CPSC 436V Term Project Milestone 3: Carbon Emissions Canada

Team
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Note to Reader (1): CO$_2$e/carbon emissions refer to a standardized system of carbon emissions measurements where all different types of greenhouse gas emissions are standardized into carbon dioxide equivalents.

Note to Reader (2): This visualization was designed for desktop screens of at least 1920 x 1080 pixels. Screens of different sizes may see different results.

1. Overview

Teaser image (screenshot) of your visualization.
Concise summary of your project (max. 250 words).

Canada's Climate is Changing.

Here's Canada's carbon emissions and what Canada is doing to cut them.

Click the buttons below, use the menu (top-left menu button) or scroll to see Canada's carbon emissions.

Methodology and Sources

Figure 1: Homepage screenshot with navigation buttons (center), menu (top-left), and associated content (throughout).
Our project focuses on exploring the annual trends of Canada’s carbon emissions over time. Our goal is to provide users (i.e. the Canadian public) with the knowledge to understand where Canada has been and where Canada wants to go in reducing carbon emissions and creating a healthier low-carbon future. We provide two main visualizations to allow users to see historical and projected future emissions.

In the first visualization we let the user explore historical emissions from 1990 to 2018 across Canada in a multiform overview/detail visualization that combines a heatmap, choropleth, and stacked bar chart. The user can toggle between three major carbon metrics (absolute emissions, carbon intensity per capita, and carbon intensity per million dollars Gross Domestic Product) and contrast the emissions over time and per province in the heatmap. Similarly, the choropleth provides a geographical encoding of the same information - one year at a time and based on the metrics chosen by the user. The years change as a user scrolls up/down through the years. Finally, the stacked bar chart shows absolute emissions data broken up by their economic sectors for a jurisdiction (e.g. Canada/Province/Territory) selected in the two other views (Figure 2 below).

![Figure 2: Our historical emissions data visualization with heatmap (top-center), choropleth (bottom-left), and stacked bar chart (bottom-right).](image.png)

The second visualization allows the user to compare actual emissions with emissions that are planned to be mitigated by different policies. The policies are roughly mapped to the economic sectors of the stacked bar chart (Figure 3 below). A toggle allows the user to either explore the policies in depth or to contrast the efforts against the actual emissions.
Food for Thought: As of 2019, the government source for this dataset (details available in Methodology and Sources) listed 238 carbon emissions reduction/mitigation policies, about 66.5% (151) did not come with estimates of carbon impacts.

Figure 3: Our policy impact dataset that outlines Canada’s carbon policy commitments, with the option (not shown) to juxtapose the commitments against historical carbon emissions.
2. Data

Description of your data in both domain-specific and abstract language (dataset type, scale/cardinality).

We have compiled two sets of data: 1.) a historical dataset, and 2.) a carbon policy impact dataset. These two datasets feature governmental data on carbon emissions in the past and where they hopefully will be in the future.

1.) Historical Dataset:
The National Inventory Report is Canada’s annually-updated, official greenhouse gas inventory produced to help track Canada’s international commitments on climate change (Environment and Climate Change Canada 2020b). Our subset of data focuses on emissions produced by ECCC economic sectors by province, and by year. There are 16,251 items in the dataset with 5 main attributes each (out of a total of 10) that we will be focusing on. Table 1 shows the attributes. The data was downloaded from Open Government Canada as a CSV.

Table 1: National Inventory Report Canada Dataset Attributes

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Type</th>
<th>Range/Cardinality</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Region</td>
<td>Categorical</td>
<td>14 levels</td>
<td>British Columbia</td>
</tr>
<tr>
<td>Source</td>
<td>Categorical</td>
<td>23 levels</td>
<td>Transport</td>
</tr>
<tr>
<td>CO2eq (megatonnes)</td>
<td>Quantitative</td>
<td>[1.4E-09,742.3128462]</td>
<td>500</td>
</tr>
</tbody>
</table>

In our second dataset, we will be drawing again from Statistics Canada (2020a) for economic data (expenditure-based gross domestic product, GDP) following the ECCC methodology for climate data calculations (Environment and Climate Change Canada, 2020a). There are 445 items, with 3 attributes of interest (out of a total of 16 attributes). The attributes are described in Table 2. This data was downloaded from Statistics Canada as a CSV.

Table 2: Statistics Canada GDP Dataset Attributes

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Type</th>
<th>Range/Cardinality</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEO (region)</td>
<td>Categorical</td>
<td>14 levels</td>
<td>British Columbia</td>
</tr>
<tr>
<td>VALUE (GDP)</td>
<td>Quantitative</td>
<td>[667, 2,063,887]</td>
<td>2,000,000</td>
</tr>
</tbody>
</table>
For our third dataset, we will be using population data from Statistics Canada (2020b). There are 406 items, with 3 attributes of interest (out of a total of 16 attributes). Table 3 describes the attributes. This data was downloaded from Statistics Canada as a CSV.

Table 3: Statistics Canada Population Dataset Attributes

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Type</th>
<th>Range/Cardinality</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEO (region)</td>
<td>Categorical</td>
<td>14 levels</td>
<td>British Columbia</td>
</tr>
<tr>
<td>VALUE (population)</td>
<td>Quantitative</td>
<td>[22,154, 37,065,178]</td>
<td>300,000</td>
</tr>
</tbody>
</table>

Derived Data:
The derived data consists of two major sets of calculations using all three of our:

- CO2eqtn_per_person:
  Using the emissions and GDP data to derive a new attribute, tonnes Carbon emitted/$ GDP, by dividing carbon emissions over GDP (quantitative).

- CO2eqtn_per_mil_GDP
  Using the emissions and population data to derive a new attribute, tonnes Carbon emitted/person (emissions per capita), by dividing carbon emissions over population (quantitative).

They are summarised as below in Table 4.

Table 4: Derived Data Attributes

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Type</th>
<th>Range/Cardinality</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Region</td>
<td>Categorical</td>
<td>14 levels</td>
<td>British Columbia</td>
</tr>
<tr>
<td>CO2eqtn_per_person (tn CO₂e emitted/person)</td>
<td>Quantitative</td>
<td>[2.46E-06, 76.53]</td>
<td>4.201752798</td>
</tr>
<tr>
<td>CO2eqtn_per_mil_GDP (tn CO₂e emitted/$ 1 million CAD, 2012 dollars)</td>
<td>Quantitative</td>
<td>[181.24, 1205.92]</td>
<td>549.7914284</td>
</tr>
</tbody>
</table>
**Combined Historical Dataset:**
Below we have listed our combined dataset in Table 5.

Table 5: Combined Historical Dataset Attributes.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Type</th>
<th>Range/Cardinality</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Region</td>
<td>Categorical</td>
<td>14 levels</td>
<td>British Columbia</td>
</tr>
<tr>
<td>Source</td>
<td>Categorical</td>
<td>11 levels</td>
<td>Buildings</td>
</tr>
<tr>
<td>CO2eq (tn CO\textsubscript{2}e)</td>
<td>Quantitative</td>
<td>[1.4E-09,742.3128462]</td>
<td>500</td>
</tr>
<tr>
<td>Carbon intensity per capita (tn CO\textsubscript{2}e emitted/person)</td>
<td>Quantitative</td>
<td>[2.46E-06, 76.53]</td>
<td>4.201752798</td>
</tr>
<tr>
<td>Carbon intensity per unit GDP (tn CO\textsubscript{2}e emitted/$ 1 million CAD, 2012 dollars).</td>
<td>Quantitative</td>
<td>[181.24, 1205.92]</td>
<td>549.7914284</td>
</tr>
</tbody>
</table>

Note to reader: A deeper inspection of the CSV files will have the attributes of GDP and Population, they are vestigial attributes used to calculate carbon intensities per capita and carbon intensities per unit GDP.
2.) Policy Impact Dataset:
For our second dataset and second group of visualizations, we will also be using information from Canada’s Fourth Biannual Report on Climate Change to show what Canada has done and plans to do in reducing carbon emissions. We will also be using historical emissions data (previously described above), particularly for total emissions across all of Canada between 1990-2018 to juxtapose emissions reductions goals to actual historical emissions.

There are approximately 230 items in this dataset with 8 key attributes (out of a total of 11). These attributes are described in Table 6. This data was extracted from a PDF version of the report and reformatted as a CSV.

Unfortunately we were only able to use 74 of those 230 items as some policies did not have specific emissions reductions estimates associated with them.

