# Introduction: Domain problem characterization

Since the early part of the last decade, total electricity generation for the most part has remained relatively the same in the United States. That said, the manner in which it is generated due to changes in technology have changed over time while some are used more than others. Renewable energy sources for electricity generation such as solar, wind, and hydro through the use of photovoltaics and turbines technologies, have increased in use accounting for over 16% on a national level. Alternatively, generation from nuclear sources and fossil fuels such as coal, natural gas, and oil continue to dominate the power landscape despite changes from the beginning of the start of the century. In the United States, coal was the major source power accounting for over half the total of electricity generation according to the U.S. Energy Information Administration (EIA). Since then, coal use has dropped dramatically to just under 30% of the total electricity generation. Conversely and due to advances of fracking which in turn have unlocked resources from shale deposits all around the country, natural gas takes its place as the leader in the U.S. at 32%.

Closer to home in the South East region of the United States, the changes in electricity generation between renewable and fossil fuels/nuclear sources have not kept pace with the rest of the country. By the end of 2017, renewable energy sources account for just over 6% of the region’s electricity which is just a slight increase from 2001. While the region as a whole continues to rely heavily in favor of fossil and nuclear sources, each state within the South East tells a different story as the various sources have changed over the years or more accurately for some states, a lack thereof. In our visualization and by using 2001 to 2017 data provided by the EIA, we attempt to illustrate how electricity generation has changed over time for each state in the South East region of the United States. Specifically, we illustrate changes by renewable and non-renewable energy sources as well as the various resource types across states. Furthermore, we supplement these visuals by showing carbon emissions across the various states over the same time period.

# Encoding/Interaction design

In our design, we utilized a map of the U.S. South East region as the main visualization and serves as the initial focal point. States included are Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, Tennessee, Virginia, and the Carolinas. Each plot represents individual electricity plants given by their latitude and longitude coordinates. The size of the plot point represents the energy generation measured by megawatts as the color illustrates the energy source type. To supplement the main visualization and as part of the tabs located to the right of the dashboard, we utilized a stacked vertical bar chart to show total net generation by energy source over the time frame. In addition, we included a time series line graph showing net generation for each of the energy sources over the years. Like the main visualization, color is used to differentiate the various energy sources for both supplemental charts.

Upon the initial load of the visualization, the map shows data for the most recent year, 2017. Located at the top right is an action button and when activated, changes the year as indicated by the time line at the top of the page, to the beginning of the data set. This action at first shows data for 2001 and automatically progresses to each following year. This in turn, animates the regional map, the stacked bar and line charts to show the yearly changes for each plot.

To drill down and focus on an individual state within the South East region, we placed a pull down menu located at the top left side of the dashboard. By utilizing, an interactor can choose a state and filter the data and visualization. Once selected, the map zooms in to that state while the supplemental visuals show filtered values. Like the regional map, the action button can be used to animate and display the year to year changes of electricity generation for an individual state.

# Algorithmic design

For our time series line graph that illustrates the energy generation of renewable versus nonrenewable resource types, we utilized the ‘plot\_ly’ function from the plotly library R/R Studio. To create the data frame for this function and using the using the original base data set, we grouped by ‘Year’ and ‘renewable’ attributes and summarized the ‘net\_gen\_mw’ column. This data frame allowed us to use the ‘plot\_ly’ function to create a line chart. Arguments such as ‘type’ and ‘mode’ were set to ‘scatter’ and ‘lines+markers’, respectively to create a line chart that displays a plot point for each year’s value.

We used a similar process for other line charts such as renewable versus nonRenewable broken down by resource type as well as the line chart for its emissions counterpart.

# User evaluation

# Functionality. Does the visual representation provide all of the functionalities requested by the instructors and identified during the requirements elicitation?

# Effectiveness. Does the visual representation provide the instructors with a better knowledge of the number of messages read and written in a discussion forum than the traditional interfaces provided by the tool? In particular, does the use of visual representations allow the instructors to have information on the number of messages sent and read with better accuracy and precision than other tools? Or, is there additional information that is made available exclusively by the visual representations?

# Efficiency. Can the visual representation provide the instructors with information more rapidly than the tools provided by the system?

# Usability. Is the interaction with the graphical interface simple and intuitive enough for the instructors?

# Usefulness. In what way, and in what context, is the information provided by the graphical representation useful to the instructors?

# Future work

Include the ability to highlight and/or filter the energy source types either by selecting one of the categories in the legend in the map as well as in stacked bar/line charts in the supplemental section.