

Energy Visualization of Data from the US Energy Information Administration

The webpage is used to see visualizations of data from the US Energy Information Administration. The data sets include the production and the consumption values for *Total Primary Energy*, *Total Electricity*, *Renewable Electricity*, *Renewable Biofuels*, *Petroleum*, *Coal* and *Energy-related CO₂ emissions* for over 230 different regions. The webpage is built using HTML, CSS and JavaScript with D3, AngularJS and Angular Material libraries included to support the webpage.

The webpage is entirely a single page application which supports the different visualizations; `/index.html` is the home page for the application

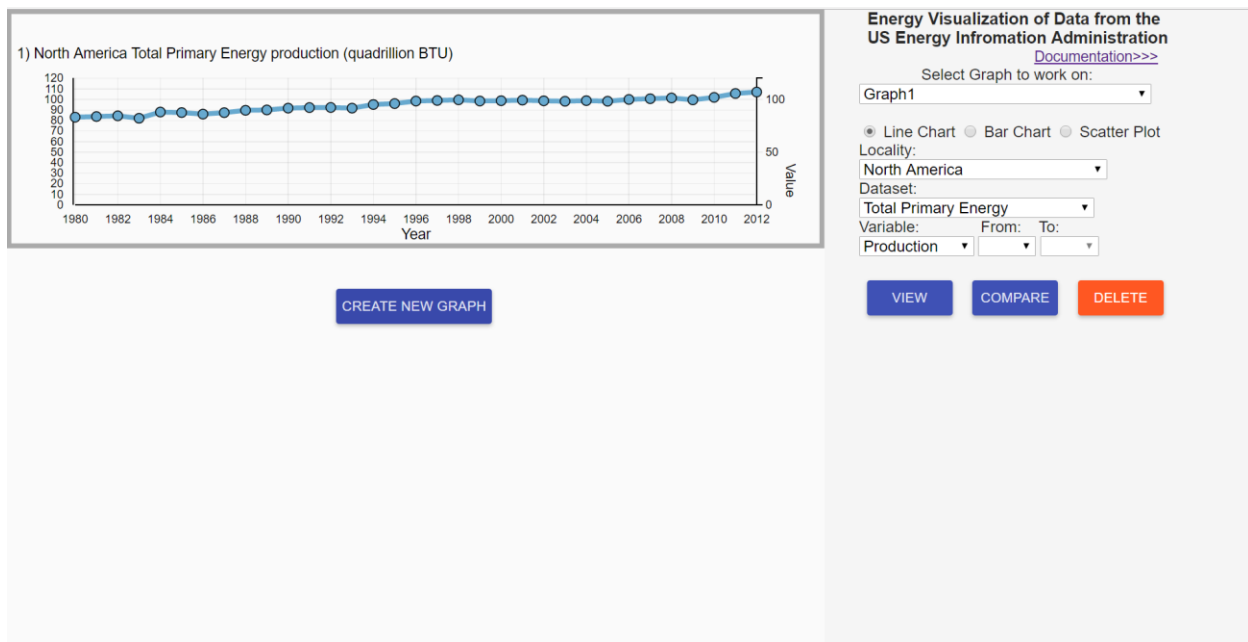


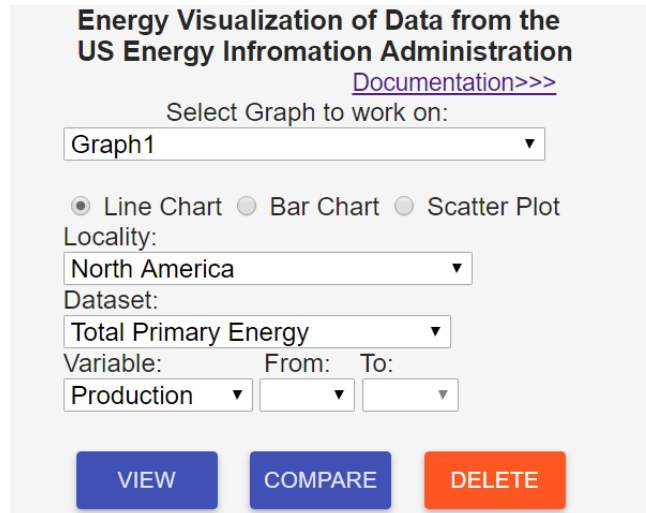
Fig. 1: The home page/index.html when initially loaded. The page is initially loaded with a line chart

The webpage is primarily divided into two components; the **main visualizations** (used represents the data in the form of charts/plots) which is the primary focus of the user is on the left, with the **visualization tools** on the right (which has controls to change the content in the main visualization).