Table 6: Canada’s 4th Biannual Report on Climate Change Dataset Attributes

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Type</th>
<th>Range/Cardinality</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name of Mitigation Action</td>
<td>categorical</td>
<td>230 levels (74 were used as the rest contained missing data)</td>
<td>Clean Energy for Rural and Remote Communities</td>
</tr>
<tr>
<td>Sector(s) Affected</td>
<td>categorical</td>
<td>17 levels</td>
<td>Electricity</td>
</tr>
<tr>
<td>Status of Implementation</td>
<td>categorical</td>
<td>15 levels</td>
<td>Implemented</td>
</tr>
<tr>
<td>Start year</td>
<td>quantitative</td>
<td>[1990, 2030]</td>
<td>2001</td>
</tr>
<tr>
<td>Implementation Entity</td>
<td>categorical</td>
<td>47 levels</td>
<td>Prince Edward Island</td>
</tr>
<tr>
<td>Mitigation Estimate Impact (Kt CO₂eq reduced at 2030)</td>
<td>quantitative</td>
<td>[2, 30,000]</td>
<td>12,000</td>
</tr>
<tr>
<td>Description</td>
<td>categorical</td>
<td>230 levels</td>
<td>“New Brunswick submitted a design for a provincial output-based pricing …”</td>
</tr>
</tbody>
</table>

Note for reader: Mitigation Estimate Impact (Kt CO₂eq reduced at 2020) is a field within the CSV version of the data that was retained as we previously were interested in plotting this data, but decided against it to reduce conceptual clutter for users reading our visualizations.
Include a URL linking to the source of your data.

1.) Historical Dataset:
   - Canada’s National Inventory Report, Environment and Climate Change Canada (Emissions Data):
     https://open.canada.ca/data/en/dataset/779c7bcf-4982-47eb-af1b-a33618a05e5b
   - Statistics Canada (Economic Data, GDP):
   - Statistics Canada (Population Data):

2.) Policy Impact Dataset:
   - Canada’s Fourth Biennial Report on Climate Change, Environment and Climate Change Canada (Policy Emissions Impact Projection Data):
     https://www4.unfccc.int/sites/SubmissionsStaging/NationalReports/Documents/1687459_Canada-BR4-1-Canada%E2%80%99s%20Fourth%20Biennial%20Report%20on%20Climate%20%202019.pdf

Briefly describe your current data preprocessing pipeline, if there is one.

1.) Historical Dataset:
The main data pre-processing pipeline uses python to merge data and derive new attributes. We are focused on the historical dataset for now (rather than the stretch goal of using future policy data). Our pipeline is composed of several steps:
1. Import necessary packages (pandas and NumPy)
2. Read in greenhouse gas data (National Inventory Report, 2020)
3. Subset greenhouse gas emissions data to only year, region, source and CO\textsubscript{2}eq
4. Read in economic data (Statistics Canada, 2020a)
5. Rename economic data columns “REF\_DATE”, “GEO”, and “VALUE” to “Year”, “Region”, and “GDP”
6. Subset economic data only to “Year”, “Region”, and “GDP” columns
7. Read in population data (Statistics Canada, 2020b)
8. Rename population data columns “REF\_DATE”, “GEO”, and “VALUE” to “Year”, “Region”, and “Population”
9. Subset population data only to “Year”, “Region”, and “Population” columns
10. Merge economic, economic, and population datasets
11. Derive emissions intensity variables for each jurisdiction:
   - Carbon intensity per capita: CO\textsubscript{2}eq/population
   - Carbon intensity per unit GDP: CO\textsubscript{2}eq/ GDP (only for jurisdictional total columns, not for subsectors as GDP data is tracked at a national/provincial/territorial rather than economic sector level
12. Export data as csv.
2.) Policy Impact Dataset:

Policy impact data was scraped from tables in a federal government report outlining the project impacts of current government policies from 2019. The data was originally in a Portable Document Format (PDF) where it was converted to a Word Document (.docx) and had the relevant tables pasted into a CSV.

Policy goal data (e.g. 30% below 2005 levels or net-zero by 2050) were taken from federal government websites.

Where ranges existed, the maximum value was taken as the visualization’s goal is to show what Canada concretely hopes to do, rather than what a low-ambition scenario.

Of note, from 231 listed policy actions at the federal, provincial, territorial levels, 157 of them (for various reasons) do not appear to have carbon emissions impact estimates. We chose to use this data anyways as it is the best itemized estimate available from the government. While there are other estimates, such as those in Canada’s 2020 update to its climate change plan (Environment and Climate Change Canada, 2021).
3. Goals and Tasks

Description of your intended task(s) in both domain-specific and abstract language. Do not discuss the visual encoding or interaction idioms chosen in this section.

The overarching goal of our assignment is to tell the story of Canada’s past, current, and future carbon emissions. We do this by showing historical climate data (to the most recent year possible) and by showing policy impact data (for what Canada has promised to do) for future emissions reductions.

Task Abstractions:
1. Compare provinces/territories with each other over time with respect to GHG emissions, carbon intensity per unit GDP and carbon intensity per capita.
2. Analyze and explore trends for one province/territory with respect to overall GHG emissions and carbon intensity per unit GDP and carbon intensity per capita.
3. Compare the contribution of different economic sectors to the GHG emissions of Canada and its provinces/territories.
4. Explore Canada’s policies to reduce GHG emissions and compare their projected impact (by the year 2030) with past emissions.
4. Visualization

Note: This visualization was designed for desktop screens of at least 1920 x 1080 pixels. Screens of different sizes may see different results.

Describe the visualization interface that you have built. What views are there and what do they allow users to do?

Our project focuses on exploring the annual trends of Canada’s carbon emissions over time to provide users (i.e. the Canadian public) with the knowledge to understand the past, present, and future of Canadian carbon emissions. We provide two main visualizations to allow users to see historical and projected future emissions.

In the first visualization, users can explore historical emissions from 1990 to 2018 in Canada. The user can switch between three major carbon metrics (absolute emissions, carbon intensity per capita, and carbon intensity per million dollars GDP) and contrast the emissions over time and per province in a heatmap. It is a multiform overview/detail visualization that combines a heatmap, choropleth, and stacked bar chart. This is primarily so that users can see the geographical relationships between the data based on Canadian jurisdictions (e.g. provinces and territories). Similarly, a choropleth provides a geographical encoding of the same information - one year at a time and based on the metrics chosen by the user. A choropleth was chosen as a more familiar idiom for users to see geographical relationships. The years change as a user scrolls up/down through the years. Finally, the stacked bar chart shows absolute emissions data broken up by their economic sectors for a jurisdiction (e.g. Canada/Province/Territory) selected in the two other views. The combination of all these three views and their interactions (e.g. direct province/year selection and scroll-based year selection) constitutes our innovative view. The shared colour palettes in the choropleth and the heatmap were chosen (i.e. yellow-green, yellow-green-blue, and yellow-orange-brown) to minimize the impact of hues for colourblind users (e.g. avoiding red/green together).

The second visualization allows the user to compare actual emissions with emissions that are planned to be mitigated by different policies. The policies are roughly mapped to the economic sectors of the stacked bar chart. A toggle allows the user to either explore the policies in depth or to contrast the efforts against the actual emissions.
For each view, describe your visual encoding choices and include the rationale for your design choices. How can users interact with your project within each view, and how are views linked?

1.) Historical Emissions Visualization (Innovative View)
Our innovative view brings together all three different plots together, by tying the data displays of the three plots primarily through scrolling to express changes through time (e.g. seeing Canadian carbon emissions from 1990-2018). It is a multiform overview/detail visualization that combines a heatmap, choropleth, and stacked bar chart.

i) Heatmap:
Marks:
- Interlocking areas: Each rectangle represents a given year and carbon emissions attribute (e.g. actual greenhouse gas emissions, carbon intensity per capita, carbon intensity per unit GDP).

Channels:
- Hue: Encodes the type of carbon emissions attribute (e.g. actual greenhouse gas emissions, carbon intensity per capita, or carbon intensity per unit GDP)
  - The shared colour palettes in the choropleth and the heatmap were chosen (i.e. yellow-green, yellow-green-blue, and yellow-orange-brown) to minimize the impact of hues for colourblind users (e.g. avoiding red/green together).
- Saturation: Encodes the magnitude of the carbon emissions attribute (e.g. actual greenhouse gas emissions, carbon intensity per capita, or carbon intensity per unit GDP)
- Position on a common scale (horizontal): Encodes the year that the attribute was estimated for (e.g. GHG emissions for all of Canada in 2012).
- Position on a common scale (vertical): The jurisdiction where emissions occurred (e.g. British Columbia, Quebec).

