
# PROCESS BOOK

**Data Visualization: *Climate Change***

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# Path

Our inspiration comes from **Bill Gates**'s book on Climate Change: "*How to Avoid a Climate Disaster*". Climate change is an important topic that concerns all of us and we thought it would be interesting to make simple visualizations that can be understood by the majority of users. Indeed, most of the resources that exist about the topic are very scientific and complicated to understand for everyone. On top of that, it is easy to find visualizations on one subtopic related to climate change, but it is more challenging to get a broad overview, for people who would like a starting point. That is why we got inspired by Bill Gates' book: he follows a **top-down approach**, starting by explaining the current state of $CO_2$ emissions, and then dives deeper into each sector.

As a result, we first started by brainstorming about what topics we wanted to cover as there are many subjects related to climate change.
We agreed to focus on ***$CO_2$* emissions**, as they are the main causes of global warming. It is also the metrics that are currently being used by scientists to quantify human activity and how much it pollutes.

It was also at this moment that we decided how to structure our story: we first wanted to give a **global overview** of the emissions in the world. Then, we would treat **each sector independently**.

We then started by searching different datasets for each part and tried to come up with ideas for visualizations using the data. We distributed the research workload between each of us and then gathered to build the first sketch of our website. In the meantime, we performed a first exploratory data analysis to get a sense of our data. We identified where we had missing data, how to transform it to be in a usable format, and what could be interesting to do with it.

Then, we started working on each visualization to have a working prototype quickly. We each work independently on our assigned part.

In our very first version, for milestone 2, we had the following structure: there was a global overview, ie, a choropleth map of the world, where the color of each country was linked to its global emissions for 2017. The darker the color, the more it polluted. On top of this map were some stack bars that represented the contribution of each sector (**Energy**, **Industry**, **Agriculture** and **Transportation**) to the total.

Then, we had a static plot that represented the electricity production of each country using a horizontal stacked bar chart.

For the industrial part, we had a stream chart representing the evolution of $CO_2$ emissions for various materials.

After, the agriculture section had a static bubble plot representing the amount of $CO_2$ emitted per kg of food.

Finally, we had a treemap for the transportation sector, where each square surface is proportional to the amount of emissions by one means of transport in 2020.

To be honest, our first prototype was pretty ugly, not very engaging for the user and poorly designed. But there was a clear potential to make great visualizations using our data, and have a good story for the user.

Following milestone 2, our goal was to improve all of our visualizations. We kept working on our own visualization, but we **gathered every week** and took this time to **get feedback** from the others. That is how we started having good ideas and made improvements. We will detail all our improvements and design choices in the *Design & Sketches* part. Once we were happy about the visual and functionalities of our visualizations, we started merging our work. When everything was working as intended, we started focusing more on the **layout, organisation and aesthetic** of our website. We wanted to make the data story as interactive as possible, and that is why we chose to go with slides. Each section of our

website can be seen as an independent slide from a presentation.

Also, we started allocation space for text, as we wanted to accompany each visualization with a good context. That is when we focused on the data story aspect of our website. The goal of this website is to educate people with general facts about climate change: What is causing it? What is the contribution of my country? What is polluting the most between all planes and all cars? etc…

We crafted a **simple story** that should give the user a good overview of what is happening, and what will be the hardest challenges to tackle climate change. We chose some good resources and decided to add a References section so that people can directly look at which data we used, and have access to additional resources.

Finally, once the visualizations and the text were ready, we focused more on the general aesthetic. It is always more engaging for the user when the website is appealing. Because we are not designers, we wanted to keep things simple. We discussed general guidelines for design. The font, the different colors used, additional icons etc…

# Challenges

The first challenge we encountered was linked to the **datasets**. Indeed, there are lots of different sources regarding climate change. We had to select the ones that were usable for a visualization. On top of that, we had to **transform** them into a **proper format** before starting to work on our visualizations. For example, the data that we use for the global overview is very dense. There are lots of specific sectors such as "fugitive emissions" or "bunker fuels". We had to gather some sectors together to make it simple for the user. As it covers all countries since 1990, there were lots of **missing data** points that we had to take care of. Finally, the base choropleth map we started from had a geojson file for the countries border that used country code with 3 chars (alpha-3), which is quite uncommon compared to 2 chars (alpha-2). Thus we had to find a mapping to use our dataset with the baseline map.

