Visualizing A Connection Between Electrical Generation and Surface Temperatures and CO_2 Emissions
CSE6242 - Team 52

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1 DEFINING OUR PROBLEM SPACE:

We will use the following datasets to develop analytical tools for presenting geographic and time-based visualizations:

(1) Berkely Earth - temperature data [Rohde et al. 2013] [link]
(2) CDIAC - CO_2 emissions [Andres et al. 1997] [link]
(3) EIA-923 - US Power Generation Statistics [link]

2 HEILMEIER'S QUESTIONS

2.1 What we are trying to do:

We will construct a visualization toolkit to aid in analysis of long-term trends in surface temperature, CO_2 emissions, and energy mix in the United States. We aim to offer a presentation of these diverse datasets that is easy to digest.

2.2 How it is done today:

Most current visualizations on these subjects are static and siloed, i.e. they do not allow for interactivity or correlated between linked data.

One example is available from the Energy Information Administration (EIA) website [link].

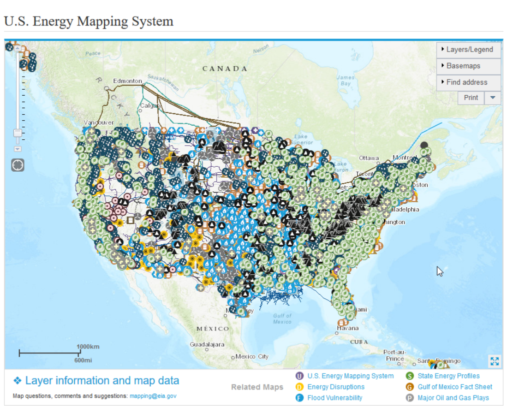

Figure 1: EIA Mapping System Example

2.2.1 *Shortcomings:*

- Poor interactivity and responsiveness
- Inability to display graphical data versus time
- Minimal and confusing data filtering options
- Low data-to-ink ratio

2.3 How this is a new approach:

We propose a set of interactive visualizations which will allow users to explore data from multiple sources on common media.

The success of our approach will require clear visuals which allow users to develop their own conclusions on climate impact, instead of being presented with a tailored narrative.

2.4 Who should care:

Climate change is a concern of individuals and organizations worldwide. More effective visualizations can reduce the awareness gap between scientific experts and the public.

2.5 Measuring Success and Expected Impact:

Success is measured by the effectiveness of our visualizations at conveying similar data as others while adding interactivity and blending of data sources. Impact is measured through user engagement and interaction.

2.6 Risks

- Resource needs to process, clean, and present three large datasets
- Responsive performance for multiple visualizations on one page
- Geographic data granularity is insufficient to provide insights

2.7 Payoffs

- Visualization provides real-world data for independent conclusions
- Climate insights from coal reduction and renewable expansion
- Sparks conversation and challenge around tailored climate data

2.8 Costs

- Team time investment for data processing and visualizations
- Computational resources for large data set use
- Minimal monetary costs may be required for hosted solution

2.9 Measuring Progress:

Progress will be measured against **Table 1**. Weekly meetings are used to hold everyone accountable. Individual effort will be monitored and appropriate actions taken.

Table 1: Team 52 Actions

Task	Due	Owner
Submit Progress Report	3/29	All
Begin Final Poster	3/29	All
Complete Final Poster	4/12	All
The Data		
Download and clean CO_2 Dataset	3/14	D. Carvallo
Download and clean Berekley weather dataset	3/14	W. Smith
Using EIA API pull power plant information	3/14	C. Comfort & J. Bonifield
Combine datasets into a single database	3/19	All
Visualizations		
Determine Visualization Platform (D3/Python/Tableau, etc)	3/14	All
Base (non-dynamic) visualization working (either energy or climate only)	3/26	All
Time Dependent visualization working	4/2	All
Full Visualization Working	4/9	All
Completed Tasks		
Locate 2 possible datasets	Complete	All
Locate 3 survey sources each	Complete	All
Attend Tue and Thu Team Meetings	Complete	All

2.10 Checking Progress:

The final exam will be a user test of the finalized visualization. The midterm check will be a cleaned, organized, and combined dataset organized geographically and a basic functioning visualization.