1) The Visualization Tools

The visualization tools are located to the right of main visualization. The visualization window is programed to change dynamically depending on the functionality chosen by the user. Initially, the **Title** is followed by a **link to the documentation** and then the controls are preloaded with the first graph being selected, displaying a **Line Chart**, the **Locality** as 'North America', **Dataset** as the 'Total Primary Energy', **Variable** as 'Production' and a blank **From** field and a blank and disabled **To** field. The 'From' and 'To' fields are left blank for convenience since the application does not require the users to enter 'From' and 'To' dates. For the sake of simplicity, and to reduce the number of clicks the user performs over the application, having a blank 'From' date will result in automatically choosing 1980 and a blank 'To' date will result in automatically choosing 2012.

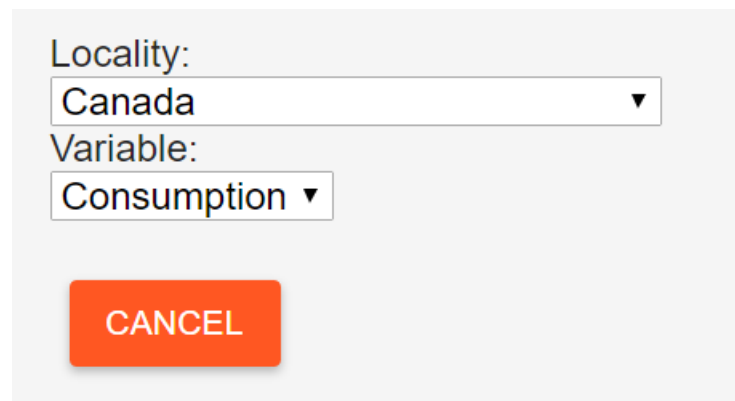
The 'To' value can only be chosen after choosing a 'from' value and choosing a 'To' date is not required. 'To' dates can only have values which are equal to, or greater than the 'From' date. Followed by those are three buttons to **View, Compare and Delete** graphs. The **Delete** button is marked in red since there isn't an option to undo a delete operation



The screenshot shows a web interface titled "Energy Visualization of Data from the US Energy Information Administration". Below the title is a link "Documentation>>>". The main section is titled "Select Graph to work on:" and contains a dropdown menu with "Graph1" selected. Below this are three radio buttons for "Line Chart" (selected), "Bar Chart", and "Scatter Plot". There are three more dropdown menus: "Locality:" with "North America" selected, "Dataset:" with "Total Primary Energy" selected, and "Variable:" with "Production" selected. To the right of the "Variable:" dropdown are two empty dropdown menus labeled "From:" and "To:". At the bottom are three buttons: "VIEW" (blue), "COMPARE" (blue), and "DELETE" (red).

Fig 2. The initial state of the visualization tools.

From the visualization tools, users can choose to change the type of chart i.e Line Chart/Bar Chart/Scatter plot and the Locality (region), Dataset, Variable and the From and To dates. Clicking on '**View**' will ask the main visualization to fetch the required data and display them. Clicking on '**Compare**' will change and the shrink the visualization tools to be able to compare the selected graph visualization with another country or a different variable. The **Cancel** button in red can be used to move back to the original visualization tools. This feature will be explained below in detail in a latter part of the section.



The screenshot shows a smaller version of the visualization tool. It has two dropdown menus: "Locality:" with "Canada" selected and "Variable:" with "Consumption" selected. Below these is a red button labeled "CANCEL".

Fig 3. The visualization tool on clicking 'Compare'

The functionality of the visualization tool is the same as described in case of '**Bar Charts**'. The tool however changes when using a '**Scatter Plot**'.

2) Main Visualization

The main visualization consists of a single graph by default but has the option of creating new graphs using the 'Create New Graph' functionality. The first visualization when the page loads shows a **Line Chart** with the X-Axis indicating **Years** and the Y-Axis indicating **Values** as per the measuring unit of the data. '**Bubbles**' indicate points through which the line passes and is primarily used for aesthetics. The **Label** on top of the line chart indicates the title of the graph/graphs which are plotted.