Then we had to face many challenges when **coding** our visualization with d3.js. Indeed, this library was new to us and it took us some time to get used to it.

Afterwards, each visualization had its own challenges. For the global overview, we used an open-source map. We also added a stacked bar chart to represent the contribution of each sector. We wanted it to be as interactive as possible, which made this visualization more complicated than we imagined. The user can select a specific year and a specific country. Then, each user interaction triggers an update for the bar chart and the map. Every element on its own is quite simple, but when we had to combine everything (slider, clicks on the map, bar chart, title), make it work with our biggest dataset and make it smooth for the user, it got a little bit complicated.

The energy visualizations had its own challenges, especially making the chart sortable by each individual energy source took a long time to figure out, as well as how to adjust the axis and the size of the graph based on relative/absolute sorting. Then we noticed that the bars of almost all individual countries shrunk so much that you could not see any data, that's why we implemented the feature to exclude them in the graph with a button click.

After the coding, the **merging**. Once every visualization was ready, we started merging our work. This was a little bit tedious as we had to encapsulate the various JavaScript code, merge the css, and make sure that everything was working as planned. As we sometimes used the same naming for different elements, we encountered some unexpected problems. The next challenges we had while merging was regarding **css**: we have different operating systems and we realized that the website was not displayed the same way on each of our laptops. It took us some time to find the correct

properties to assemble our visualizations in a clean way, that was fine for all of us.

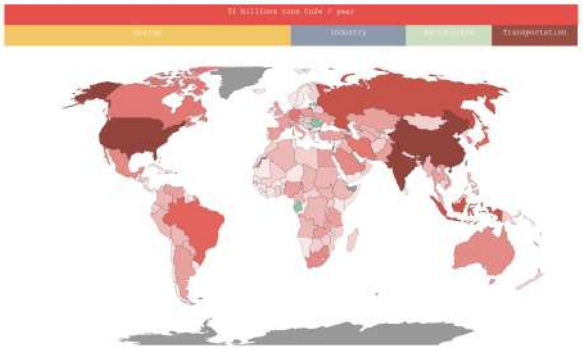
Finally, we wanted our data story to be **engaging and interesting** for the users. As the climate change topic can quickly become complex, we had to select information that was simple, but covered enough of the "big picture". After taking some feedback from our friends and family, we realized that our first version had too much text, which was not appealing for the user. One challenge was also to find good resources to justify ourselves. This is a very sensible topic, so we thought it was necessary to add **reference** for every fact.

# Design & Sketches

In this part we will first describe our **design choices** and **improvements** for each of our visualizations, and finally we will discuss the general **aesthetic** and guidelines we followed for our website.

## General Overview of $CO_2$ emissions

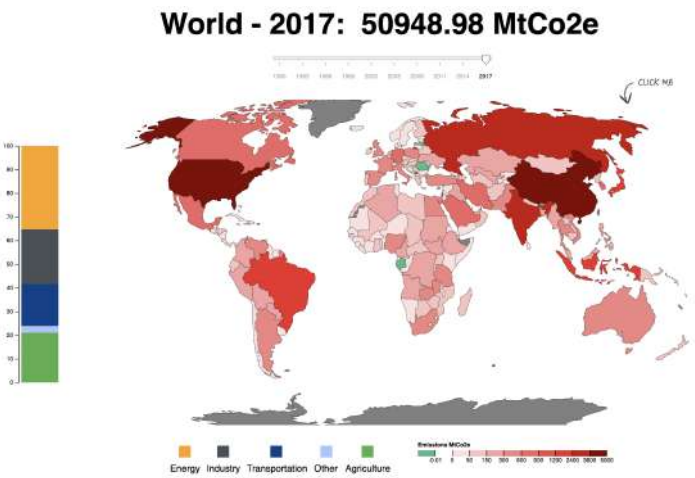
After the milestone 2, we had a choropleth map and a big stacked bar chart on top of it. It represented the total emissions per country in 2017, and the split between each sector for this year. This version can be seen in the following figure:



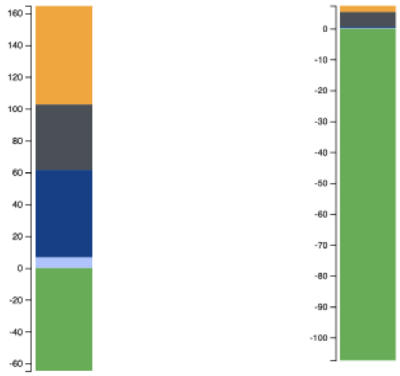
The first improvement came up after one of our meetings. As we had historical data from 1990 until 2017, we thought that it would be a good idea to include all the other years. We concluded that adding a slider to change the year would make it easy to see and use for the user.

Then, we wanted to make the map interactive. As we have the data for each country (total emissions, and split per sector), we wanted the user to be able to click on one country, and then update the bar chart to see the changes. This is where we made a design choice. In our first version, the top bar in red was showing the total emissions, and then the stacked bars at the bottom were showing the sectors split. If the user clicked on a country, the sector split would be updated, but what about the top bar? We could change the text, but it would be confusing, as it was supposed to represent the total worldwide emissions. We thus decided to remove the top red bar, and instead have a title showing which country (or the world) is selected, as well as the total emissions for this entity.

Then, we thought that the stacked bars were taking too much space. Also, we initially made it using only html and css. The problem was that it is difficult to animate. We thus decided to switch to a vertical stacked bars chart using d3.js, as it will both be easier to animate, and to improve. For example, we added an axis, and tooltips to let the user get more information. Moreover, we made the map colors more vivid, and chose other more obvious colors for each sector. We also added legends, for both the map and the stacked bar chart. Also, to make it more obvious to the user that the map is interactive, we added a "Click Me" icon. The final result can be seen in the following figure:



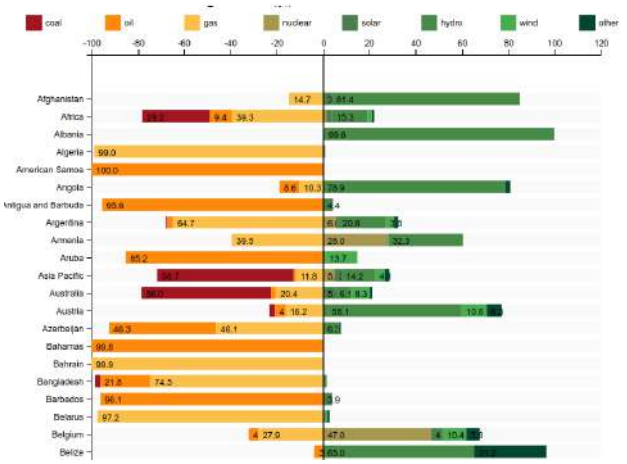
Finally, there is a last design choice that might seem surprising. The agriculture sector is at the bottom of the stacked bar chart, even though it is not the "last sector" in terms of emissions. The problem is that this sector is the only one that can be negative, in the case where a country is reforesting. Thus, we wanted to show this negative contribution in the bar chart as well. As a result, in the case where it is negative, the y-axis will update itself: the agriculture part will have a negative contribution, and the remaining ones will sum up to more than 100%. However, when summing every sector, the total contribution will be equal to 100%. On top of that, if the country has a negative contribution, it will sum up to -100%. The first case is on the left, and the second on the right:



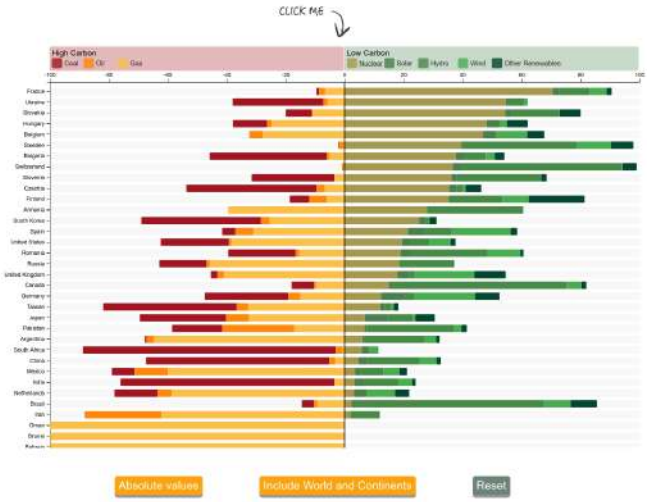
For this visualization, we started with an open-sourced d3.js choropleth map. For the slider, we used d3-simple-slide. Finally, the legend was built with help from this ObservableHq tutorial.

## Energy

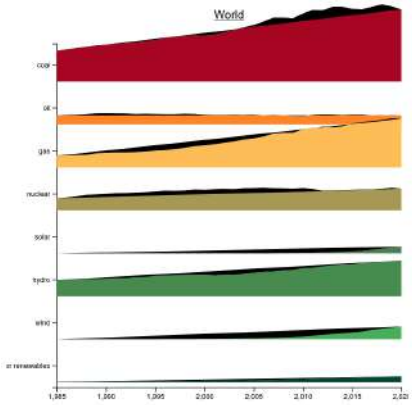
The goal of this visualization was to show the different sources of electricity from each country. Since the numbers alone without context don't tell the whole story we decided to show all the countries in a table together, each having its own stacked bar chart. The key thing was, to add the x-Axis in the middle of the "High emissions" and "Low emission" sources, and coloring them in adequate colors (worst emitter "coal" is in dark red, whereas the renewables are colored green), that way it is immediately clear which country is doing well and which could lessen its emissions by changing the electricity source. Here is the first prototype:




It already looked good but was lacking features that would make it truly shine such as the ability to sort the table. After that was added we made the design choice to just show a scrollable window of the chart, instead of letting the table span all the way into the next "slide", because that would not have worked well with the auto-scrolling feature which we deem important for the overall feel of the website.



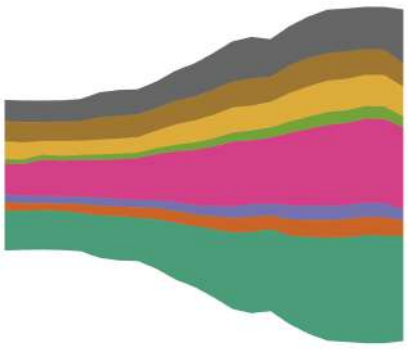

We also added a ridgeline graph which displayed the historical energy data of each country when clicking on it. But we decided to leave it out in the end as it made the page too crowded and we didn't like the aesthetics of it. Below is an image of it.




## Industry

For this part, we decided to use a stream graph to represent the evolution of emission for each kind of material. The choice of a stream chart was suited with the data we had. Indeed, We had the evolution of $CO_2$ emissions for various materials, from 1995 until 2016. Using a surface instead of a line for each material allows the user to see the increase over time more easily.

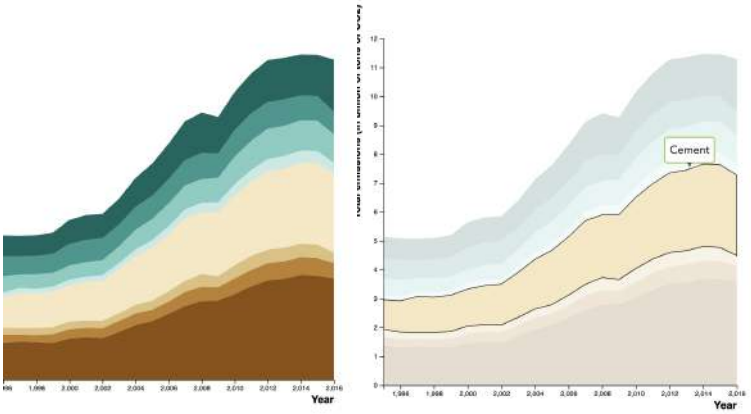
Our first version had the origin of the stream centered. As the total emissions increased over the past decades, the end of the stream was larger than the origin. After getting some feedback, we realized that it could be confusing for some users. Indeed, some materials had a stream that finished at a lower point than their origins. Even though the stream was larger in the end, it was not super clear. Our first prototype for this visualization can be seen in the following figure.