3 LITERATURE SURVEY

3.1 CO_2 Emission Projections from Electrical Generation [Bruninx et al. 2013, Page Count: 11] and [Hammons 2006, Page Count: 17]

Main Ideas: Consisted of two papers which utilized climate modeling to predict CO_2 emissions based on energy production changes in Germany and Russia, Greece and Italy respectively.

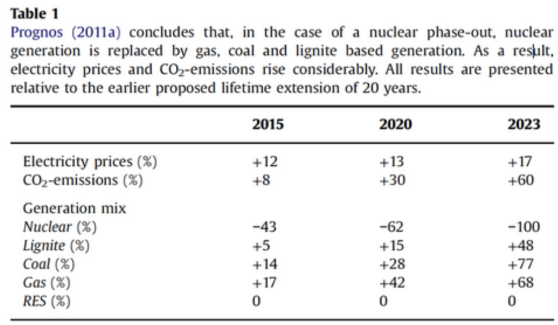

Table 1

Prognos (2011a) concludes that, in the case of a nuclear phase-out, nuclear generation is replaced by gas, coal and lignite based generation. As a result, electricity prices and CO_2-emissions rise considerably. All results are presented relative to the earlier proposed lifetime extension of 20 years.

	2015	2020	2023
Electricity prices (%)	+12	+13	+17
CO_2-emissions (%)	+8	+30	+60
Generation mix			
Nuclear (%)	−43	−62	−100
Lignite (%)	+5	+15	+48
Coal (%)	+14	+28	+77
Gas (%)	+17	+42	+68
RES (%)	0	0	0

Figure 2: CO_2 Emission Impact Table [Bruninx et al. 2013]

Uses: There is an overall correlation between CO_2 emissions and energy production. The larger the percentage of low (or zero) CO_2 plants the lower overall CO_2 concentrations were predicted.

Shortcoming: CO_2 concentration results were projected to show a future state while our proposal focuses on measured data.

3.2 Contemporary Climatic Analogs for 540 North American urban areas in the late 21st century [Fitzpatrick and Dunn 2019, Page Count: 7]

Main Idea: This survey developed analysis and visualization techniques that link current contemporary urban area climate-analogs to predict how future conditions in other urban areas may be similar.

Uses: It provides an interesting visualization approach through connecting similar climate areas in an effort to provide context to future climate change.
Shortcomings: In some cases (**Table 3**) the visualization becomes very busy connecting urban areas.

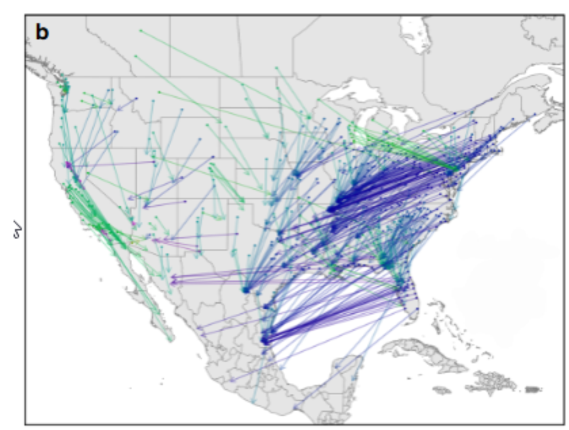

Figure 3: Urban Area Connected Analog [Fitzpatrick and Dunn 2019]

3.3 Prospective Analysis of Life-Cycle Indicators through Endogenous Integration into a National Power Generation Model [García-Gusano et al. 2016, Page Count: 17]

Main Idea: Due to the lack of integration between Energy systems modeling and life cycle modeling, the authors of the report combined the two into one model to be utilized for forecasting. Their final proved to be useful in energy forecasting decision making.