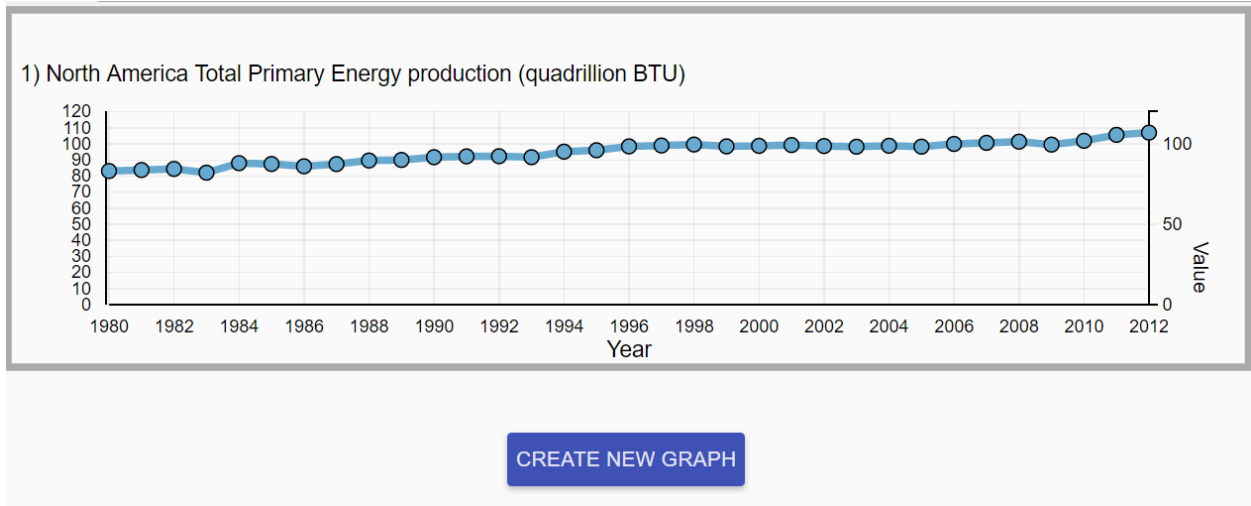


Fig 3. Showing the initial line chart representing the Total Energy Production of North America In quadrillion BTU's with labels, scales and a grid

The line chart consists of a Y-Axis oriented to the right which shows only 3 ticks; a 0 value, the highest value and a middle value. The ticks are different from the Axis on the left and this is used to help the user find values which may be significant such as 'greater or lesser than half' and can also be used as an anchor point from which users can always count the number of '**Grid**' lines towards the top or the bottom of the tick. The X-Axis has ticks for every two years since having ticks for each year would be overloading the graph when years are viewed from 1980 to 2012. Hence displaying every two years is treated as an acceptable trade-off for these visualization.

By clicking on the 'Create New Graph' icon, the user has a new graph created and automatically selected for working on it. The selection is indicated by a '**Grey**' boundary to indicated the selected graph. Graphs can always be switched between or deleted from the tool menu used for visualization. To change the type of chart, the radio buttons can be used. By clicking on the 'Bar Chart' radio button, we can see a bar chart being visualized on a new graph which was created.

The bar Chart has the same attributes as a line chart but using rectangles and the 'Grid' feature is not used in a line chart as having rectangular grids over rectangular bars seemed to cause obscurity in the presentation of the visualization. All other attributes are the same.

