Scatter Plot of Gross Domestic Product and Fossil Fuel Consumption for Countries between 1989 and 2019*
- *Average GDP for each Country from 1989 to 2019*



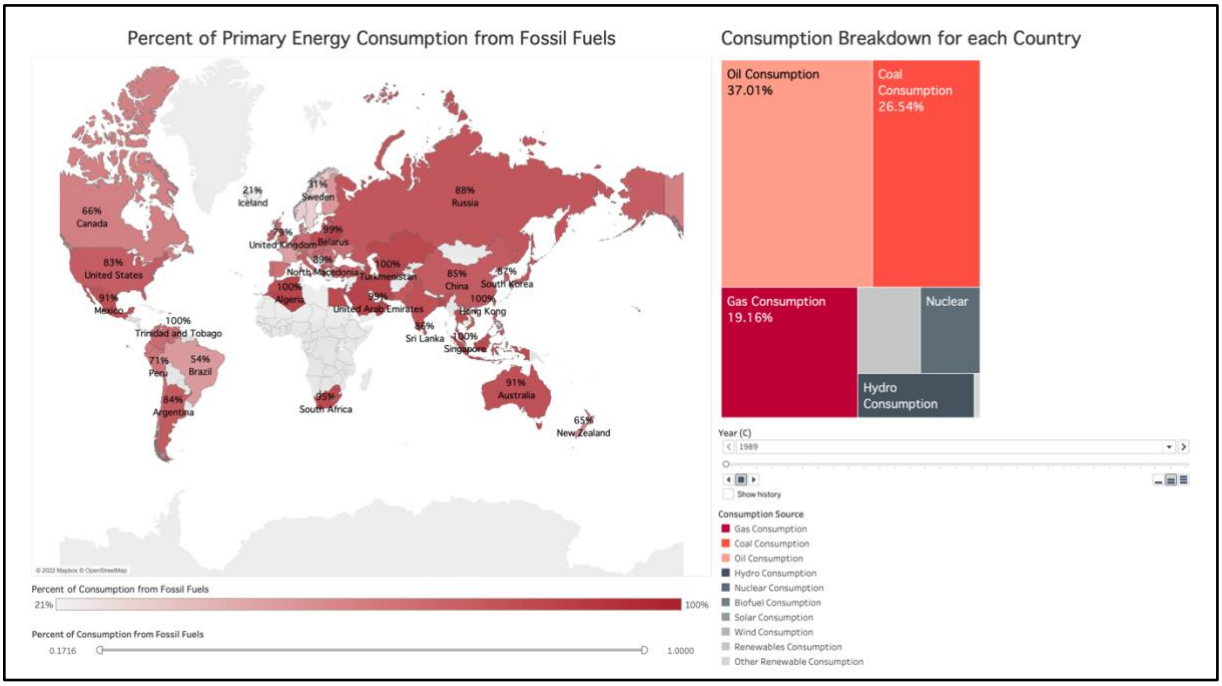
When examining records for each country across this thirty-year window, we see that the two measures are highly correlated with an R-Squared of 0.91372 and a P-value of less than 0.0001. This means the correlation is highly significant with the variation of one of these variables explaining roughly 91% of the variation in the other variable. While correlation does not equal causation, we see that GDP and Fossil Fuel Consumption have a close relationship when examined over time among several countries. Additionally, when looking into this relationship over time on a country-by-country basis, the correlation remains significant, but some countries have higher R-squareds than others. This visualization is filterable using the Average GDP table on the right to examine the trendline

for certain countries. In the top five average GDP countries, the United States had an R-squared of 0.316, China's was 0.976, Japan's was 0.714, India's was 0.990, and Germany's was 0.879, all of which had significant P-values. While I'm sure that fossil fuel usage is not the sole factor affecting GDP, but these correlations indicate that it could be a relevant measure to investigate.

