CS171 Final Project

Global Energy Consumption by Type (1971-2007)

Wahaj Ahmed Chaudhry

Wesley King Chen

Muhammad Ibrahim

Table of Contents

Proposal

Overview and Motivation:

Visualization is a tool to help show trends and relationships that may be difficult to see from the looking at the numbers. For our CS171 project, we knew that we wanted to

visualize something of global relevance. Wahaj and Wesley are taking a Frontiers of Modern Chemistry, where a chapter was devoted into energy consumption and efficiency of various systems. Among various case studies included global energy consumption. There are many types of energy consumption - all with certain effects. We wanted to show not just the trends of total energy use, but also the types of energy that each country used relative to all other countries. Our goal is to highlight trends that are occurring both throughout the world and over the decades. From such trends, we hope to also be able to make inferences on related consequences - such as greenhouse gas release and global warming.

Project Objectives:

- What are the relative amounts of total energy consumption between countries and how can we most clearly show these comparisons?
- What are the specific types of energy (e.g. coal, nuclear, solar, etc.) that are being by each country and what are the underlying trends between countries of the world and over the past four decades?
- What is the power consumption and distribution losses in the context of energy extraction and consumption from one country to the next?
- How much energy is imported and how much is exported of each type?
- What is the total global energy consumption? What is the total global energy consumption of each type of power source? Scaled per capita?
- Are certain countries more progressive in their use of alternative energy sources? Do we see trends in this shift? By region? By GDP?
- Is there a direct correlation between a country's use of a specific resource and its capacity to produce it (e.g. Does Saudi Arabia consume more oil relative to its other sources?)

Data:

Global energy data was found from The World Bank and can be found here. A

library of related global datasets and non-interactive graph summaries are also on the site, found here. The source of most of the above data has been extracted and compiled from the World Health Organization, the World Bank, and research institutes concerned with global health, energy consumption, poverty rates, and additional sociological studies, forming a reliable, open data set.

Data Processing:

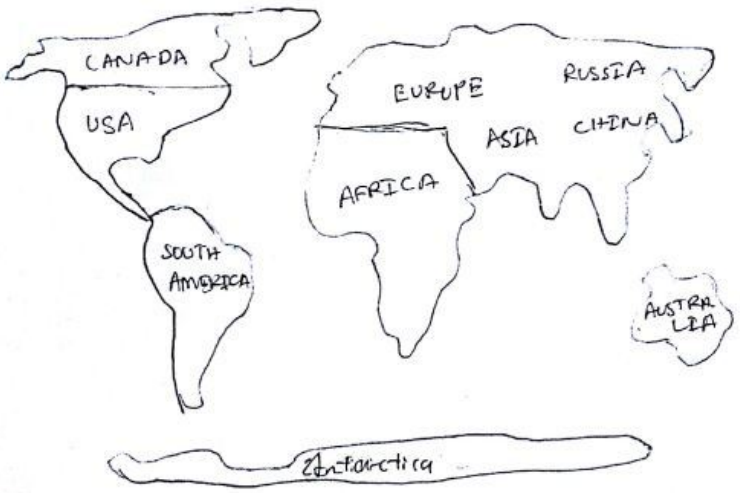
We spent a lot of time searching for a data set to ensure that we would be able to work with a data set that is fairly complete without needing to scrape a website. The data set that we found is already compiled into an excel file. However, there is no real-world data set that is perfect. There are still some parsing and some filtering we will have to do with our data. First of all, our data set is 3-dimensional - varying by country, by energy type and per year. Because we would want to look at this data on all three dimensions, we will need to further organize (either create copies or map out where each dimension is located when reading the file in). There are also some missing data point which we could decide either to extrapolate or ignore. These decisions will be made once we start working with the data more.

Visualization:

TRADITIONAL MAP

⊙ TRADITIONAL MAP ○ BLOCK MAP. * Dynamic ranking

→ map has different colors based on energy consumption.



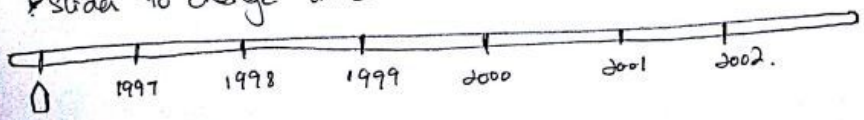
RANKINGS:

1.
2.
3.
4.
5.
6.
7.
8.