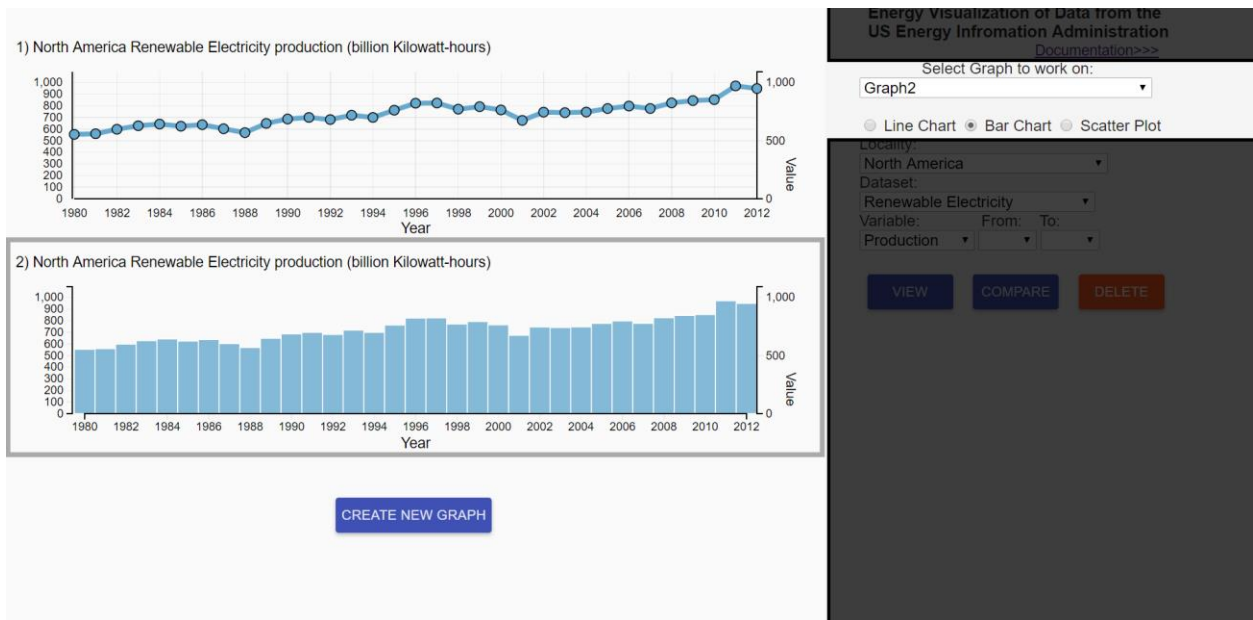


Fig. 4 shows the bar chart representation of the same data set in a new chart which was created. The top left of the screen shows the kind of chart being used and the graph which is currently selected.

3) Comparing Values

By using the **'Compare'** button, values which are currently represented can be compared with other values from other variables. On clicking compare, options of changing the dates, Datasets, Type of chart, and graph selection will be removed. This is to make the interface coherent as comparing between two different datasets will not be meaningful and comparing between two different dates will not be intuitive within the same scale. Comparison is designed to be made with two different countries or different variables such as 'production or consumption' such that the unit of comparison between the two values are the same. The primary visualization is represented in **Blue** and the data to compare is represented in **Orange**. Clicking on **'View'** every time a graph needs to be changed is not necessary as there are only two options and constantly clicking on a button is not required. However, in the previous, there were more than 6 options the user could choose and having the graph switch dynamically with every option might cause some irritation to the user. The scales in the graph is automatically set to the dataset with the greater value so that the visualization is coherent.

With respect to a bar chart, the orange comparison bars are positioned in between the primary blue bars to avoid incongruity or ambiguity in the representation of data. If the bars were placed side by side from the center, that would result in one bar to the right of a year mark and one bar would be on the other side of it; this would imply that one value was observed after that year and one was observed before. This problem is avoided with this design. Comparison between charts can be stopped by clicking on the **"Cancel"** button to go back to the default visualization tools.