We thus decided to have the origin of the streams at the bottom left of the plot. As a consequence, we could directly see that the total emissions had increased for each material.

On top of that, we added x and y-axis to give more context. Finally we changed the coloring of each material, and took the same tool-tips as the other visualizations to be consistent. The final result can be seen below, with the effect of hovering on the plot.

For this plot about industry, we took inspiration from the following plot.




## Agriculture

For this sector, our very first prototype was a static bubble plot. As we have one metric per type of food, it was simple to make a bubble plot. Indeed, it is visual and we can directly see which type of food emits lots of $CO_2$ while being produced. However, compared to our other visualizations, this one was clearly lacking interaction. This was our first prototype:

Our first design decision to improve our prototype was to add some kind of interaction. We thought that it would be interesting to assign each food type to a group, and then group them together at the click of a button. As d3 makes transitions easy, whenever the button is clicked, we can make each bubble move to its new location, and simulate some kind of force.

Finally, we also decided to use the same tool-tips as other visualizations. To make it more appealing, we decided to remove the text on each bubble and use only icons instead. On top of that, each bubble has a different color border depending on the food type.

To build this plot, we started from the following tutorial. We then carefully picked our icons from flaticon. Here is the result:



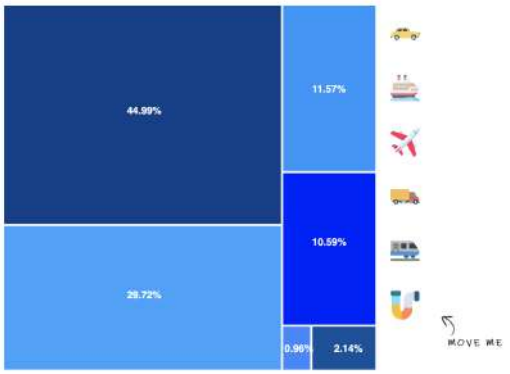
## Transportation

For the last part, we had in mind to make it like a quiz. Indeed, people tend to overestimate the impact of planes or boats (shipping) for example. The goal was to make the user drag some icons representing the different kinds of transports to their corresponding total emissions in 2020.

At first, we thought that it would be a good idea to have a pie chart that is unlabeled. However, we quickly realized that it was a bad design choice as it is difficult to estimate the areas. Thus, we went with a treemap instead, as it is easier to estimate square surfaces. The user then has to move each icon, representing a means of transportation, in its corresponding square. Our first prototype was not interactive yet:


Following milestone 2, we took some feedback from friends and decided to add the percentage of the total emissions to give a better context. We also worked on the interaction, so that the user first moves the icons, and can then click on a button to have the solution. Each icon then directly moves to its corresponding box, and the text is displayed. We also changed the colors, and two icons: the plane so that it has a better contrast with the blue square, and we added a pipe icon, to represent the emissions linked to pipeline usage.

For this visualization, we took inspiration from the following visualization.





### General Design choices

For the layout of our website, we decided to use fullpage.js to make it look like a slide presentation. It makes the overall experience more engaging, as the user can move vertically and sometimes horizontally.
We also took different colors for each sector, and then built a palette around the main colors for each part. The coolors website was very handy!
Finally, we took our freely-usable images from unsplash.

# Peer assessment

During this semester, we had the chance to be able to meet every week in person. During those moments, we took all the decisions regarding our project together. It was also a good time to discuss ideas and get feedback on our individual work. We crafted the data story and worked on the design and layout together. Finally, we did the process book altogether.

Otherwise, we divided the work and did everything from data sourcing, to transformation and coding for each visualization independently.

Adalsteinn took care of the energy part, hosting and general layout.

Nada did the industry and transportation visualization part. She also helped with the design and the layout of the website.

Maxence was in charge of the global overview visualization and the agriculture one. He also helped regarding the layout and design of the website.

Here is the link to see our final website!
Enjoy it!