As we may witness a shift away from fossil fuel reliance in the near future due to global events, it's important to note which countries have already made the shift and which countries find themselves still heavily dependent on fossil fuels. A significant portion of countries consumed over 90% of fossil fuels in terms of their energy consumption profile. In Figure 4 we see a map of countries shaded according to the percentage of primary energy consumption that was comprised of coal, gas, or oil consumption.

Figure 4.

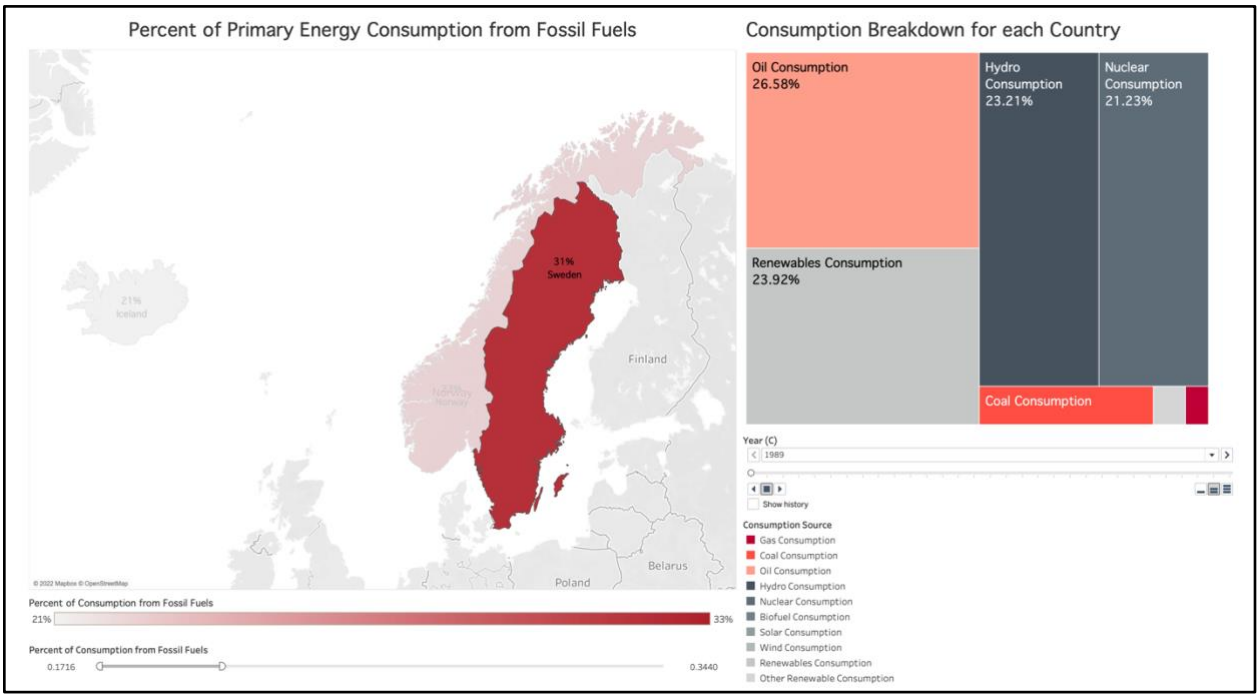
Dashboard Indicating Countries with High Dependency on Fossil Fuels and Corresponding Breakdown of Energy Consumption Animated from 1989 to 2019



While easier to view within the application, the portion on the left indicates just how much of the world still reports incredibly high fossil fuel consumption, and therefore, dependency. With the vast majority of these countries reporting over 80% of energy consumption in fossil fuels, it is clear that it is difficult for countries to shift over to cleaner energy sources. This portion of the graph is filterable using the slider at the bottom and in doing so we can find countries that have limited their fossil fuel consumption significantly. By selecting these countries on the map, we can move to the right portion of the visualization to see how consumption habits changed over time for the country. For example, we can look at Sweden which had a 31% of its energy consumption come from fossil fuels in 2019 below in Figure 5.

Figure 5.

