

Powering the Nation: Sources and Drains on Energy in Our Society

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Abstract - The goal of this project is to create a deeper understanding of the changing energy economy in the United States. As the US has grown, its demand for more energy has led to an increase in both consumption and production of energy. In addition to this, the makeup of where that energy is coming from, as well as where it is being spent, has changed as well. Our goal in this visualization is to create a way to view the changes to energy consumption/production over the past 70 years, and for each year be able to see the relative comparisons of the sources and drains on those values. We do so by using d3 to build a three-panel layout which breaks down information into a breakdown of information. The primary panel is used to display the changes in energy consumption and production over time, and to select a year to inspect more closely. Upon selection, the two remaining panels will display a bar chart outlining the energy production sources and energy consumption drains, respectively. This allows for both a general overview and a detailed inspection simultaneously.

Introduction

Our planet is facing a crisis. Rampant use of fossil fuels has led to global warming on a scale which has not been seen in millions of years. This has led to extreme weather conditions such as frequent hurricanes and droughts, mass animal extinctions, and a continuously rising sea level. In recent decades there has been a nominal effort to switch to greener alternatives, but the demand for energy continues to grow and with it the burning of polluting fossil fuels. In order to better understand the relationship our society has with energy, we must understand both where the energy is coming from (e.g. green energy vs fossil fuels) as well as where those energies are being used.

It is for these reasons that we believe that this is a ideal task for a visualization task. Our visualization is able to determine at any given year how much energy is being used and generated, and what the sources behind those are. By being able to have this comprehensive view of how energy usage and production has changed over time, it should become easier to figure out where the problems behind the damage to our environment are. Not only will it be simple to see how the problem is growing, but at each point along the line we can see the specifics of what has been and needs to be addressed.

Related work

US Energy Transitions 1780-2010 -MDPI [1] focuses more where the energy is being consumed, especially when it came to different forms of oil, rather than our research which focused on more how the energy was produced. There is nothing wrong with this angle on the problem and the paper has several helpful insights such as the energy used per capita is actually decreasing. This paper mostly uses several line graphs as its visualization, while our tool has one static line graph that can be explored via interaction.

Current and Future Energy Sources of the USA [2] does an excellent job of showing how energy production flows. Not only does it show production of both renewable and non-renewable energy sources in stacked line graphs but also showing how different energy sources are consumed. When describing a single year's production this paper chooses to use pie charts instead of our bar graphs, this choice emphasized how little renewable energy sources are being utilized in recent years compared to non-renewable sources as it combined all renewable sources into one wedge and it is still the smallest wedge.

12 Economic facts on energy and climate change [3] sectioned itself as a dozen stand alone facts and it focuses more on the aspect of climate change than the energy sources themselves. This paper's method of segmenting itself makes the paper not flow well and it can be hard to follow at times. After fact number two the paper goes into speculations and expectations for the future which is not promising for a paper that has the word "facts" in the title. Most of the visualizations are bar graphs with a few state maps and it feels fairly repetitive especially with the paper's disjoint nature.

Design Method:

Our design is fairly straightforward. The layout is broken down into 3 sections. The largest section and source of interaction with the user takes up the bottom half of the screen and depicts energy production and consumption over time. This is a line graph of the two values displayed over time, with the production in blue and the consumption in red. The user will have the ability to click on any of the year 'columns' on the x-axis of the graph that will affect the other two sections. This selects the year, highlights that column with a transparent gray bar, and creates a text box which displays the production and consumption for that year.

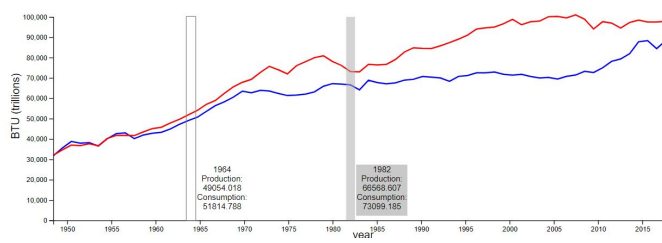


Fig 1: Line graph comparing total production and consumption. The currently selected year is in solid gray.

The other two sections each take up half of the top of the screen, split vertically. The left section displays each of the sources of energy displayed as a bar chart. The y-axis is a measurement of kilowatt-hours as a percentage of

the total level of production for that year, ordered by descending levels of pollution. Energy types are clustered by color families into renewable energy, fossil fuels, and nuclear. The year's data which is displayed here is determined by the year selected in the bottom section. The right section is energy consumption, using the same design as the energy production bar chart. This displays the four consumer categories of energy: residential, commercial, industrial, and transportation.

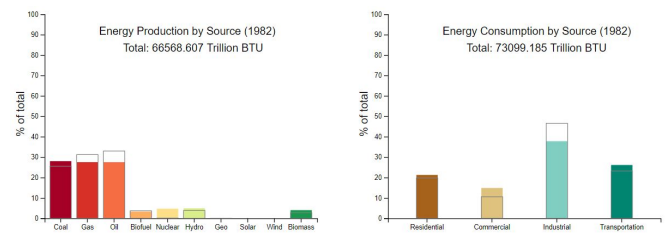


Fig 2: Bar charts from 1982 (in color) being compared to another year's data (in gray outline.)

At any point, the user can click on a new year, which will change the data presented. When this happens, the old year's data will be presented a grey outline in both the line graph and bar charts. This allows for simple and easy comparison between any two given years (seen in figures 1 and 2).

Finally, there is a panel on the far right side which contains a legend for the line graph and a description of the purpose of the visualization.