Interactions:
- Sorting: Regions (e.g. Canada, provinces/territories) can be sorted alphabetically or via the magnitude of the quantitative attribute (one of three metrics) being displayed.
- Selection: Individual jurisdictions (e.g. provinces/territories) can be selected, reducing the visibility of other jurisdictions. This selection will update the stacked barchart view and also the choropleth.
- Tooltip: Hovering over a point mark, a tooltip will appear and display exact emissions values for a jurisdiction for a given year.
ii) Choropleth:

Marks:
- Interlocking areas: Each polygon/group of polygons (i.e. jurisdictions with islands), represents a sub-national jurisdiction in Canada (e.g. Alberta, the Yukon Territory).

Channels:
- Hue: Encodes the type of carbon emissions attribute (e.g. actual greenhouse gas emissions, carbon intensity per capita, or carbon intensity per unit GDP)
  - The shared colour palettes in the choropleth and the heatmap were chosen (i.e. yellow-green, yellow-green-blue, and yellow-orange-brown) to minimize the impact of hues for colourblind users (e.g. avoiding red/green together).
- Saturation: Encodes the magnitude of the carbon emissions attribute (e.g. actual greenhouse gas emissions, carbon intensity per capita, or carbon intensity per unit GDP)

Interactions:
- Selection: Selection within this view will outline a province in a thicker line and will update the selected province in both the heatmap and the stacked bar chart.
- Tooltip: Hovering over a jurisdiction, a tooltip will appear and display exact emissions values for a jurisdiction for a given year

iii) Stacked Barchart

Marks:
- Lines: Lines represents the number of emissions in CO₂ equivalents for a given economic sector for a given year

Channels:
- Hue: Encodes the sector of emissions (e.g. transportation, heavy industry)
- Position on a common scale (horizontal): Magnitude of emissions for a given year
- Position on a common scale (vertical): The year that the emissions were generated

Interactions:
- Tooltip: Hovering over a bar will display exact emissions values per sector for a jurisdiction for a given year

iv) Coordinated Global Interactions:

Overall:
- Change over time: Visually encoded data subsetting through scrolling. By scrolling up or down with a scroll wheel, the data highlighted (heatmap/stacked bar chart) or the data displayed (choropleth) will change. The motion of the selected year through time helps communicate which data is most important at the moment. The movement will be particularly pronounced with the choropleth as the hues change provincially through time.
Similarly, the current year will highlight data by changing non-current year opacities in the heatmap and the stacked bar chart to emphasize the current year.

2.) Policy Impact Visualization

Marks:
- Lines: Line length represents the number of emissions/emissions reductions in CO₂ equivalents for a given year in Canada

Channels
- Hue: Encodes emissions (gray) or type of emissions reductions by sector (all other colours)
- Position on a common scale (horizontal): Magnitude of emissions for a given year
- Position on a common scale (vertical): The year that the emissions were generated/removed

Interactions:
- Tooltip: Hovering over a bar will display exact emissions/emissions reductions for a given year and for a given policy
- Superimpose: A selector to include historical emissions data, when clicked, will trigger an animated rescaling of the emissions reductions relative to the magnitude of historical emissions levels.
Include a usage scenario walking through how your visualization can be used during an interactive session, illustrated with screenshots of your system in action. It may be different than what you originally envisioned in your proposal, that’s fine.

The main usage of these visualizations is for people who are interested in understanding the extent of Canada’s historical emissions and their relationship to Canada’s economic development and population growth quickly and visually (i.e. without reading policy documents). A potential scenario could be as follows:

Markus is a British Columbian with a high-school diploma who is passionate about climate change. He wants to learn about where Canada’s carbon emissions are at, and what Canada is doing to help curve them. He has a general idea of what causes climate change and the different ways that greenhouse gas emissions might be generated, but he is not clear on the magnitude and the driving sources of emissions in Canada. Markus wants to be able to explore historical data on carbon emissions and to compare between provinces in order to gain an understanding of the biggest polluters within Canada’s economy.

He will see our webpage homepage and see our website for the first time and he will get acquainted with the navigation controls (e.g. menu, homepage navigation buttons, and via the scroll wheel, see Figure 4 below).

Figure 4: Our website homepage with navigation buttons (center), menu (top-left), and associated content (throughout).

Scrolling down, Markus will get a very big picture understanding of Canada emissions relative to that of the larger world to give him context how much Canada is polluting as a whole in a landing page for the historical visualization (see Figure 5 below).
Figure 5: The historical visualization landing page with some contextual write up (center) and a navigation button (lower-center). A user can also scroll to continue.

Scrolling down into the historical visualization, he will see a view in the style of a heatmap that shows these data for all of Canada’s provinces over the available time range (1990 - 2018). He will see on the bottom-left corner a map of Canadian provinces and territories displaying emissions data at the default year - 2018 (the latest year data was available from our data). On the bottom-right, he will see a historical overview of Canada’s carbon emissions. Markus might find out that the energy sector is the most heavily polluting for Canada. This is summarized in Figure 6 below.
Figure 6: Our historical emissions data visualization provides an overall view of Canadian emissions with a heatmap (top-center), a choropleth (bottom-left), and a stacked bar chart (bottom-right).

In terms of interactions, Markus can see climate data on a total aggregate level or he can use radio buttons to also display carbon intensity data (i.e. emissions per $ of gross domestic product and emissions per person). This will update both the choropleth and the heatmap so that Markus can see the geographical relationships between overall total carbon emissions, economic output, the Canadian population and economic output. He can also sort the heatmap alphabetically by jurisdiction (e.g. province/territory of Canada) or numerically (highest polluters on top). This is captured in Figure 7 below.
Figure 7: Our historical emissions data with the economic intensity of carbon emissions selected in a radio button (top-center). The heatmap (center) and the choropleth update to reflect this selection. The heatmap is sorted alphabetically by default.

Markus can also click on a specific cell in the heatmap (encoded by year and Canadian province/territory). This will then update the choropleth to show that particular year and the stacked bar chart to show the selected province/territory. The selected year will also be highlighted with line borders and opacity contrasts. This can be similarly activated (with or without a province/territory selected) by scrolling down to see year-by-year highlights in the heatmap, yearly geographical distributions in the choropleth, and highlights by year in the carbon emissions stacked barchart. This is captured in Figure 8 below.
Figure 8: Our historical visualization with Alberta selected in the year 2000. The heatmap highlights the selected year through outlining the affected boxes (years and geography, center-top), the choropleth has extra-thick strokes to also highlight the selected province (bottom-left), and the stacked bar chart outlines the emissions (as separated by economic sector, bottom-right).

A navigation button in the bottom-left will also allow Markus to escape the scrolling-based interaction and jump to the Policy Visualization (see Figure 8).

Tooltips are also available for all of the views (heatmap, choropleth, and stacked barchart) to allow users to see exact quantification of each datapoint (see Figure 9 below).
Figure 9: A view of an activated tooltip for the heatmap in the historical visualization (center). This provides exact quantitative information for the emissions for the province of Ontario in 2005.

Markus is also interested in what Canadian provinces/territories and the federal government have done to reduce carbon emissions. Scrolling down or clicking the ‘Skip to Policy Visualization’ button, Markus sees a landing page describing Canada’s climate goals. He will become aware that 2030 is the target date for Canada’s international commitment (Paris Climate Agreement) to reduce carbon emissions to 30% below 2005 levels. This is captured in Figure 10 below.

![Canadian Climate Policy Impacts (at 2030)](image)

*Canadian Climate Policy Impacts (at 2030)*

Canada has made a few promises on climate change ([Office of the Auditor General of Canada, n.d.](https://www.oag-bvg.gc.ca/)).

Our current goals were made in 2015 ([Office of the Auditor General of Canada, n.d.](https://www.oag-bvg.gc.ca/)) and have expanded in 2020 ([Environment and Climate Change Canada, 2021](https://www.ec.gc.ca/)).

Overall, Canada wants to reduce emissions to 30% below 2005 levels by 2030 and eventually reach net-zero emissions by 2050.

![Pictured: Algonquin Provincial Park (Ontario)](image)

Figure 10: The landing page for our policy impact visualization with expositional text (center) will allow users to get a better understanding of Canada’s carbon commitments in the past and what it wants to do in the future. Users can proceed to the next section by scrolling downwards or by hitting the arrow button (bottom-center).

He can scroll further down and will be able to explore a national-level view of Canadian climate policies and what they are doing to reduce emissions by 2030 (see Figure 11 below).
Figure 11: Our policy impact view, detailing the categories of carbon emissions reductions in a stacked bar-chart that outlines their year of implementation and their emissions reductions project impact in 2030.

He will also see the impact of emissions relative to Canada's historical emissions levels to get a better sense of the magnitude of work that Canada has done and will need to do to meet Canada's climate ambitions by clicking the checkbox ‘Compare with historical emissions’ (see Figure 12 below).