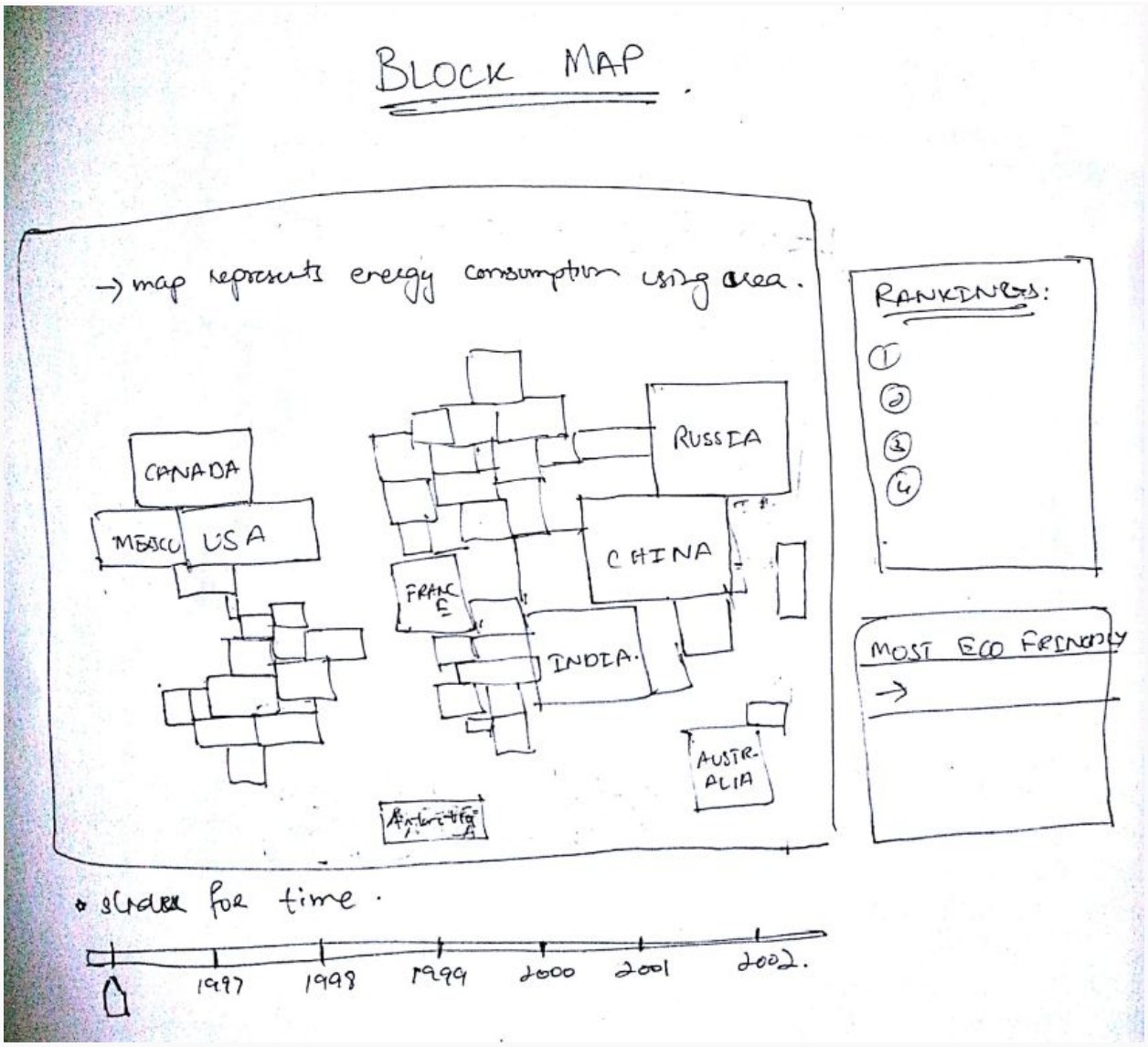
MOST ECO FRIENDLY

→

* Slider to change time.



BLOCK MAP


→ map represents energy consumption using area.
CANADA
MEXICO
USA
RUSSIA
CHINA
FRANCE
INDIA
AUSTRALIA
RANKINGS:
1
2
3
4
MOST ECO FRIENDLY
→
• slider for time.
1997
1998
1999
2000
2001
2002.