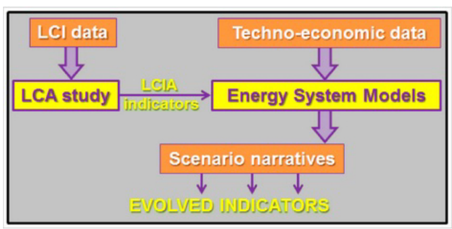

Figure 4: Merging LCA and ESM Approach [García-Gusano et al. 2016]

Uses: Proves the need to integrate energy data with climate data. Further, it provides an example of an existing model that combined both for forecasting reasons.

Shortcomings: Their model is specific to the Spanish energy market end focuses solely on one major climate indicator and simplifies energy production into three main sources (nuclear, renewable and fossil).

3.4 The global climate change and its effect on power generation in Bangladesh [Khan et al. 2013, Page Count: 10]

Main Idea: Energy sources in developing countries are more susceptible to different climate effects. Unless stopped, current trends estimate the effects of climate change to exponentially increase with time.

Uses: Provides examples of major climate factors that affect power generation and describes a need to reduce the effects of climate change.

Shortcomings: Data is specific to Bangladesh and smaller countries. Model presented extrapolates climate change effects which may be unrealistic.

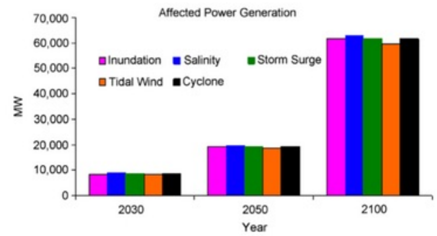

Figure 5: Affected power generation by climate change till 2100 [Golombek et al. 2012]

3.5 Climate Change: Impacts on Electricity Markets in Western Europe [Golombek et al. 2012, Page Count: 14]

Main Idea: Quantifies the effects of temperature and precipitation for electricity markets in Western Europe.

Uses: Paper provides quantifiable values which can be compared to values in our visualization to determine world-wide differences.

Shortcomings: Large model variability in countries depending on generation production split.

3.6 Reflections—What Would It Take to Reduce U.S. Greenhouse Gas Emissions 80 Percent by 2050? [Heal 2017, Page Count: 16]

Main Idea: Details the path to reducing CO2 emissions by 80% by 2050. The greatest potential improvement being by replacement coal and gas with wind and solar.

Uses: The analysis and projections of the author can inform our visualizations of trends in recent capacity across differing electricity production sectors.

Shortcomings: Ignores the emission-reducing effects of other generation methods such as nuclear.

3.7 Visualization of Climate and Climate Change Data: An Overview [Nocke et al. 2008, Page Count: 6]

Main Idea: The effective visualization of Climate Change is essential. Surveys climate scientists and researchers on most used visualization strategies and software, and seeks to bridge the gap between cutting-edge climate and visualization research.

Uses: The results and analysis of this usage research can help the team craft a more effective visualization.

Shortcomings: Places insufficient emphasis on interactivity.

3.8 Visualizing Climate change Risk and Adaptation Options for California [Koy 2014, Page Count: 24]

Main Idea: California is particularly sensitive to climate disruption. Visualization tools are critical to communicating the risks to local communities.

Uses: The results and analysis of this usage research can help the team craft a more effective visualization.

Shortcomings: California specific focus limits general applicability.

3.9 Visualising the potential impacts of climate change on rural landscapes [Dockerty et al. 2005, Page Count: 23]

Main Idea: Broad visualizations of climate change are often not as effective at communicating a message as specifically tailored local approaches. By using a GIS database combined with photorealistic software and scenarios powered by decision rules specific the impact on specific communities

Uses: The results and analysis of this usage research can help the team craft a more effective visualization with respect to scenario modeling.

Shortcomings: Difficult to scale local approaches to all communities due to high variance in geographic/climate factors.

3.10 CO_2 Emission Trends for the US and Electric Power Sector [Klein 2016, Page Count: 14]

Main Idea: The US has made remarkable progress recently in reducing CO2 emissions. From 2005-2012, more CO2 reduction occurred in the US than in all other countries combined. Electric power generation was the greatest contributor to this decline.

Uses: Contains very relevant data for our research detailing the effects of power generation mix on CO2 emissions.

Shortcomings: Many visualizations are used which suffer from the same problems discussed elsewhere. We aim to bring this same data to life by adding interactivity.