Figure 12: The policy view with the historical data activated juxtaposes the policy commitments to the scale of the reductions required to eventually meet Canada’s goal of 2030 below 2005 levels by 2030, and to go net-zero by 2050.
As Markus scrolls even more downwards, a Methodology and Sources page provides a link to this
document as a reference for users, and it also lists out the authors of this website so Markus can read
more about this website, if he is curious (see Figure 13 below).

Figure 13: Our “Methodology and Sources” page with a link to this document, and information about the
authors of the website for reference.

Finally, if Markus wants to go back either now, or at any other point as he traverses the website, the
menu (top-left) has been present this whole time. It can be extended to allow Markus to return to
previous sections of the website (see Figure 14 below).

Figure 14: The navigation menu (extended; left side of screen) allows users to navigate to any other
section of the webpage to see parts of the website again.
Markus will leave the webpage with a deeper understanding of Canada’s emissions history and how Canada is reducing its emissions.
5. Credits

Indicate any sources of inspiration, including any specific D3 code blocks that you consulted or built upon. Explain what changes you made and their magnitude (e.g. unchanged vs. minor tweaks vs. major functionality additions) for any code that you built upon.

The majority (unless otherwise stated) of credits were of the minor variety, mainly used to tweak code or to make visualizations work. Sometimes class or online tutorials were used to learn how to make larger items (e.g. navigation menus, backgrounds, or choropleths) work. These were then customized to fit our needs, aesthetics, and data (e.g. adding icons/listeners for menus, custom pictures & captions, choropleth interactivity, colouring and highlighting).

Conceptual Credits:
- Canada’s Changing Climate Report: General inspiration for displaying climate data/idea to visualize Canadian climate data: https://changingclimate.ca/CCCR2019/

Coding Credits:
- General Layout:
  - Window.innerHeight(): Finding the height/width of a window to that we can proportionately size graphs: https://developer.mozilla.org/en-US/docs/Web/API/Window/innerHeight
  - CSS Colouring: Making buttons change colour after mousing over them: https://css-tricks.com/change-color-of-svg-on-hover/
  - Rounded corners (making buttons and other objects look rounded for styling): https://www.w3schools.com/css/css3_borders.asp
  - Fixing the position of objects (making buttons stay in exact positions, e.g. menu): https://stackoverflow.com/questions/7576342/css-to-keep-element-at-fixed-position-on-screen
  - Tutorial: How to create sidebar (moderate amount of styling edits/minor functional edits on javascript for closing behaviour for implementing a close when clicking the menu again): https://www.w3schools.com/howto/howto_js_collapse_sidebar.asp
- General Advice:
  - Button Styling: General advice on how to style buttons: https://www.w3schools.com/css/css3_buttons.asp
  - Button HTML Scripting: General advice on how to place buttons into a HTML document: https://www.w3schools.com/tags/tag_button.asp
- Intra-document linking: Guidance on how to use `<a>` to link different parts of a webpage together: 
  https://blog.hubspot.com/marketing/jump-link-same-page
- Captions within images: How to place captions within an image, minor changes to position, changes for custom caption content:
  (Upper Left Caption) 
  https://www.w3schools.com/css/tryit.asp?filename=trycss_image_text_top_left
  (Bottom Right Caption) 
  https://www.w3schools.com/css/tryit.asp?filename=trycss_image_text_bottom_right
- French Language Character Support: Added HTML declaration to support accented characters in HTML: 
  https://www.lifewire.com/html-codes-french-characters-4062211
- CSS Positioning: For general styling and positioning of website elements (landing pages): 
  https://www.w3schools.com/css/css_positioning.asp
- CSS Positioning: Understanding why fixed elements overlapped each other: 
  https://stackoverflow.com/questions/44316638/stop-fixed-position-div-from-overlapping
- HTML Subscripting (for CO₂e styling): 
  https://www.w3schools.com/tags/tag_sub.asp
- Subscript Character (for CO₂): 
- Historical Visualization
  - Overall:
    - Colour Schemes (Heatmap and Choropleth): Seeing a gallery of different colour schemes available in d3 and selecting them for use: 
      https://github.com/d3/d3-scale-chromatic
    - Item Alignment: Aligning all buttons to the top 
      Additional guidance on button alignment: 
    - Removing space in h1: Removing space to allow for more pixel real estate after title: 
      https://stackoverflow.com/questions/40822576/removing-space-between-h1-and-h2
    - CSS Element Coordinates: Initializing a start position for the historical graphics container to allow for sticky positioning: 
    - CSS Flexboxes: Distributing buttons to be flat to allow for my pixel real-estate: 
      https://css-tricks.com/snippets/css/a-guide-to-flexbox/
- Styling of metric selector with radio buttons:
  https://www.w3docs.com/snippets/css/how-to-style-the-selected-label-of-a-radio-button.html
- Guidance on how to use javascript functions to jump around the page based on clicks (jump to a specified div):
- Guidance on how to smoothly scroll a div into view after a javascript jump:
  https://stackoverflow.com/questions/12102118/scrollintoview-animation
- Learning how to make subclasses (to support different classes of buttons):
  https://medium.com/insider-inc-engineering/delightful-ways-to-write-reusable-css-using-subclasses-903e90c9cf87
- Getting Sticky CSS to work to coordinate with Waypoints:
  - CSS Styling of Absolute vs. Relative Positions in Nested Styling (used to help place captions in correct places):
    https://stackoverflow.com/questions/3956043/css-how-to-position-element-in-lower-right
  - CSS Styling Hierarchy of Absolute Positioning: Used to understand why relative pages were overlapping each other:
  - CSS Sticky Elements: Debugging why sticky elements were broken inside historical visualization:
  - Appending Class Information: Appending a fixed attribute to class (implementing sticky behaviour):
    https://www.w3schools.com/jsref/met_element_setattribute.asp
  - Removing Class Information: Removing a fixed attribute (implementing sticky behaviour):
    https://www.w3schools.com/howto/howto_js_remove_class.asp
- Data pre-processing with python and pandas library (review of how to use code):
  - Selecting certain rows:
    https://stackoverflow.com/questions/17071871/how-to-select-rows-from-dataframe-based-on-column-values
  - Getting a specific cell:
  - Renaming columns (for example from VALUE in GDP spreadsheet to GDP):
- Selecting multiple columns:

- Merging data frames:

- Writing to a csv file:

- Coordination of Views/Interactivity:
  - Implementing sticky vs. non sticky elements in Waypoints:
    https://pudding.cool/process/how-to-implement-scrollytelling/demo/waypoints
  - Document.getElementById(): General understanding on how to use Javascript to find and then modify HTML elements:

- Heatmap:
  - Main inspiration, CPSC436V d3 heatmap case study:
  - Inspiration: Heatmap style d3 example:
    https://www.d3-graph-gallery.com/graph/heatmap_style.html
  - How to remove spaces so that province/territory names can be used as unique identifiers for highlighting a province/territory’s selection:
    https://stackoverflow.com/questions/5963182/how-to-remove-spaces-from-a-string-using-javascript
  - Learning how to use double-click interactivity to the heatmap (for deselecting/selecting provinces/territories):
    https://stackoverflow.com/questions/20031254/how-can-i-make-double-click-event-on-node-in-d3-js
  - Review of Dispatch to learn how to integrate it with a double-click event (for selecting/deselecting provinces/territories):
    https://github.com/d3/d3-dispatch

- Choropleth:
  - General:
    - CPSC 436V D3 choropleth example for guidance on structuring code and syntax:
      https://codesandbox.io/s/github/UBC-InfoVis/2021-436V-example
les/tree/master/d3-choropleth-map?file=/js/choroplethMap.js:57-58

- Data Processing:
  - General documentation on how to use the javascript filter function: https://developer.mozilla.org/en-US/docs/Web/JavaScript/Reference/Global_Objects/Array/filter

- Boundary Styling:
  - Adding a border to provinces/territories https://stackoverflow.com/questions/54856638/create-a-curved-border-around-a-d3-map-projection