Consumption Breakdown Dashboard for Sweden



In 1989 we see that Sweden was utilizing oil resources but also was ahead of the curve in consuming three forms of energy entirely unrelated to fossil fuels. Using the animation, we can watch the consumption patterns of the country change over time. Featured below are snapshots from the country's 2005 and 2019 measures in which we see Sweden eventually shift further away from oil consumption and invest more in renewable, nuclear, and hydropower.

Figure 6.

Sweden Dashboard 2005

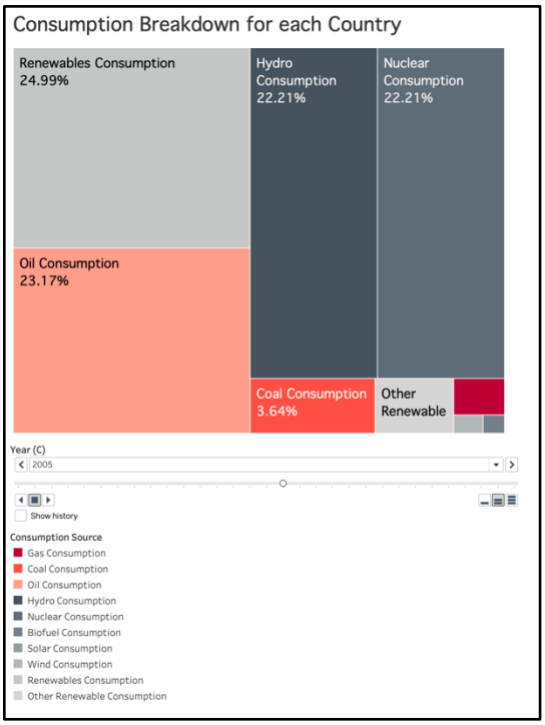
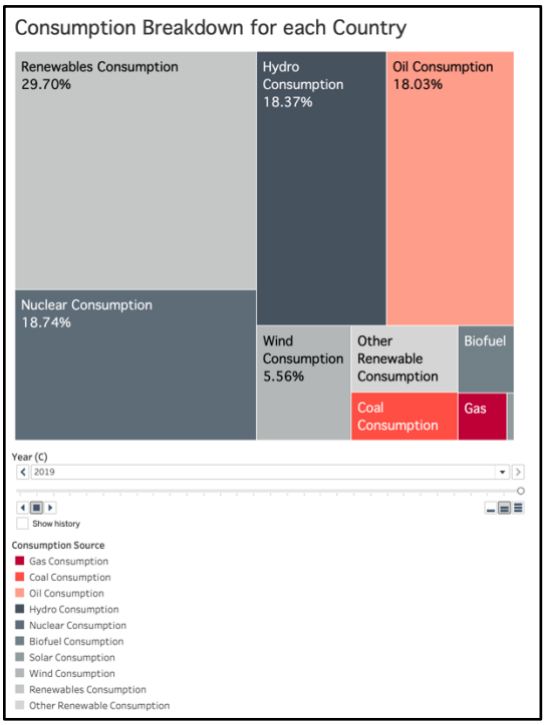


Figure 7.

Sweden Dashboard 2005



Sweden was capable of successfully decreasing its dependency on oil resources and diversifying its energy consumption profile. Many countries may look into the strategies of Nordic countries like Sweden in their efforts to decrease energy market vulnerability and improve their resiliency to uncontrollable global events.

While we often hear about net-zero commitments and big changes being made to reduce our environmental impact, we have now seen that energy consumption in broad terms is still incredibly reliant on fossil fuels. The world's most powerful states are the largest producers of these products whether it is out of necessity to power an economy structured around fossil fuels, or a desire to reach maximum production and export benefits, it is likely we will still see this dependency into the foreseeable future. We've seen that some entities in the energy sector like OPEC and Russia have captured a significant

share of the market for fossil fuel products and hold a supply that people around the globe rely upon. In the case of Russia, and likely in more cases to come, unforeseen events impact the market and leave dependent countries and their citizens in economic pain. However, we've seen that diversifying a country's energy consumption profile is possible and can be accomplished within decades. Hopefully, more countries will consider and implement alternatives to fossil fuels and make the energy sector more robust.

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