3.11 Climate Change 2013: The Physical Science Basis, Chapter 2 [Stocker 2014, Page Count: 90]

Main Idea: Provides a complete survey of recent results in climate science across a broad range of sources with a wealth of visual content. A central finding since previous reports is that there is widespread agreement in temperature increase estimates among the various temperature datasets.

Uses: Inform our understanding of state-of-the-art techniques in climatology on a global scale, specifically with respect to atmosphere and surface.

Shortcomings: Visualizations lack interactivity and are often jargon-heavy, failing to highlight recent findings adequately for observers with little domain knowledge.

4 TEAM MEMBER EFFORT:

All team members have contributed equally to the project.

5 WORD COUNT - SEE APPENDIX

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APPENDIX - WORD COUNT

Word count

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Words in text: 1142
Words in headers: 220
Words outside text (captions, etc.): 48
Number of headers: 29
Number of floats/tables/figures: 7
Number of math inlines: 11
Number of math displayed: 0
Subcounts:
    text+headers+captions (#headers/#floats/#inlines/#displayed)
  8+15+0 (1/0/1/0) _top_
  34+4+0 (1/0/1/0) Section: Defining Our Problem Space:
  0+2+0 (1/0/0/0) Section: Heilmeier's Questions
  40+6+0 (1/0/1/0) Subsection: What we are trying to do:
  60+6+4 (2/1/0/0) Subsection: How it is done today:
  48+6+0 (1/0/0/0) Subsection: How this is a new approach:
  24+3+0 (1/0/0/0) Subsection: Who should care:
  31+5+0 (1/0/0/0) Subsection: Measuring Success and Expected Impact:
  26+1+0 (1/0/0/0) Subsection: Risks
  23+1+0 (1/0/0/0) Subsection: Payoffs
  24+1+0 (1/0/0/0) Subsection: Costs
  23+2+3 (1/1/0/0) Subsection: Measuring Progress:
  30+2+0 (1/0/0/0) Subsection: Checking Progress:
  0+2+0 (1/0/0/0) Section: Literature Survey
  74+13+4 (1/1/7/0) Subsection: CO$_2$ Emission Projections from Electrical Generation\\ \cite[Page Count:~11]{Comfort_1_Bruninx} and \cite[Page Count:~17]
  {Comfort_2_HammonsT2006IoEP}
  63+17+4 (1/1/0/0) Subsection: Contemporary Climatic Analogs for 540 North American urban areas in the late 21st century \cite[Page Count:~7]
  {Comfort_4_FitzpatrickMatthew2019Ccaf}
  99+17+5 (1/1/0/0) Subsection: Prospective Analysis of Life-Cycle Indicators through Endogenous Integration into a National Power Generation Model \cite[Page Count:~17]
  {Endogenous_resources5040039}
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  44+12+0 (1/0/0/0) Subsection: Climate Change: Impacts on Electricity Markets in Western Europe \cite[Page Count:~14]{Western_Europe_GolombekRolf2012Ccio}
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  45+12+0 (1/0/0/0) Subsection: Visualizing Climate change Risk and Adaptation Options for California \cite[Page Count:~24]{California_Report}
  82+13+0 (1/0/0/0) Subsection: Visualising the potential impacts of climate change on rural landscapes \cite[Page Count:~23]{Rural_Landscape_DockertyTrudie2005Vtpi}
  81+13+0 (1/0/1/0) Subsection: CO$_2$ Emission Trends for the US and Electric Power Sector \cite[Page Count:~14]{Emission_trend_KLEIN201633}
  85+12+0 (1/0/0/0) Subsection: Climate Change 2013: The Physical Science Basis, Chapter 2 \cite[Page Count:~90]{Climate_change_2013_stocker2014climate}
  9+3+0 (1/0/0/0) Section: Team Member Effort:
  0+4+0 (1/0/0/0) Section: Word Count - See Appendix
  0+3+20 (1/1/0/0) Section: Appendix - Word Count
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Figure 6: The word count for this document, including this section is: 1142 using TeXCount Web Service.