- Stacked Bar Chart:
  - General:
    - General structure of the stacked bar chart taken from: https://github.com/UBC-InfoVis/2021-436V-examples/tree/master/d3-stacked-bar-chart
    - For the use of the d.data.nameOther in rendering: https://observablehq.com/@d3/stacked-bar-chart
    - General information on ways to implement scrollytelling: https://bl.ocks.org/baronwatts/2a50ae537d7c46670aa5eb30254ef751
    - General information on ways to implement scrollytelling: https://towardsdatascience.com/how-i-created-an-interactive-scrolling-visualization-with-d3-js-and-how-you-can-too-e116372e2c73
    - Finding max in 2D matrix to get highest value in the last element of stacked data: https://stackoverflow.com/questions/31249419/how-to-find-max-value-from-a-2d-matrix-using-d3-js
    - How to rotate and place y-axis label: https://bl.ocks.org/d3noob/23e42c8f67210ac6c678db2cd07a747e
    - Reference for color schemes: https://observablehq.com/@d3/color-schemes
    - How to properly select classes: https://stackoverflow.com/questions/17435838/how-to-use-d3-selectall-with-multiple-class-names/17436116
    - Basic outline of renderVis() for a stacked bar chart: https://github.com/UBC-InfoVis/2021-436V-examples/tree/master/d3-stacked-bar-chart
  - Tooltips:
    - Documentation on adding newlines within text: To space out tooltip entries:
- Documentation on how to append HTML elements: To find out how append new div elements dynamically (for labelling the tool tip emissions data):

- Documentation on Object.entries: To find out how to access object key-value pairs as an array:
  https://www.samanthaming.com/tidbits/76-converting-object-to-array/

- Documentation on Math.round: To find out how to use the Javascript implementation of the function:

- Policy Visualization
  - Data pre-processing: finding start years for different policy works
    - Ontario Emissions Reduction fund date 2021
    - 'Alberta Coal-Fired Electricity Generation phaseout**'
    - 'New Brunswick Output Based Pricing (OBPS) for Industry and Electricity**'
      https://www2.gnb.ca/content/dam/gnb/Departments/env/pdf/Climate-Climatiques/MadeInNBRegulatoryApproachForLargeIndustrialEmitters.pdf
    - 'British Columbia Promoting Use of Low Carbon and Renewable Materials in Infrastructure'
    - 'Ontario Greenhouse Gas Emissions Performance Standards Regulation'
    - 'Prince Edward Island Alternative Land Use Services Program'
      https://www.princeedwardisland.ca/en/service/alternative-land-use-serv
es-alus-program
  - Data pre-processing: other
    - remove * and ** from first column:
- Timeline implementation
  - P2 melissa's bar chart:
    - [http://bl.ocks.org/mstanaland/6100713](http://bl.ocks.org/mstanaland/6100713)
  - Custom stacked bar chart implementation: For the policy stacked bar chart, I (Melissa) had to add custom attributes y0 and y1 to allow the data to be stacked. I tried using the d3 stack generator but it did not work because the d3.stack.keys were not keys in the data object. My keys were values of the 'Sector_Affected' attribute. I also took some inspiration from a tip in the 'Data Sketches: A Visualization A Month - Shirley Wu and Nadieh Bremer' video from Week 13: [https://www.youtube.com/watch?v=4EOG7KwFspk](https://www.youtube.com/watch?v=4EOG7KwFspk) In it, they recommend doing some data preprocessing on datasets to help with styling. I thought that creating y0 and y1 key-value pairs could be useful. To style the height and y value in the d3 'rect' data join, I followed the class example 'stackedBarChart' [here](https://www.youtube.com/watch?v=4EOG7KwFspk).
    - user 'ericsoco'
  - Adding in the historical dataset, using promise.all in main, like in the historical main. We had to change the domains of the axis.
    - Had to move the x-axis from the top to yscale(0), following this source [http://bl.ocks.org/maaquib/6e989956b99b819d69e9](http://bl.ocks.org/maaquib/6e989956b99b819d69e9)
    - Conditional rendering for historical data in policy timeline [https://stackoverflow.com/questions/10784018/how-can-i-remove-or-replace-svg-content](https://stackoverflow.com/questions/10784018/how-can-i-remove-or-replace-svg-content)

- Image Sources:
  - Dirt road through wheat fields, Saskatchewan: [https://www.flickr.com/photos/8478531@N03/4797556078](https://www.flickr.com/photos/8478531@N03/4797556078)
  - Marché Bonsecours - Montréal, Quebec: [https://commons.wikimedia.org/wiki/File:March%C3%A9_Bonsecours_Winter.jpg](https://commons.wikimedia.org/wiki/File:March%C3%A9_Bonsecours_Winter.jpg)

- Icon Sources:
  - Stacked Menu Bar Icon: W3 Schools [https://www.w3schools.com/howto/howto_js_collapse_sidebar.asp](https://www.w3schools.com/howto/howto_js_collapse_sidebar.asp)
  - Other Icons: Bootstrap [https://icons.getbootstrap.com/icons/](https://icons.getbootstrap.com/icons/)

- Website Factoid Sources:
- World Bank (2020a) Global GDP Rankings:
  https://datacatalog.worldbank.org/dataset/gdp-ranking
- World Bank (2020b) Global Population Rankings:
  https://datacatalog.worldbank.org/dataset/population-ranking
- Walton (2021): Weight equivalencies to a car
  https://www.autolist.com/guides/average-weight-of-car
- Office of the Auditor General of Canada (n.d.) Canadian Carbon Policy History:
  https://www.oag-bvg.gc.ca/internet/English/sds_fs_e_41101.html
- Environment and Climate Change Canada (2021): Canadian Carbon Policy Commitments (30% Reductions by 2030 and Net Zero Emissions by 2050)
6. Reflection

Describe how your project has developed from your initial proposal, through your first submission, to your final product.

Following the course’s set of milestones (proposal, work-in-progress, and the final product), we found that the process was an intense project that involved the team in vigorous sprints to produce our products.

Milestone 1: Project Proposal
In developing the idea, we had started by looking around at different types of climate data, narrowing down the Canadian scope, and then progressing to drafting some visualizations.

Across the team, we were all interested in looking at climate data from different sources, such from campus climate data, global emissions data, or national-level emission data. We settled on Canadian emissions data for a variety of reasons, including familiarity with the country (we are all attending a Canadian institution) and the centralized availability of data (Canada provided robust datasets on emissions data and on econometrics such as populations and economic data; Environment and Climate Change Canada, 2020, Statistics Canada, 2020a & 2020b).

We had originally envisioned telling a story about the complex relationships between economic activity, the Canadian population, and with carbon emissions through the past and into the future. Canada’s national climate plan emphasizes this theme of both environmental protection and economic growth for all people in Canada (Environment and Climate Change Canada, 2021). The data appeared at first to support this at first, as there were economic sector breakdowns of the data available. The policy data appeared to offer this economic-level categorization as well. However, we ran into the issue that what Statistics Canada (2020a) meant by economic data and what Environment Canada meant by economic sectors were not the same. It meant that there was no way to harmonize the economic sectors between the emissions data and the dollar-value data that Statistics Canada had. Thus, we were not able to explore sector-level impacts of emissions on Canadian jurisdictions’ economies (e.g. national, provincial, and territorial). We settled on reducing the scope of the visualization to include a more limited geographic-level comparison between emissions levels for jurisdictional economies in aggregate form (e.g. total national emissions/total national gross domestic product) and a separate visualization that shows the projected impact of different policies.

In terms of drafting the visualization, we were all interested in telling a story. We wanted to tell the story of Canadian carbon emissions from the past, present, and into the future. We believe that the past/present/future views can give users a good grounding of what Canada is doing on a national, provincial, and territorial level. This is important for people who care about the environment and also for all Canadian voters as it is an ever important election issue. About 2/3rds of Canadians believe in recent polling that Canada should be doing more on climate change (CBC News, 2020). We discussed many
different ideas and exact points in our group meetings (e.g. marks, channels, encodings, interactions). This included drawings (see Figure 15 below for an example of a future view), or even digital prototypes done on Google Slides (https://drive.google.com/file/d/1t2TBzGzD6Lyk1eEXCva_uTAtam9UUj60/view?usp=sharing).

![High ambition goals of our visualization:](image)

Figure 15: A very early conceptual draft of how we could emphasize Canada’s goal to reach net-zero emission by 2050 (Environment and Climate Change Canada, 2021).

We settled on a historical visualization focused on emissions between 1990-2018 - the maximum extent supported by the Environment and Climate Change Canada’s (2020) climate data. We could then combine that with comparisons of emissions history on a geographic level (choropleth), sectoral level (stacked barchart), and on a comparative level (heatmap). As a stretch goal, we decided that we would try to tell the story of future policy impacts based on a dataset we found that Canada produced for the United Nations - the Fourth Annual Biennial Report (Environment and Climate Change Canada, 2019). We did not know for sure what the policy visualization would look like.
**Milestone 2: Work-In-Progress**

Milestone 2 was a “quieter” coding process. We were able to get some form of progress on all three elements of the historical visualization (heatmap, choropleth and stacked barchart). We already had some of the interactivity included (stacked barchart was able to change region), however the views were not yet linked with each other and we ran into some troubles of showing all the views correctly in the viewport. We also made some minor modifications to the design - for instance, we decluttered the heatmap and finally decided to use scrolling as a way to navigate through the different years (more about that below).