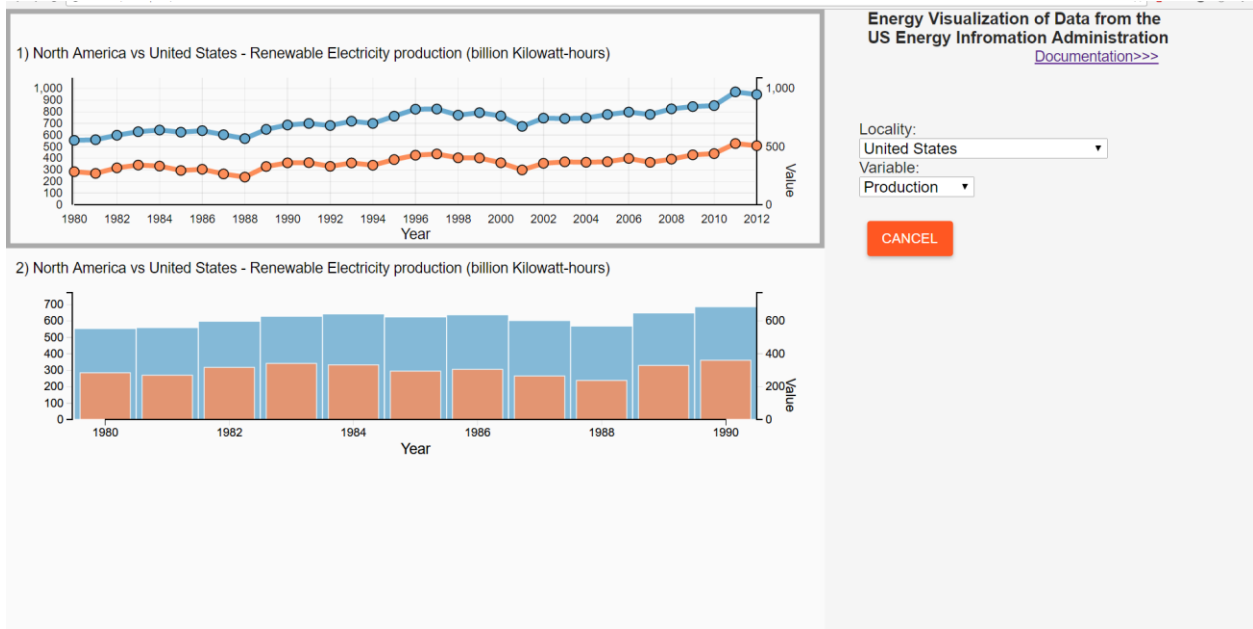


Fig. 5 Shows the comparison between different data sets having the same unit of measurement in the forms of a line chart and a bar chart with the labels of each chart indicating the data being compared in each visualization

4) Scatter Plots

Scatter plots have both a different visualization tool as well as a different kind of main visualization. Scatter plots essentially compare two independent data sets with one dependent variable. The dependent variable here is 'Time'. So for a given range of time, scatter plots can be used to compare two data sets.

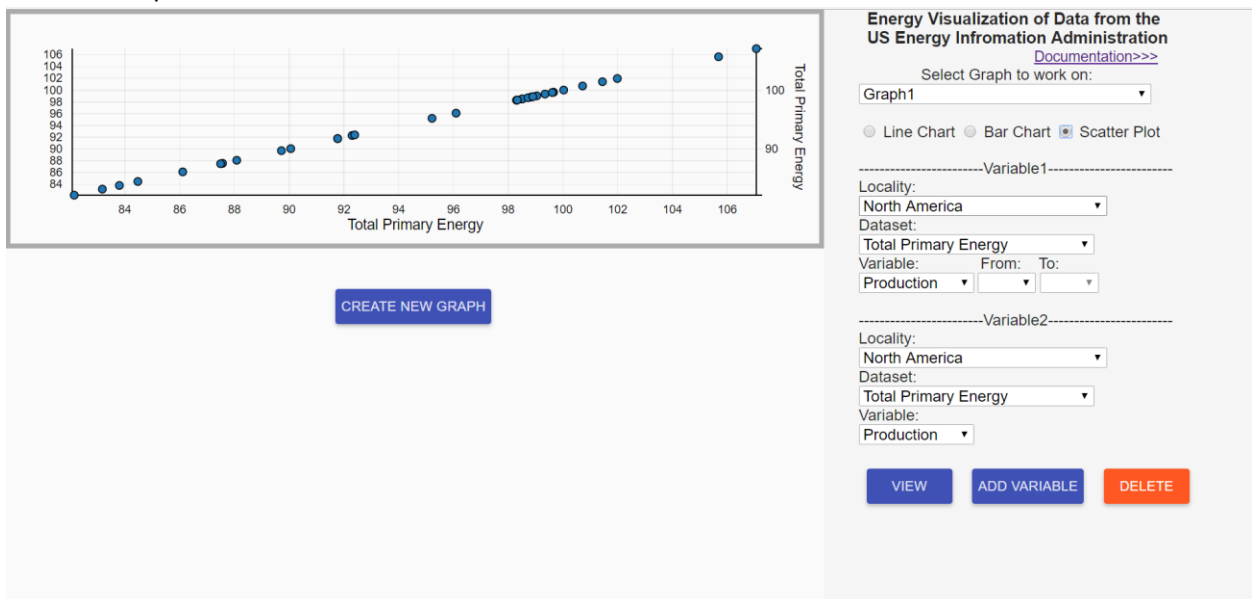


Fig. 6 Shows the visualization tool as well as the main visualization for a scatter plot initially plotting a graph between the Total Primary Energy production of North America against itself from 1980 to 2012. It shows a symmetric graph.