We have data on energy consumption for different countries by type and how it changes over time. From a high level, we want our visualization to tell a story. We will start with an introduction animation which will include an option tutorial of how to interact with our visualization. The main part of the visualization will be a map of the world. We will distinguish each country by its proportion of energy consumption. This can be done by a heat map of color or by an area-resized map. There will be some degree of interactivity to include radio buttons to filter by energy type. Users can also click on the country and have it highlighted to show a tooltip for more information. For a more detailed overview, see the breakdown of features:

Must-Have Features:

- Intro animation that introduces the visualization and all its features
- The traditional map showing the countries with respect to energy consumption using color
- The timeline feature which shows changes in energy consumption over the years
- Filtering data with respect to different categories
- Summary of best/worst 1/3/5 countries per category listed as a summary table
- More details upon clicking on a country

Optional Features:

- The area-based map representing the different countries of the world with respect to their energy consumption (“block map”)
- Color the area-based map by primary source
- Title boxes and rankings of countries based on energy consumption
- Sort by combinations of energy type - so checkboxes that are cumulative rather than radio buttons that are exclusive
- Filter by energy consumption relative to the country’s own total consumption (eg: 45% of China energy is coal vs. 10% of US energy is coal)
- Put individual pie chart per country in tooltip

Project Schedule:

The implementation section of the process book will be updated every week. Dates in futures are high set goals which would allow for completion of all optional features. Real work will be documented as time goes on

- Wednesday, March 19: Wahaj, Wesley, Ibrahim: Over break, begin to set up and visualize the implementation starting points for the final project
- Sunday March, 23:
  Wahaj: Find source code necessary for creating visualizations
  Wesley: Create the Github environment for collaborative editing
  Ibrahim:
- Friday, March 28: Wesley: Gather world map country data for display, Display country data in main html index, Start creating interactive zooming and panning for the world map
  Wahaj: Gather information relating to library usage in making visualization generation simpler
  Ibrahim:
- Friday, April 4: Wahaj: complete implementation of Bar graph and line graph from NVD3 and readjust JSON code
  Wesley: Complete the main page outline of world map including pan and zoom, Start to interface with bar graphs and data, Manually clean up the data from the world country data to match the names given in our energy data
  Ibrahim:
- Thursday, April 10th: Wahaj, Wesley, Ibrahim: Combine all separate elements into one display prototype, Demonstrate other components in the testing phase, Start to add interactivity and data binding between the components
- Week of April 14: Project review with the TFs
  Wahaj, Wesley, Ibrahim: Clean up and optimize code, add usage details, clean up transitions and optimize force diagram

- Week of April 21:

  Process Book Completion*

  Wahaj: Complete compilation of figures, screenshots, images, and links in process book. Write Overview, related work, and questions

  Wesley: Write Data scraping process and Exploratory Data analysis

  Ibrahim: Write Design evolution, evaluation, and include all design sketches

  * Implementation section should be up to date
- Wesley, Wahaj, Ibrahim: Complete Screencast
- **Thursday, May 1: Projects due (including screencast)**

Implementation

Initial Comments from TF:
This topic looks really interesting - I think you're off to a good start. You may want to think about a small linked line or bar chart in your visualization showing something like the top n countries for a particular category. I also like the block map as well.

1). The data collection, cleaning and wrangling has to be done and it must be in a form that can directly be used by the visualization. It's OK if the dataset isn't complete (e.g., there will be more rows in a file), but the structure of the file and a reasonable sample must be there.

2). There must be a visible and working visualization of the major views. This doesn't have to be everything (i.e. doesn't need to be the complex final version, doesn't need to have all the interaction), but it should be there and it should be in D3.

Data Wrangling

As mentioned in the project proposal, the data about global power consumption was obtained from here. The data was compiled by the World Health Organization, the World Bank, and other research institutes concerned with global energy and energy consumption.