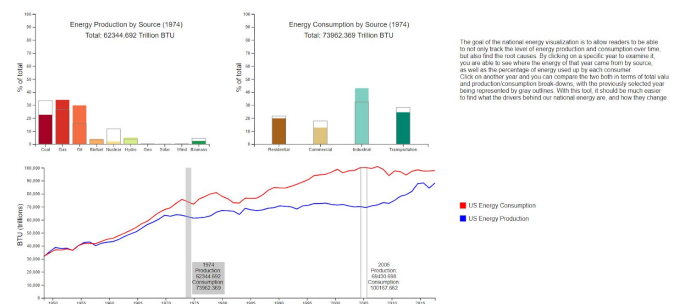


Fig 3: The entire visualization, presented with legend and description

The data in this approach is abstracted by representing its magnitude along a vertical axis. For the line graph this means each year's total consumption and production of energy, and for the bar charts it means showing the percentage of each producer/consumer as it related to the total production/consumption for that year. In the line chart, the x-axis represents the year, and in the bar charts it represents the producer/consumer. Since not all producers and consumers can be shown at once, user interaction is what allows a closer inspection of the year.

The task was simply a matter of finding a way to present the data that would be the most clear and informative. We found that many existing visualization to be either uninformative towards the general picture, or misleadingly biased. By allowing a general overview with selection to more closely examine each year, we feel we achieved this task.

When designing our system, we had to consider the data that was available to us, and how much could be reasonably displayed in one visualization. The data provided by the US Energy Information Administration [4] was extremely helpful and detailed, but we focused on just the primary representations of energy usage and production. This allowed us to not have the visualization become too cluttered.

Implementation Method

The data for this project was taken from the webpage for the US Energy Information Administration [4]. Specifically, the CSV files representing Total primary energy production and Total energy consumption were downloaded. These files were manually edited in OpenOffice Calc in order to remove unneeded categories, relabel titles, and convert all values into the same units. The resulting files can be found in this project's github repository [5]. These were fed into a JavaScript webpage using the d3 libraries. All coding in the webpage was done by us. The final webpage was hosted using Github's hosting service [6]. All processing was done on local machines using off-the-shelf hardware.

Evaluation was done by observation as opposed to any systematic test suite. Our goals were to make sure that everything in the visualization was presented clearly, and in such a way that it was easy to interpret what was being said. This included notes and comments from the team members, our client, and the professor.

Results and analysis of results

When we finished our initial version of the system, we sent it to our client, Karen Dean of Economic Environmental Solutions International. Our goal as discussed with her was to create a tool with the ability to easily evaluate energy data over the course of time, and get a more detailed view on a yearly basis. She works with a number of environmental organizations and government entities, many of whom do not have a technical background, so a simple tool such as this can be invaluable. After getting a chance to look over our system, she reported that the simplicity of the tool's interface and the ability to toggle between different views were especially useful. She also praised the intuitive transition between macro and micro trends.

She did, however find one bug and had one suggested change that she wished to see. The bug was an off-by-one error in regards to the year being displayed in one of the bar charts. This was trivial to fix. The suggested change was that she desired to see a way to compare two different years directly, as opposed to needing to take notes or remember them. In order to satisfy this requirement, we implemented the "gray outline" approach which will leave an outline of the data for whatever the previous year you selected. This allows the simple comparison between any two years' data by selecting one year and then the other immediately after it. The full client evaluation can be found on our Github repository [5].

After presenting our tentatively "final" version of the system to Professor Chen, we were given a number of final suggestions for improvement. The first was that we should make all bars the same width between the production

and consumption charts. This was to ensure that there was no erroneous meaning attributed to area as opposed to height. The second was adding text to the visualization describing what its purpose is for the user. Finally, we added the feature that line chart text boxes which list the year and production/consumption values would remain next to the selected years for the current and previous values. After all these changes were implemented, we felt that our system had fully satisfied all of our goals and designs.

Discussion of results

As far as discussion is concerned, we feel as though this tool is best suited for helping the US energy producers and consumers be more aware of how their habits have changed on a larger scale. It also has the ability to be put to even larger scales if so desired, as we also hope that this tool is used to inspire creation of bigger and more commercial tools that could even get the average person more aware of their own energy usage.

Conclusions and future work

Finally we are very pleased with how our tool and visualizations turned out and we hope it can inspire later works to be done in similar fields that can help bring clarity of energy usage to the average American.

However, America isn't the only place that needs to keep an eye on its energy consumption and production. In the future this tool can be expanded upon to compare the consumption and production of different countries across comparable years and have a better understanding of the global energy situation. This kind of research could lead to a more concise method of countries importing and exporting different energy sources and could help the global economy as a whole. Such a comparison of energy consumption across countries could be a necessary step in slowing global warming.

Another potential future expansion of the visualization would be to allow in depth views into which energy sources are feeding into which

consumers. For instance, is the industrial sector using more from natural gas or coal? This could be very helpful in identifying causes behind overusage.

This tool has a lot of potential and we are excited to see where humanity research is going and how tools like ours can assist in them.

References

- [1]: <https://www.mdpi.com/1996-1073/7/12/7955/pdf>
- [2]: <https://www.e-education.psu.edu/egee102/node/1930>
- [3]: http://www.hamiltonproject.org/papers/twelve_economic_facts_on_energy_and_climate_change
- [4]: https://www.eia.gov/energyexplained/?page=us_energy_home#tab3
- [5]: <https://github.com/jluken/NationalEnergy>
- [6]: <https://jluken.github.io/NationalEnergy/>