At the end of Milestone 2, we felt comfortable enough with our progress that we wanted to press forward with our stretch goal of showing the projected future impact of different policies, however we weren’t sure yet in what form we would do that.

**Milestone 3: Final Product**

Milestone 3 was the most intense and involved submission. While we had made great progress, we found significant difficulties in working out the CSS and html. This was probably the biggest challenge for us and really frustrating, as the actual d3 part progressed quite smoothly.

In terms of progress, we were able to finish all static and interactive elements of the historical dataset, as well as implement a barchart to visualize our policy data. We were satisfied with how it all came together. We also were able to draft a structure for our webpage with a menu and functional buttons for navigation (see Figures 16, menu extended, and 17 menu un-extended below). The menu is functional throughout the entire website.

![Figure 16: Homepage with menu extended.](image-url)
In terms of working with CSS, some notable issues we encountered included the styling of the scroll wheel interaction and with the tooltips. Otherwise, “garden-variety” CSS issues we could typically solve with reading through some documentation or Stack Overflow entries. With the scroll interaction in the historical dataset, the difficulty came from aligning how the sub elements to container divs would work out. Each div needed its own styling (e.g. flexboxes for selection boxes/radio buttons so they would all line up in the right row). Then, came positioning for heatmap, choropleth, and the stacked barchart in the historical dataset. After that, syncing up a “sticky” positioning with the waypoints package was another significant time sink. Debugging this took around 6 hours. In terms of the tooltips we found that sometimes our entries such as with the historical visualization’s stacked bar chart or with the policy visualization, they would leave the page. This was too hard to accomplish in the time that we had left, but we think that we could try to apply a mathematically-adjusted offset in javascript in calculating the x and y position to keep the tooltip away from the edge of the screen. There could also be libraries for this as this would seem to be a fairly common problem for modern web designers to face.
How have your visualization goals changed?

Our goals have remained mostly the same in terms of the higher-level picture. We maintained the same types of task abstractions and goals. We have some changes in terms of our technologies used, changes in response to TA feedback, and some changes on our stretch goal to display future policy data.

The technologies and specific implementations have slightly changed. Instead of using a timeline bar selector approach for the choropleth (interactively tied to the rest of the views), we changed to a scrolling-enabled view. Scrolling with a scroll wheel coordinates the display of data through time, particularly through the choropleth. Change of the current year using the scroll wheel will also lightly highlight data in the heatmap and the stacked bar chart to help the user track the year that is being displayed. This highlighting will be accomplished with changes in opacity (i.e. non-selected years will be less visible). We acknowledge that there can be some confusion using both axes for time (e.g. horizontal axes for years in the choropleth and the stacked bar chart; vertical axis along the entire webpage in scrolling up/down). However, given that most users will probably experience transfer effects from other graphs they have seen before (encoding time on the horizontal axis is a very common idiom), and that scrolling down to see more/new data (e.g. new years of data), we believe that the potential for confusion is a good trade-off.

In response to TA feedback, we have changed our heatmap to be “less packed” by removing filtering out the data by category/metric.

Our stretch goal to display future policy data remained the same, however we needed to compromise on how far it was able to go. Some of earlier designs included a very ambitious view that included a circle mark timeline of emissions reductions policies and their implementation over time (see Figure 18 below).

![Figure 18: Draft policy event timeline with circle point marks on a timeline, circle size encodes impact.](image-url)
However, we ended up settling on our alternative barchart-based design as it ended up fitting our data better (see Figure 19 below).

Figure 19: Canadian carbon policy commitments to 2030 as a stacked bar chart.
How have your technical goals changed?

The technical goals have not changed much, however some components were more difficult to achieve than others. Originally, we had planned to deliver a really polished project, however we soon discovered how difficult the styling part can be. Thus, we settled for a still aesthetically pleasing but less ambitious website design to have more time to focus on the actual visualizations.

At the beginning we weren’t sure how difficult it would be to implement the scroll wheel, so we originally also planned for an alternative navigation bar that allows the user to navigate through the years. However, we were pleasantly surprised how straightforward it was to integrate the Waypoints package and thus decided to move forward with that.
How realistic was your original proposal in terms of what is technically possible in D3?

We believe that the original proposal was very possible in D3. Our data was more traditional in the sense that you could effectively tell stories with simple charts (e.g. bar graphs in both the historical and the policy visualizations). Our original proposal included mostly barcharts, choropleths, heatmaps, and a point-mark based timeline.

The barcharts and choropleths are well within the “bread-and-butter” capabilities of D3 as they were prominently featured in class examples of charts.

The heatmap was a bit more unique as there was only one class example on the effects of vaccines against infectious diseases (Debold & Friedman, 2015). We ended up extending this by adding interactions using the scroll wheel (to highlight temporally-based data), and by using click-based interactions to highlight jurisdictions in other views (e.g. choropleth and stacked barchart).

Finally, the point-mark based timeline (see Figure 20 below), was similar to an applied version of a scatter plot that would need to have care taken to avoid overplotting (there would be zero tolerance for overlapping objects). We eventually elected to do a stacked bar chart instead for simplicity of understanding, as discussed in class, barcharts are very intuitive to understand.

Figure 20: Draft policy event timeline with circle point marks on a timeline, circle size encodes impact.
Was there anything you wanted to implement that you ultimately couldn't figure out how to do? If so, then what workarounds did you employ, or did you abandon your original idea?

Once we settled on the ideas of the project, the TA evaluation process provided us feedback that made sure that we had feasible ideas to implement. As mentioned earlier, we faced issues with the data in telling the story we originally imagined, and we later also had to abandon a temporary idea we had for integrating the policy related data. Finally, we also weren’t able to polish the website as much as we had wanted to.

For the data problem, we noticed that the environmental data (Environment and Climate Change Canada, 2020) and the economic data (Statistics Canada, 2020a) did not match up in terms of what each government agency categorized as “economic sectors”. Thus, it meant we were not able to explore sector-level impacts of emissions on Canadian jurisdictions’ economies (e.g. national, provincial, and territorial). We removed that goal from our design very early, even before our Milestone 1 submission.

As for the temporary idea, we briefly discussed integrating the stacked bar chart with the view on the projected impact of the different policies to make a continuous transition between the historical to the policy visualization. Unfortunately we had this idea relatively shortly before the end of the project, so we decided not to implement that.

Finally, our struggles with CSS and html were quite time consuming for the M3 submission. Given that none of us had substantial experience in web design, we are very happy with our end result. However, if we had more time we would try and polish everything a little more.
If you were to make the project again from scratch (or any other interactive visualization), what would you do differently?

We believe that the main issues we had were technical. While the visualization was satisfactory in our eyes, some of the technical aspects that could be improved would be to design the views to be more functional on smaller screens, to architect the system to be less resource intensive, and to find alternative implementations of colouring to make things run.

In terms of scaling, our website is not designed to be mobile-first at all. We make a strong assumption that either this website will be consumed by a desktop with a sufficiently large screen, or with a large enough tablet that they can fit all of the views at once. However, with smaller screens, we are not sure that our current interlocking set of views, particularly in our historical view would even make sense. The historical view functions similar to a dashboard on a car, in that it tries to convey a lot of information and that making a section smaller (e.g. a car’s odometer) will actively make the view less effective (e.g. if the heatmap is too small, there would be no way to tell the differences between jurisdictions). A redesign for mobile systems of the views may be the most effective fix here.

In terms of resource usage, the issues potentially lie on two fronts, memory and calculation intensity. Memory-wise we keep copies of the entire dataset (historical or policy) in each javascript chart object. While this made programming easier (no need to handle signaling between events), this ultimately uses more resources. We made the judgement that the memory usage for desktops (our primary target device) would be negligible (the historical CSV is about 257kB, the policy is about 168kB). However, many mobile devices have much more limited resource availability that can impede the optimal functionality of the visualization.
7. Project Management & Team Assessment

Update your work breakdown and schedule with your final status. For each chunk of work that you carried out, include the actual numbers of how long it took to do in reality (put these next to your original estimates so you can see them side by side). Do this for both estimates: the number of hours and the date completed. Also add to your work breakdown any new chunks of work that you ended up needing to do that were not included in previous versions of your plan.

Overall, we have structured this discussion around Milestones 1, 2, and 3. We found Milestone 1 to be a process dominated by video call interactions between group members in a process of prototyping designs. Milestone 2 was dominated by the discovery of time efficiencies in coding, and a reduction in meetings. Finally, Milestone 3 reversed the trend of time efficiencies in coding (CSS work was very time consuming) but we were able to work with even fewer meetings than before.