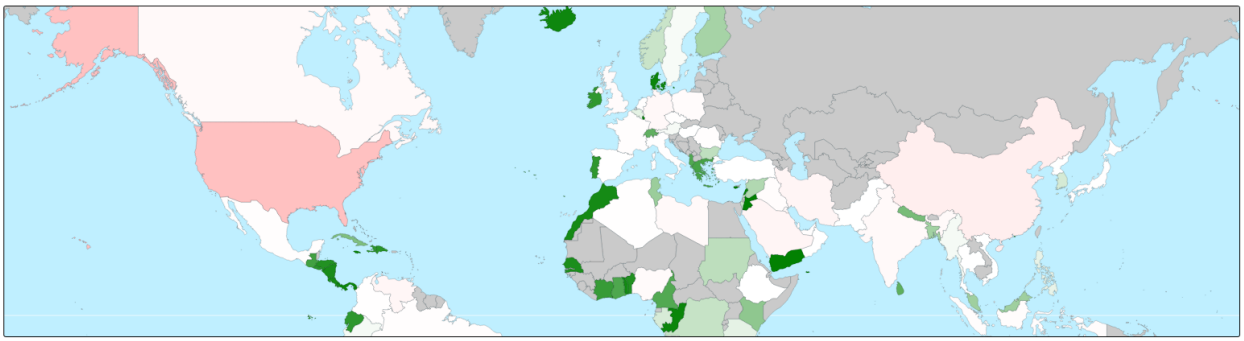
As an initial step in data cleaning, we removed the periods from the series code field in the excel file because we felt it was unnecessary. We also changed the names of the countries in the excel file to match the name of counties in the world_data.json file that we have for rendering the map so that we can tie the data easily to map objects. A part of this included ensuring that the same countries were named similarly from the data we had our energy data with the data we used to create the world map graph ex: Macedonia, FYR = FYR Macdeonia = Macdeonia).

After the initial cleaning, we wrote a script in javascript named “data.js” which takes in the csv file of the data and parses it into json objects. We break the csv file into series which contain records for countries and each country has records for each of the year. We also have some series which we might not be using for the project and we will be removing them in the next iteration. See the data_readme file inside our data folder for an example of the structure of our json object.

Global energy data was found from The World Bank and can be found. A library of related global datasets and non-interactive graph summaries are also on the site, found here. The source of most of the above data has been extracted and compiled from the World Health Organization, the World Bank, and research institutes concerned with global health, energy consumption, poverty rates, and additional sociological studies, forming a reliable, open data set.

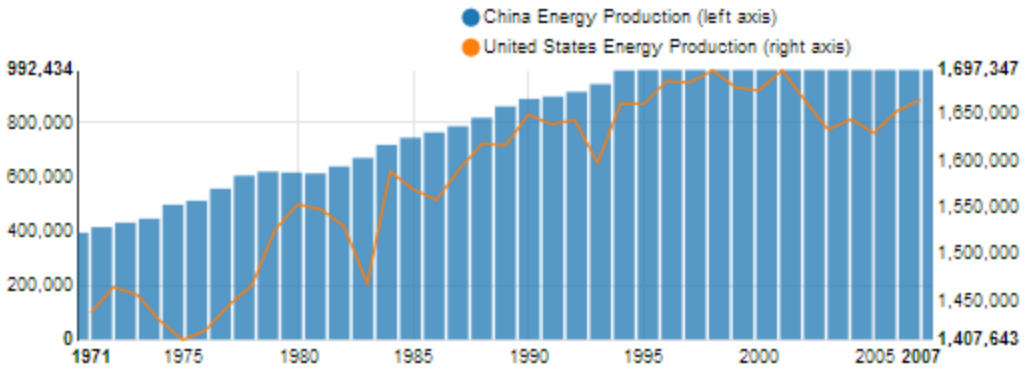
Main World Map Visualization

Our world map is the main visualization on the page where we sought to incorporate the most interactivity. The general map is able to be panned and zoomed with country borders fixed zoom. The pan screen is locked so you cannot zoom in and pan above the actual map area. All of the countries are added with tooltips upon mouse over. The countries are colored by a heat map which colors from white to red of the given data series. Currently, the year and the data series is hard coded. There will soon be a slider to change the year as well as drop down menu to change the data series (different energy consumption types like nuclear vs coal etc).



Supplementary Bar Graph/ Line Graph Visualization

A supplementary bar graph with a superimposed line graph was added to the bottom of the page which would demonstrate the information being displayed in the choropleth for a single country. The bar graph was adapted from the Line Bar Plus visualization available in the nvd3.js library. In order to properly display the appropriate data, we had to readjust the structure of our json file such that key and value pairings were represented as an object containing arrays. The purpose of the graph containing both a line graph as well as a bar graph is to be able to visually compare two sources of energy on a single graph, such that when looking at the United Kingdom, we would be able to select two sources of energy (e.g. Nuclear vs. Hydroelectric) and compare the fluctuation in usage from the 1970s to the present.



The bar graph and line graph also has interactivity, including mousing over the data points with nice tooltips that show the series as well as the data.

The visualization contains radio buttons for several energy sources and any two sources can be selected for comparison. Additionally, since all of the years are being displayed here, the visualization reveals trends in energy usage.