The page provides a different layout with options to enter details of two different datasets but with a **'From'** and **'To'** option being extras options for **Variable1** which remains constant for the graph. In addition to comparing two variables, an additional third variable can be added by clicking on the **'Add Variable'** button. By adding a third variable, the graph displays the value of the third variable in the form of **'Bubbles with different radii'**. Variables can be reduced back to 2 variables by clicking on the **'Remove Variable'** button. The values of the 3rd variable can be observed by hovering over the necessary bubble. The **X-Axis** shows the data set of **'Variable1'** and the **Y-Axis** show the data set of **'Variable2'**. The grid helps to trace the dots back to the scale values.

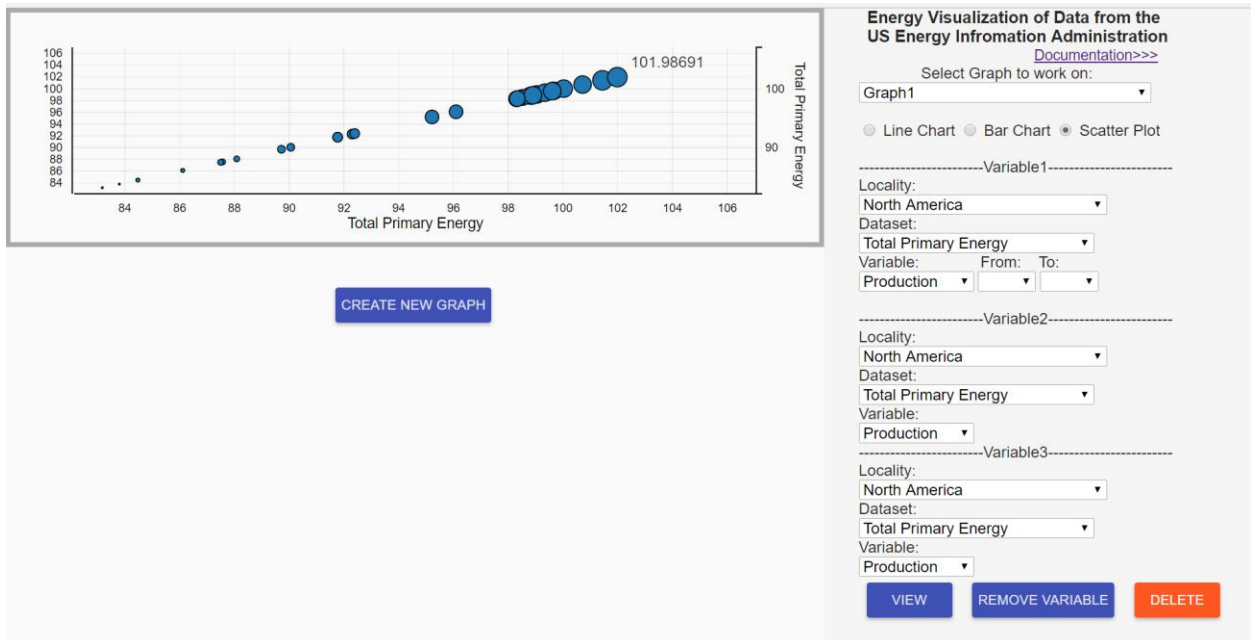


Fig. 7 Shows the data visualization of 3 variables with the value of the third variable represented as the radii of the bubbles and the actual value of it can be observed by hovering the mouse on it as shown.

All graphs can be deleted to the point where no graphs exist and the application has been tested with creating **50 different graphs** in one session. The web application is designed to work with no need for the page to be reloaded. The tutorial shows the visualization in use: <https://youtu.be/b09aTz4xg4Q>