In Table 7 below, we have listed our accounting of time between March 1st to the week that ended Milestone 1 (Week of March 10th). Progress in this Milestone was dominated by time drafting designs and with many video calls to discuss ideas.

Table 7: Accounting of Time Spent on Milestone 1.

<table>
<thead>
<tr>
<th>Task(s):</th>
<th>Target Compl. Date:</th>
<th>Target Hours:</th>
<th>Actual Compl. Date:</th>
<th>Actual Hours:</th>
<th>Owner:</th>
<th>Notes:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Meeting on Brainstorming and Planning</td>
<td>Mon Mar 1</td>
<td>6</td>
<td>Mon Mar 8</td>
<td>6</td>
<td>Group</td>
<td></td>
</tr>
<tr>
<td>Individual Research, Data Research, and Brainstorming</td>
<td>Wed Mar 3</td>
<td>2</td>
<td>Mon Mar 8</td>
<td>2</td>
<td>Melissa</td>
<td></td>
</tr>
<tr>
<td>Individual Research, Data Research, and Brainstorming</td>
<td>Wed Mar 3</td>
<td>2</td>
<td>Mon Mar 8</td>
<td>2</td>
<td>Flo</td>
<td></td>
</tr>
<tr>
<td>Individual Research, Data Research, and Brainstorming</td>
<td>Wed Mar 3</td>
<td>2</td>
<td>Mon Mar 8</td>
<td>2</td>
<td>Edward</td>
<td></td>
</tr>
<tr>
<td>Group Meeting on Progress Update and Discussing Next Steps</td>
<td>Wed Mar 3</td>
<td>6</td>
<td>Mon Mar 8</td>
<td>6</td>
<td>Group</td>
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<td>Continued Brainstorming</td>
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<td>1</td>
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<td>Melissa</td>
<td></td>
</tr>
<tr>
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<td>Fri Mar 5</td>
<td>1</td>
<td>Mon Mar 8</td>
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</tr>
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<td>Date</td>
<td>Duration</td>
<td>Task Responsible</td>
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<td>Fri Mar 5</td>
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</tbody>
</table>

**Milestone 1 (Mar 8 - Mar 14): Design Refinement and Proposal Submission**

<table>
<thead>
<tr>
<th>Task Description</th>
<th>Date</th>
<th>Duration</th>
<th>Task Responsible</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group Discussions and Finalizing Ideas</td>
<td>Mon Mar 8</td>
<td>6</td>
<td>Wed Mar 10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Group (1hr/mem)</td>
</tr>
<tr>
<td>Drafting Overview</td>
<td>Mon Mar 8</td>
<td>4</td>
<td>Wed Mar 10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Florentin &amp; Edward</td>
</tr>
<tr>
<td>M1: Finding Data Details &amp; Describing Data</td>
<td>Mon Mar 8</td>
<td>3</td>
<td>Wed Mar 10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Edward</td>
</tr>
<tr>
<td>M1: Drafting Usage Scenarios</td>
<td>Mon Mar 8</td>
<td>2</td>
<td>Wed Mar 10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Melissa &amp; Edward</td>
</tr>
<tr>
<td>M1: Sketching Visualizations</td>
<td>Mon Mar 8</td>
<td>1</td>
<td>Wed Mar 10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Edward</td>
</tr>
<tr>
<td>M1: Sketching Visualizations</td>
<td>Mon Mar 8</td>
<td>1</td>
<td>Wed Mar 10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Melissa</td>
</tr>
<tr>
<td>M1: Sketching Visualizations</td>
<td>Mon Mar 8</td>
<td>1</td>
<td>Wed Mar 10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Florentin &amp; Edward</td>
</tr>
<tr>
<td>M1: Draft Work Breakdown</td>
<td>Mon Mar 8</td>
<td>2</td>
<td>Wed Mar 10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Florentin &amp; Edward</td>
</tr>
<tr>
<td>M1: Putting Visualization Ideas into Submission</td>
<td>Wed Mar 10</td>
<td>2</td>
<td>Wed Mar 10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Melissa</td>
</tr>
<tr>
<td>M1: Proofreading and Checking Against Specs for M1</td>
<td>Wed Mar 10</td>
<td>2</td>
<td>Wed Mar 10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Melissa</td>
</tr>
<tr>
<td>M1: Proofreading and Checking Against Specs for M2</td>
<td>Wed Mar 10</td>
<td>2</td>
<td>Wed Mar 10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Florentin</td>
</tr>
<tr>
<td>M1: Proofreading and Checking Against Specs for M3</td>
<td>Wed Mar 10</td>
<td>2</td>
<td>Wed Mar 10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Edward</td>
</tr>
<tr>
<td>M1: Finalizing Submission</td>
<td>Wed Mar 10</td>
<td>6</td>
<td>Wed Mar 10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Group (1hr/member)</td>
</tr>
<tr>
<td>Converting policy dataset data from PDF to CSV</td>
<td>Wed Mar 10</td>
<td>3</td>
<td>Mon Mar 8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Edward</td>
</tr>
</tbody>
</table>
Meeting: Project Feedback and Discussing Next Steps  
Fri Mar 12  
3  
3  
Group (1hr/member)  

<table>
<thead>
<tr>
<th></th>
<th>Total Target Hours:</th>
<th></th>
<th>Total Actual Hours (so far):</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>61</td>
<td>61</td>
<td></td>
</tr>
</tbody>
</table>

For Milestone 2, we have estimated the time we spent working on it in Table 8 below. Overall, we have seen slower than expected progress, but we have been more efficient with our time than we had hoped.

We have been sidetracked due to the midterm (which took a bit more time to study than our time budget allowed) and also with some group scheduling issues (e.g. internet connectivity/interviews/personal difficulties). These issues reduced our ability to collaborate over the past few weeks. Thus, while the original timelines were preserved in Table 7 for consistency, we found that much of our work occurred much later (about 2 weeks later) in the process than was hoped.

In terms of efficiencies, we have found that we used our time much more conservatively than planned. In terms of meetings, we have met less frequently than was budgeted. This was mainly due to other coursework for each team member. We found for some shorter discussions, it was easier to communicate changes via text messages. As well, we accomplished more of our objectives in shorter than expected amounts of time.

Table 8: Accounting of Time Spent on Milestone 2.