We have currently added in interactivity that changes the data based on the country we clicked on. However, there are some scaling issues that were are still working out. Ultimately, we will also allow different series code(nuclear vs fossil fuel vs coal etc) on the bar graph.

Dynamic table

This is a table that shows the top 10 counties for the selected year and energy category. The table is dynamic and updates with the slider to represent changes in the year and with the drop down menu to represent changes in the energy category. The table also has a dynamic sorting feature which allows the user to sort by each of the three categories being displayed. Sorting functionality exists for both ascending and descending orders.

This table was implemented using an external jQuery plugin called tsort.js. To make the table we just go through our data and find the top ten countries for the year and cateogry selected. The drawTable() function spits out the html for the table and this html is replaced on every update either by the slider or by the drop down menu. tsort.js takes care of the sorting for us so we don't have to write any custom code for that.

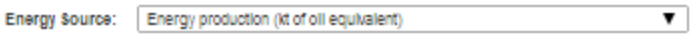
Rank	Country	Energy Usage
1	United States	1436416 kWh
2	China	394149 kWh
3	Saudi Arabia	244143 kWh
4	Iran	238833 kWh
5	Venezuela	209924 kWh
6	Germany	175208 kWh
7	Kuwait	159691 kWh
8	Canada	155839 kWh
9	India	141536 kWh
10	Libya	137512 kWh

Slider

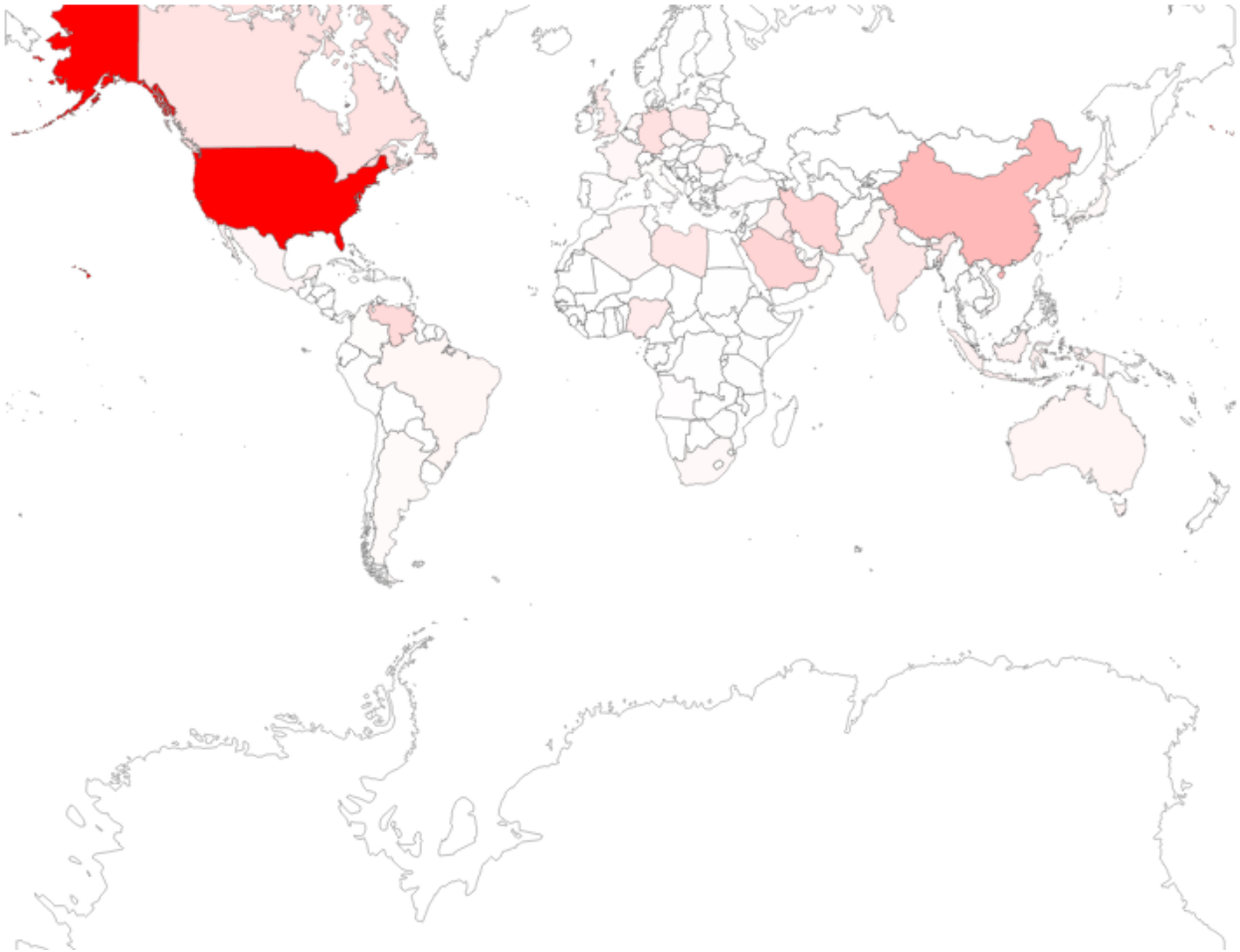
The slider shown below is used to iterate over the different years from 1971-2007. The updates to the dynamic table and the world map are instantaneous giving the visualization a very interactive feel. We tried to make the sliding as smooth as possible to make for a great user experience. The slider was implemented using the built in jQuery slider plugin and fires the slide event when the value of the slider is changed.

Drop down menu

The drop down menu allows the user to select the different energy types for which we made the visualization. You can choose from different options ranging from nuclear energy to hydroelectric energy and even their sub-groups. The onChange() event of the drop down menu is tied to all the other elements of the visualization so the bar graph, table and the main map all update when you change the energy type we are dealing with. This syncing is accomplished by using global variables throughout the project which keep track of the current year and the current energy type so you can run the update function whenever and it gives you the most updated visualization.



Experimental Cartogram



One of the optional components of our visualization was the development of a contiguous cartogram. A contiguous cartogram distorts the shape of each of the states, countries, continents that are enclosed by a series of latitudes and longitudes. The cartogram distorts its shape in order to better demonstrate, via size, the difference in magnitude f the specific energy parameter that we are looking at. The attempt made here was one in which we experimented by applying the mathematical findings of the paper, An Algorithm to Construct Continuous Area Cartograms, by Dougejik, J.A. et al., along with an example of a contiguous cartogram of only the United States, to the world map. We had attempted to separate the parameters on a continent by continent basis, which proved to be too difficult in terms of the mathematical complexity at hand. The original algorithm derived from the paper has been only applied to the states making it such that across noncontigous areas like between countries and with the presence of large bodies of water, the distortion of the countries (which were treated like states) was offset by regions of discontinuity. Therefore, the cartogram that is presented in our project provides a localized distortion of the energy data in only Western Europe, taking advantage of the highly contiguous nature of the data points of the latitude and longitude of the countries in that area. Due to the large data set, when applying the algorithm meant only for the distortion of the U.S. to the world scale, there is tremendous increase in load time. When opening the page, a single click to the fully loaded image will reveal the aforementioned changes.

Design Evolution

Originally when considering all of the visualizations we wanted a way to demonstrate energy data on a world scale. The options at hand were to do a simple map of the world and binding the values to colors. The second thing we considered was the binding of data to the shapes of the countries. This would be in the respect that either we create non continuous svg elements of all of the countries, apply a force diagram to separate them, and to distort their sizes based on the energy metric that we are analyzing. Finally, we considered solely continuous cartogram that displays changes in sizes of countries based on their proximity to one another.
In order to further highlight the data in a more tangible way, we also considered the addition of bar graphs, line graphs, tables, and pie graphs that would all be tied to a time slider displaying data for a selected energy type.

Evaluation

Using our visualization we were able to pick up on certain historical trends and major events that took place which had an impact on a global level. For instance, the likes of energy expenditure during the Cold War, the dissolving of the USSR, the modernization of Africa, the effects of globalization on energy usage, as well as the variations in energy demand. We were able to determine which countries were more intensive on their use of certain energy types, say for instance nuclear and alternative energy which was based primarily in the developed world, as well as of how the energy import and export balance largely shifted in the Middle East with the continued discovery of oil reserves. By allowing for a time slider, our visualization revealed tremendous information on the growth of energy globally since 1971 as well as changes in GDP, switching to clean energy, as well as the development of other regions of the world, like Brazil.

The contiguous cartogram, which was perhaps the most difficult part of the project, was not capable of fully demonstrating what we wanted, although it did reveal quite a bit about the complexities of creating contiguous cartograms across noncontinuously mapped regions. Nonetheless, it was an effort which provided insight into using shape as a medium to convey size.