<table>
<thead>
<tr>
<th>Task(s):</th>
<th>Target Compl. Date:</th>
<th>Target Hours:</th>
<th>Actual Compl. Date:</th>
<th>Actual Hours:</th>
<th>Owner:</th>
<th>Notes:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggregating, Cleaning and Filtering Data to Total GHG, Total GDP and Carbon Intensity</td>
<td>Mon Mar 15</td>
<td>2</td>
<td>Tues Mar 23</td>
<td>2</td>
<td>Melissa</td>
<td>Work distributed across multiple weeks</td>
</tr>
<tr>
<td>Creating Basic Logic in main.js and Other js Files</td>
<td>Mon Mar 15</td>
<td>2</td>
<td>Tues Mar 23</td>
<td>2</td>
<td>Edward</td>
<td>Work distributed across multiple weeks</td>
</tr>
<tr>
<td>Creating Basic HTML for Visualization (UI)</td>
<td>Mon Mar 15</td>
<td>2</td>
<td>Tues Mar 23</td>
<td>2</td>
<td>Edward</td>
<td>Work distributed across multiple weeks</td>
</tr>
<tr>
<td>Task</td>
<td>Start Date</td>
<td>Duration</td>
<td>End Date</td>
<td>Responsible</td>
<td>Notes</td>
<td></td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>------------</td>
<td>----------</td>
<td>----------</td>
<td>-------------</td>
<td>--------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Creating Basic Choropleth</td>
<td>Mon Mar 15</td>
<td>3</td>
<td>Thurs Mar 25</td>
<td>Edward</td>
<td>Work distributed across multiple weeks</td>
<td></td>
</tr>
<tr>
<td>Creating Basic Stacked Bar Chart</td>
<td>Mon Mar 15</td>
<td>3</td>
<td>Tues Mar 30</td>
<td>Florentina</td>
<td>Work distributed across multiple weeks</td>
<td></td>
</tr>
<tr>
<td>Creating Basic Heatmap</td>
<td>Wed Mar 17</td>
<td>5</td>
<td>Tues Mar 30</td>
<td>Melissa</td>
<td>Work distributed across multiple weeks</td>
<td></td>
</tr>
<tr>
<td>Adding Buttons, Legends and Other Static Elements</td>
<td>Fri Mar 19</td>
<td>2</td>
<td>Tues Mar 30</td>
<td>Melissa</td>
<td>Work distributed across multiple weeks</td>
<td></td>
</tr>
<tr>
<td>Meetings throughout week (x2)</td>
<td>Fri Mar 19</td>
<td>6</td>
<td>Fri Mar 19</td>
<td>Group (2 hrs/member)</td>
<td>1 meeting was cancelled</td>
<td></td>
</tr>
<tr>
<td>Milestone 3 (Mar 22 - Mar 28): Basic Charts Visible for Policy Dataset and Interactivity for Historical Dataset</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adding Interactivity Between Heatmap, Choropleth Map, and Stacked Bar Chart</td>
<td>Fri Mar 26</td>
<td>5</td>
<td>Wed Apr. 14</td>
<td>Melissa</td>
<td>Behind schedule</td>
<td></td>
</tr>
<tr>
<td>Filtering of Stacked Bar Chart by Economic Sector</td>
<td>Fri Mar 26</td>
<td>2</td>
<td>Wed Apr. 7</td>
<td>N/A</td>
<td>Florentina Behind Schedule</td>
<td></td>
</tr>
<tr>
<td>Highlighting Selected Attributes in Heatmap</td>
<td>Fri Mar 26</td>
<td>2</td>
<td>Wed Apr. 14</td>
<td>N/A</td>
<td>Melissa Behind schedule</td>
<td></td>
</tr>
<tr>
<td>General Styling</td>
<td>Fri Mar 26</td>
<td>2</td>
<td>Wed Apr. 14</td>
<td>N/A</td>
<td>Group (0.67 hrs/member) Behind Schedule</td>
<td></td>
</tr>
<tr>
<td>Meeting (x2 throughout week)</td>
<td>Fri Mar 26</td>
<td>6</td>
<td>Fri Mar 26</td>
<td>Group (2 hrs/member)</td>
<td>1 was cancelled</td>
<td></td>
</tr>
<tr>
<td>Milestone 4 (Mar 29 - Apr 4) Administrative Work and Finalizing Visualizations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M2: Writing Rationale for Design Choices Including Task Abstraction and Data Abstraction</td>
<td>Wed Mar 31</td>
<td>4</td>
<td>Wed Mar 31</td>
<td>Edward</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M2: Explanation If/How Scope Has Changed</td>
<td>Wed Mar 31</td>
<td>3</td>
<td>Wed Mar 31</td>
<td>Edward</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
For Milestone 3, we have kept track of our time spent in Table 9 below.

We found for this deliverable that we went slightly over our time budget. This was mostly due to debugging and making sure all the interactions worked as expected. There were some time savings by reducing the amount of meetings we held via video call.

In terms of debugging, while we were all familiar with coding in Javascript and in D3, we found that getting the exact CSS correct, (e.g. the exact positioning of static items; “sticky” items that would follow a user as they scrolled), these all took vastly inordinate amounts of time. Some of us found that it took 6 hour sessions of time just to debug a single feature (sticky scrolling in the historical visualization). This went above and beyond the expected time for these two weeks.

While again found time savings (similar to Milestone 2) by reducing the amount of video call meetings we had. We found that we were able to work effectively with fewer video meetings.
Table 9: Accounting of Time Spent on Milestone 2.

<table>
<thead>
<tr>
<th>Task(s):</th>
<th>Target Compl. Date:</th>
<th>Target Hours:</th>
<th>Actual Compl. Date:</th>
<th>Actual Hours:</th>
<th>Owner:</th>
<th>Notes:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meeting: Begin Drafting Final Report</td>
<td>Mon Apr 5</td>
<td>3</td>
<td>Wed Apr. 14</td>
<td>0</td>
<td></td>
<td>No meeting was required.</td>
</tr>
<tr>
<td>M3: Final Report, Overview, Data &amp; Reflection</td>
<td>Mon Apr 5</td>
<td>2</td>
<td>Wed Apr. 14</td>
<td>2</td>
<td>Edward</td>
<td></td>
</tr>
<tr>
<td>M3: Final Report, Goals &amp; Visualization</td>
<td>Mon Apr 5</td>
<td>2</td>
<td>Wed Apr. 14</td>
<td>2</td>
<td>Edward</td>
<td></td>
</tr>
<tr>
<td>M3: Final Report, Visualization &amp; Credits</td>
<td>Mon Apr 5</td>
<td>2</td>
<td>Wed Apr. 14</td>
<td>2</td>
<td>Edward</td>
<td></td>
</tr>
<tr>
<td>Finalize Individual Debugging</td>
<td>Mon Apr 5</td>
<td>3</td>
<td>Wed Apr. 14</td>
<td>10</td>
<td>Florentina</td>
<td>Work spread apart weeks of April 5th &amp; April 12th</td>
</tr>
<tr>
<td>Finalize Individual Debugging</td>
<td>Wed Apr 7</td>
<td>3</td>
<td>Wed Apr. 14</td>
<td>18</td>
<td>Melissa</td>
<td>Work spread apart weeks of April 5th &amp; April 12th</td>
</tr>
<tr>
<td>Finalize Individual Debugging</td>
<td>Wed Apr 7</td>
<td>3</td>
<td>Wed Apr. 14</td>
<td>18</td>
<td>Edward</td>
<td>Work spread apart weeks of April 5th &amp; April 12th</td>
</tr>
<tr>
<td>Meeting: Finalize Website, Approve Final Changes as a Group</td>
<td>Fri Apr 9</td>
<td>6</td>
<td>Wed Apr. 14</td>
<td>6</td>
<td>Group (2 hrs/member)</td>
<td>Ad-hoc meetings took place (e.g. online messaging, or video calls)</td>
</tr>
</tbody>
</table>

|                | 24                  | 54            |

Milestone 6 (Apr 12 - Apr 17): Final Project Submission

<table>
<thead>
<tr>
<th>Task(s):</th>
<th>Target Compl. Date:</th>
<th>Target Hours:</th>
<th>Actual Compl. Date:</th>
<th>Actual Hours:</th>
<th>Owner:</th>
<th>Notes:</th>
</tr>
</thead>
<tbody>
<tr>
<td>M3: Final Report (Near Final Draft, Individual Edits)</td>
<td>Mon Apr 12</td>
<td>6</td>
<td>Wed Apr. 14</td>
<td>6</td>
<td>Group (2 hrs/member)</td>
<td>We did not get to this/we were told was not required.</td>
</tr>
<tr>
<td>Live Demo Practice</td>
<td>Wed Apr 14</td>
<td>3</td>
<td>Wed Apr. 14</td>
<td>0</td>
<td>Group (1 hr/member)</td>
<td></td>
</tr>
</tbody>
</table>
Overall, across the project, we found we took less time than was budgeted, as listed in Table 10 below. We found that we overestimated the amount of meetings we would have, and the time it would take to code. No amount of estimation can deal with debugging and the unexpected errors that arise from software construction.

Table 10: A final accounting of time spent across the entire group.

<table>
<thead>
<tr>
<th>Milestone:</th>
<th>Time Budgeted (Hours):</th>
<th>Time Actually Spent (Hours):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milestone 1</td>
<td>61</td>
<td>61</td>
</tr>
<tr>
<td>Milestone 2</td>
<td>84</td>
<td>43.5</td>
</tr>
<tr>
<td>Milestone 3</td>
<td>36</td>
<td>67</td>
</tr>
<tr>
<td>Total:</td>
<td>181</td>
<td>160.5</td>
</tr>
</tbody>
</table>
Include brief descriptions of which team member worked on which tasks (and their responsibilities, if not equally divided).

- Melissa Bernstein:
  - Milestone 1:
    - Idea generation and sourcing of data
    - Original compilation of first milestone designs
    - Assistance in writing of M1 writeup
  - Milestone 2:
    - Heatmap implementation
    - Initial integration of historical visualization
    - Milestone 2 edits
  - Milestone 3:
    - Policy dataset design, implementation, and debugging
    - General debugging
    - Milestone 3 edits

- Edward Le:
  - Milestone 1:
    - Idea generation and sourcing of data
    - Assistance in writing of M1 writeup
  - Milestone 2:
    - Milestone 2 writeup
    - Landing page design
    - Initial work on choropleth (non-functional map)
  - Milestone 3:
    - Milestone 3 writeup
    - Overall website design
    - Integration of historical charts into larger webpage
    - General debugging

- Florentina Simlinger:
  - Milestone 1:
    - Idea generation and sourcing of data
    - Assistance in writing of M1 writeup
  - Milestone 2:
    - Stacked barchart implementation
    - Waypoints integration
    - Milestone 2 edits
  - Milestone 3:
    - Choropleth implementation
    - Milestone 3 edits
    - General debugging
    - Refactoring of main and css
References:


