

2025

[frank.computer](http://frank.computer)

# Tools for Accessible Data Interaction



Frank Elavsky



Human-  
Computer  
Interaction  
Institute



[hcii.cmu.edu](http://hcii.cmu.edu), [axle-lab.com](http://axle-lab.com), [dig.cmu.edu](http://dig.cmu.edu)



Credit: Jeff Kubina, [Wikimedia](#)

# Tools matter

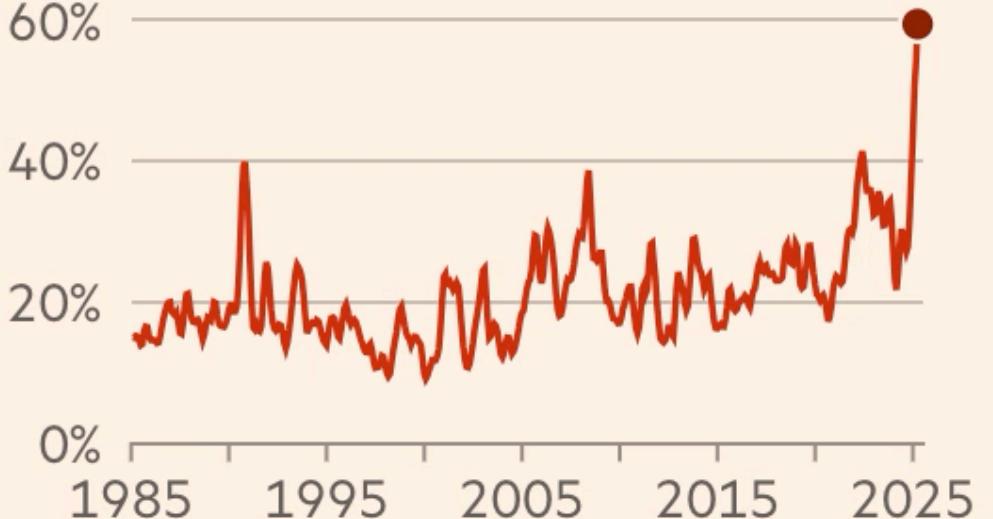
US consumers are rapidly souring on Trump's economic plan

Share of adults who...

Have a negative opinion of government's economic policy



Expect business conditions to worsen over next year



Have heard unfavourable business news coverage of government



Expect their income will grow faster than inflation in next 5 years



Source: [University of Michigan consumer sentiment survey](#)

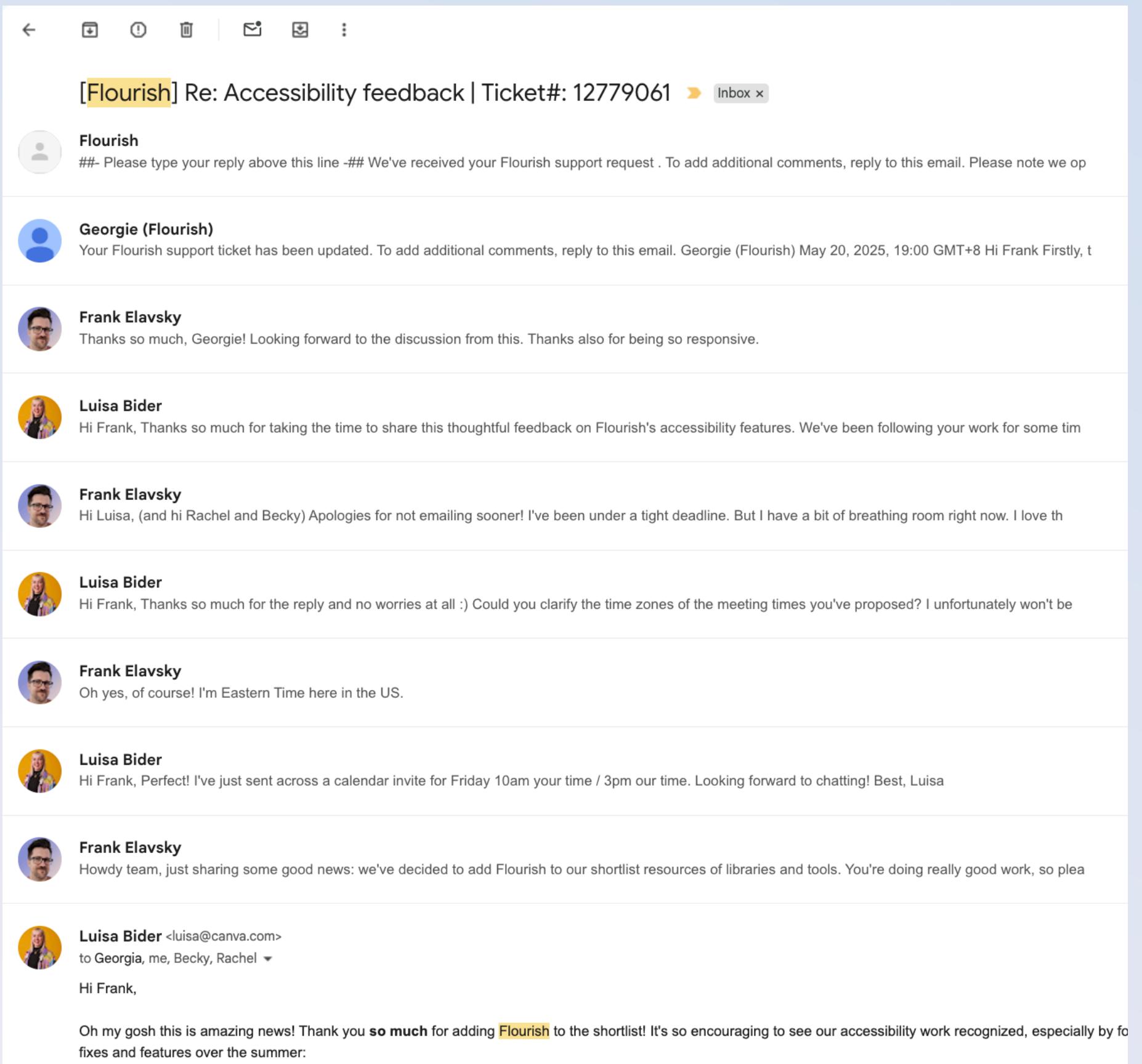
FT graphic: John Burn-Murdoch / @jburnmurdoch

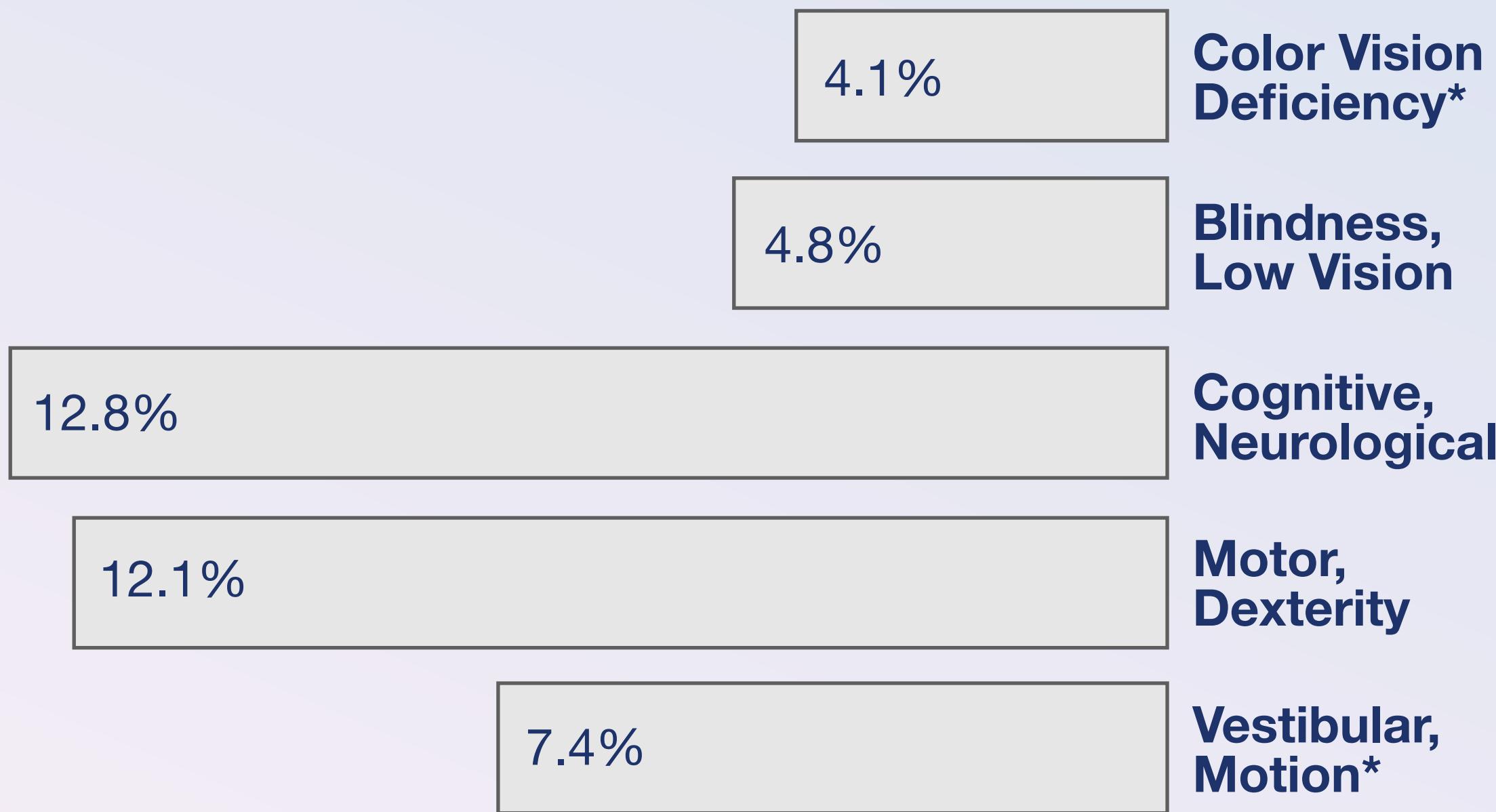
©FT

× You are currently on a frame. To enter the web area, press Control-Option-Shift-Down Arrow.

Republican. No need to take that from me: it's a well-evidenced

# Some change is easier to make happen than others





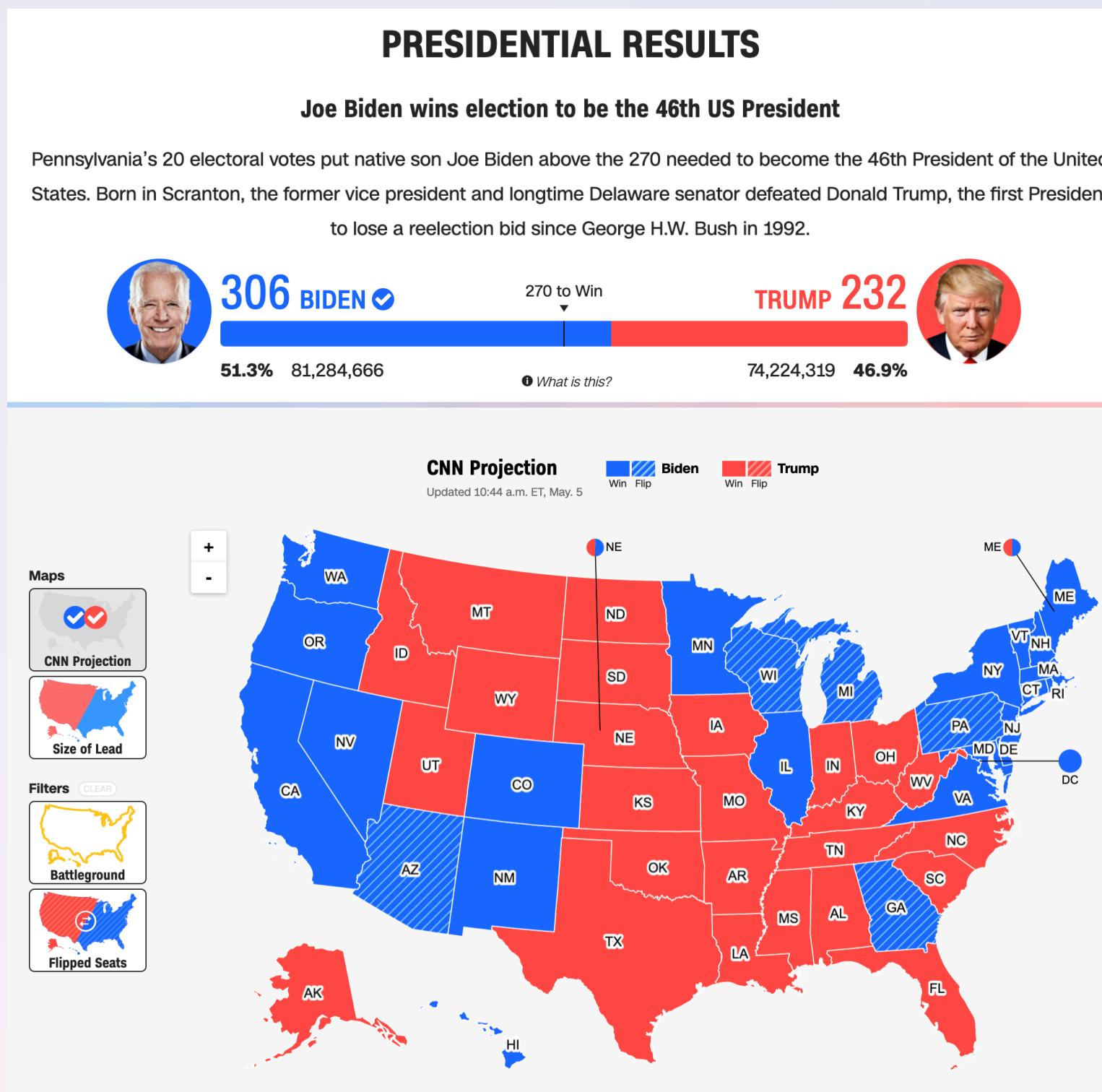
Centers for Disease Control and Prevention. Disability and Health Data System (DHDS). 2023. Available from: <http://dhds.cdc.gov>

\*No new data

~27% of people living in the United States self-report living with a disability that affects their daily life (2023)

# People with disabilities deserve to:

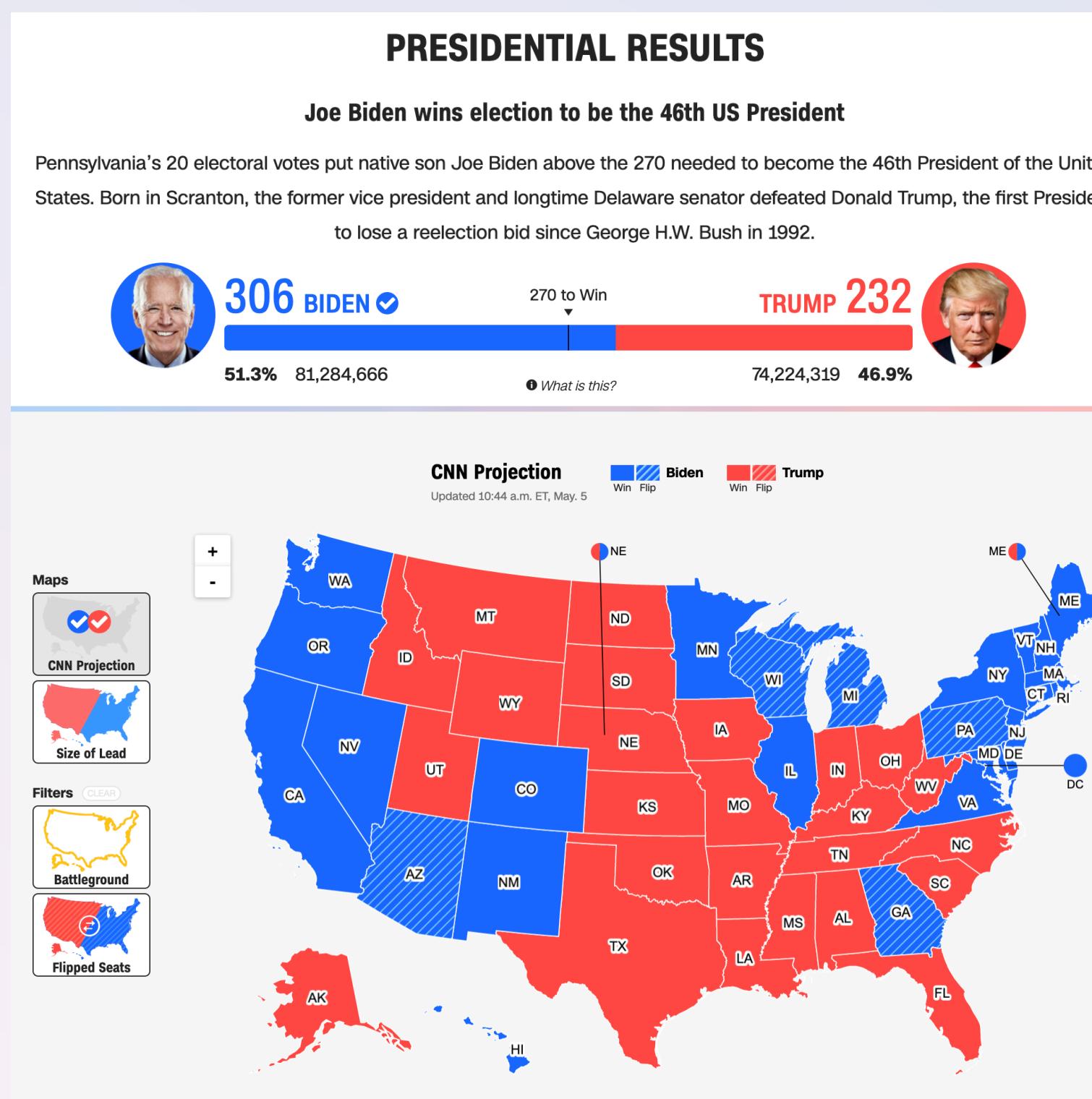
## Participate in politics



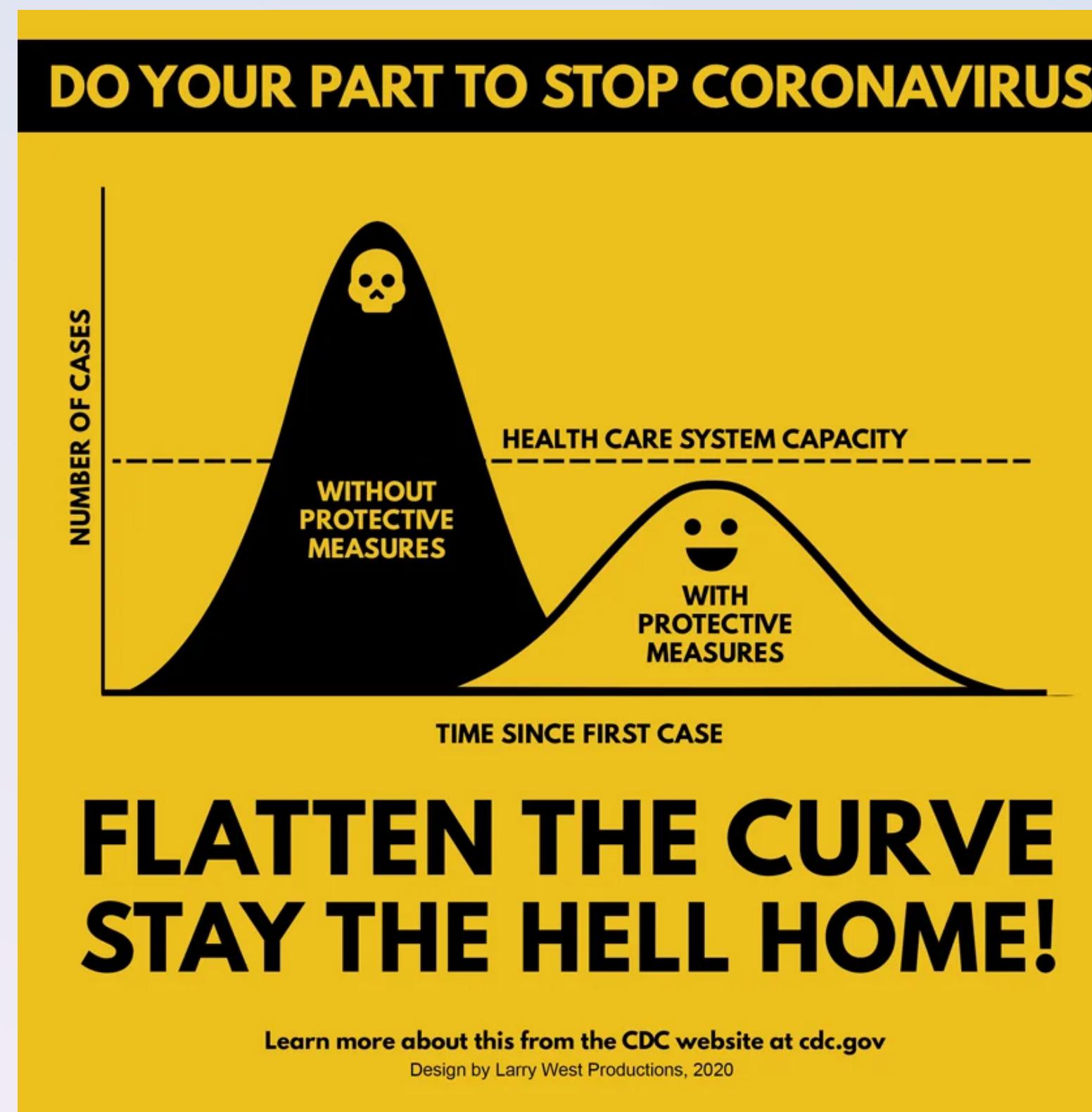
Credit: [CNN](#)

# People with disabilities deserve to:

# Participate in politics



# Make informed decisions

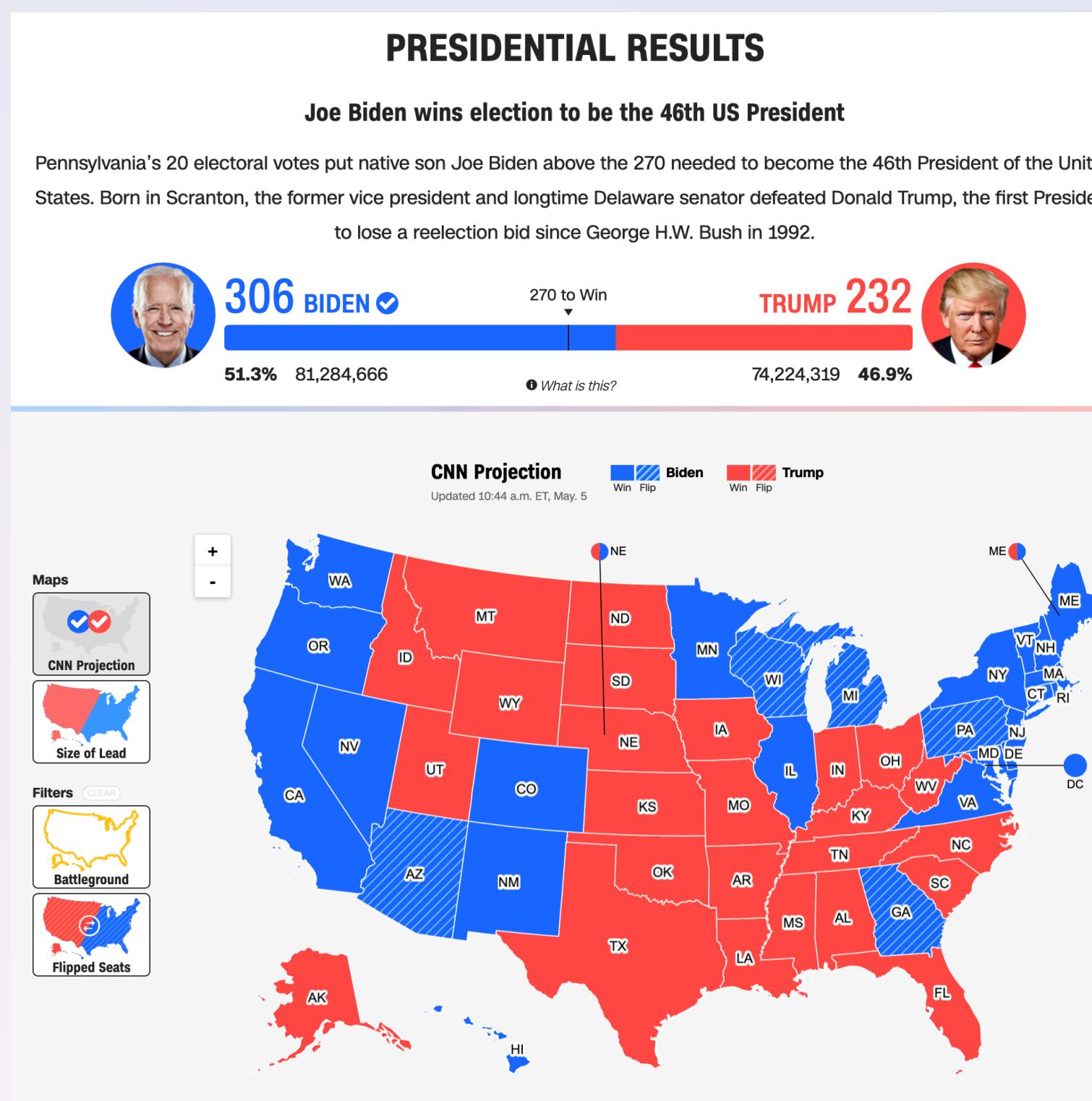


Credit: CNN

# Credit: Reddit

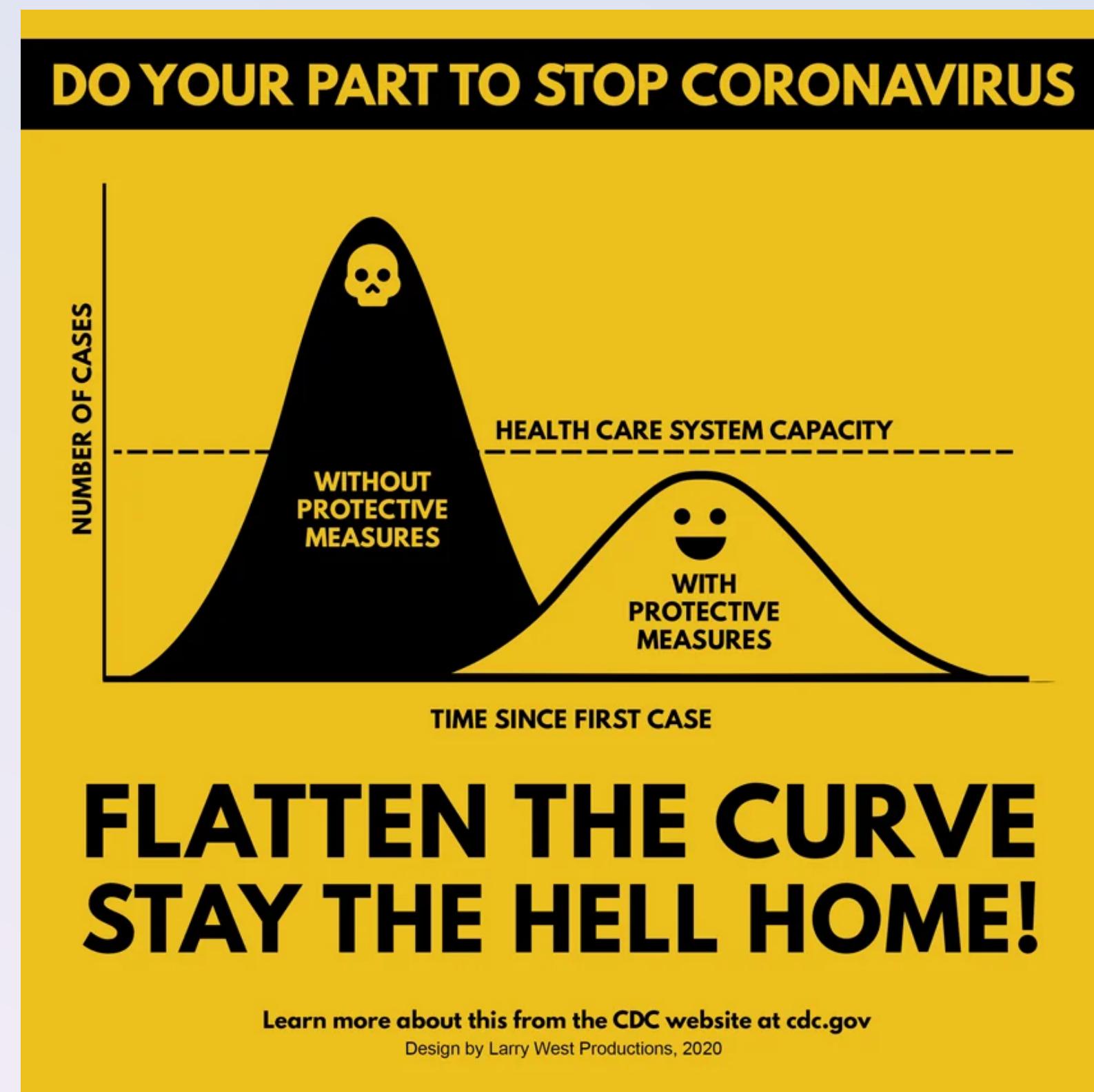
# People with disabilities deserve to:

Participate in politics



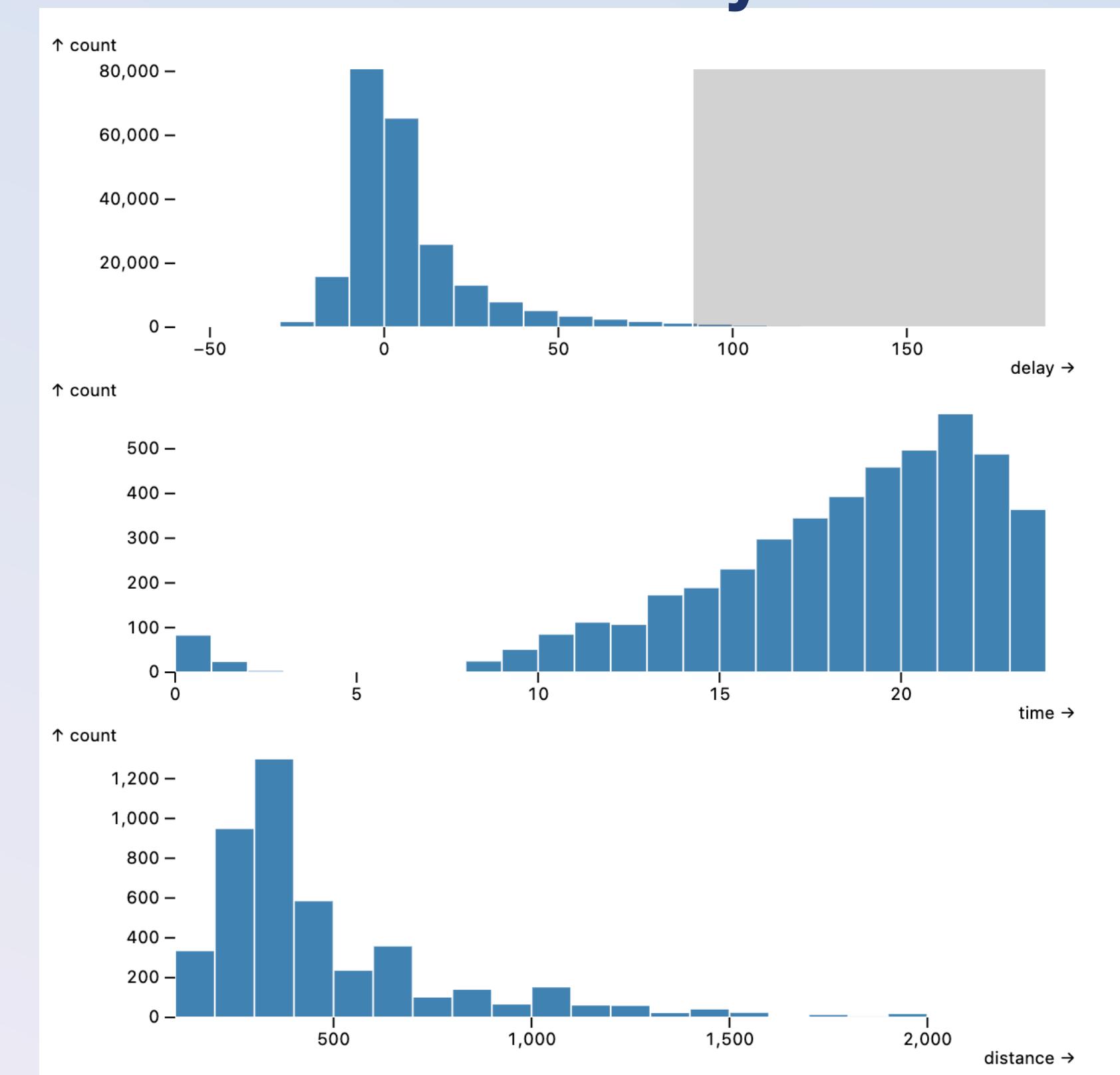
Credit: [CNN](#)

Make informed decisions

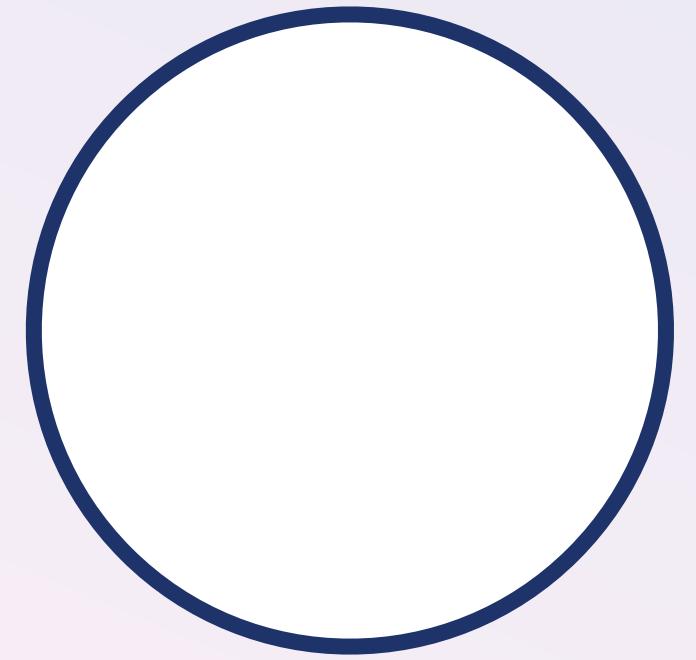


Credit: [Reddit](#)

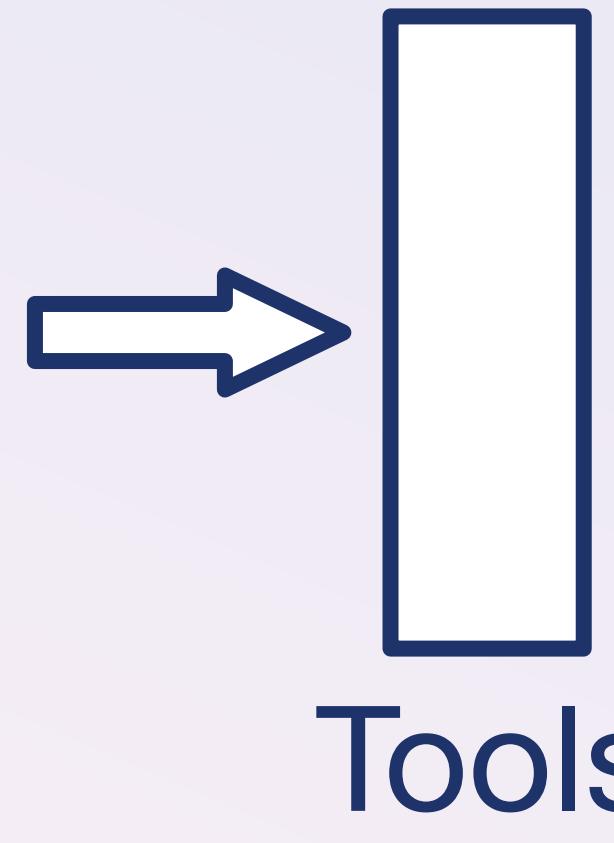
Analyze data quickly and efficiently

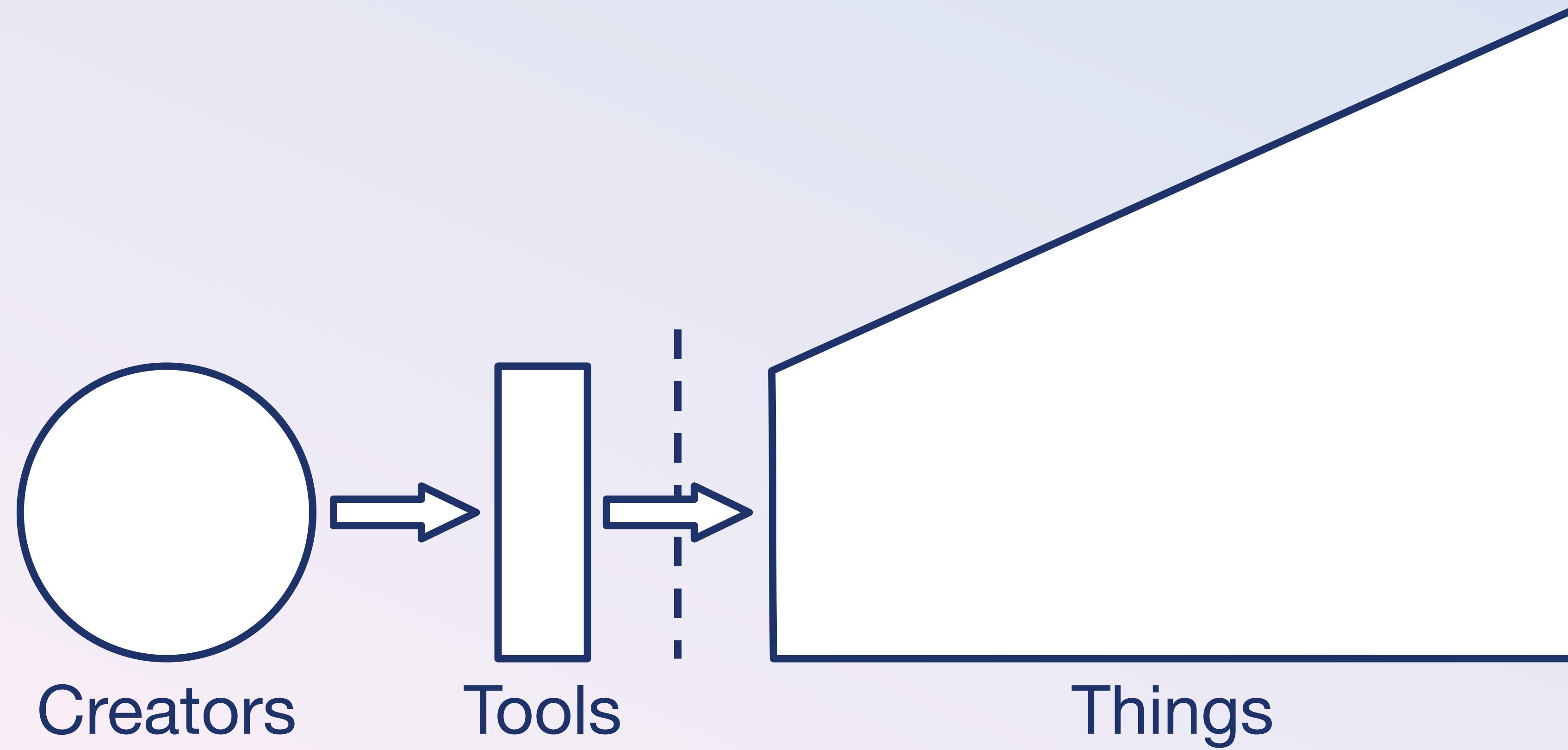


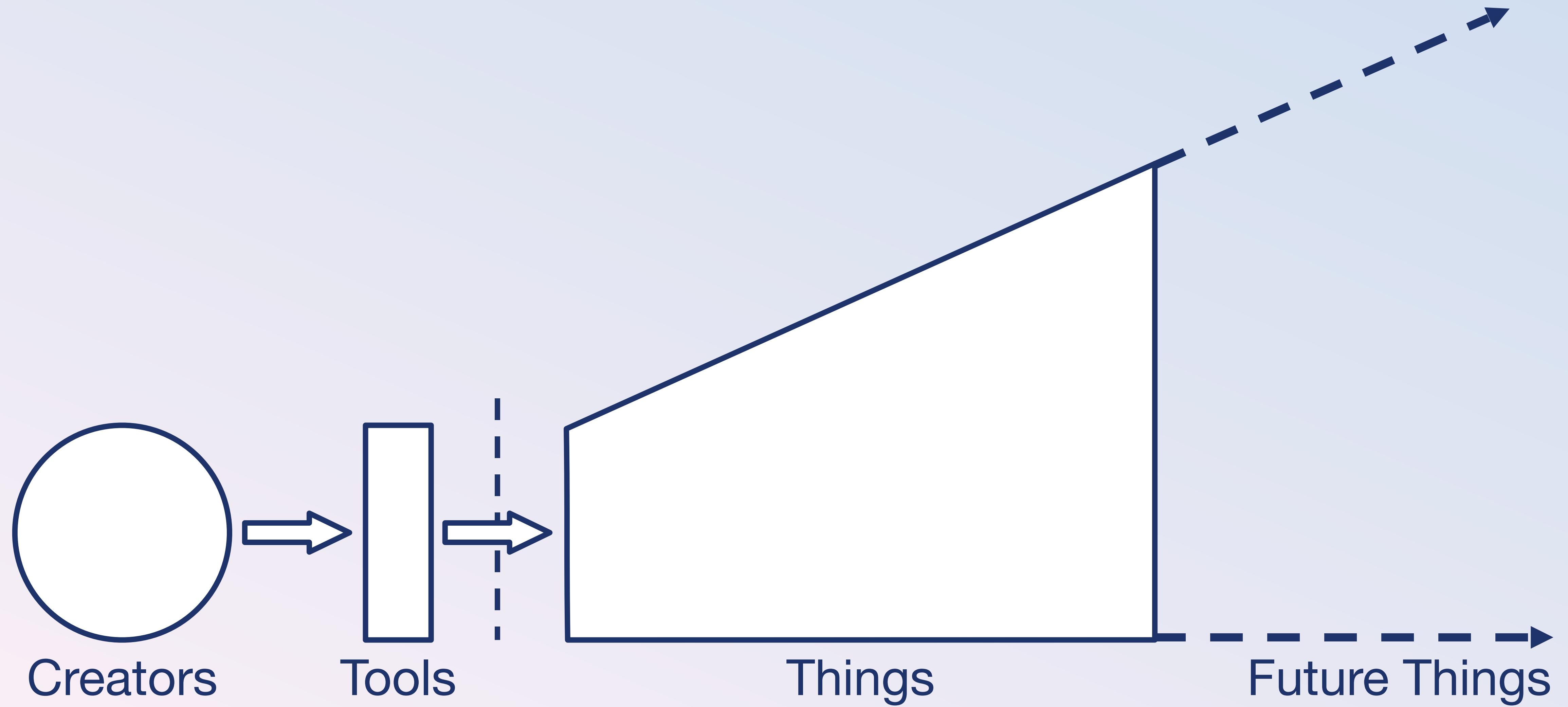
Credit: [Our research](#)



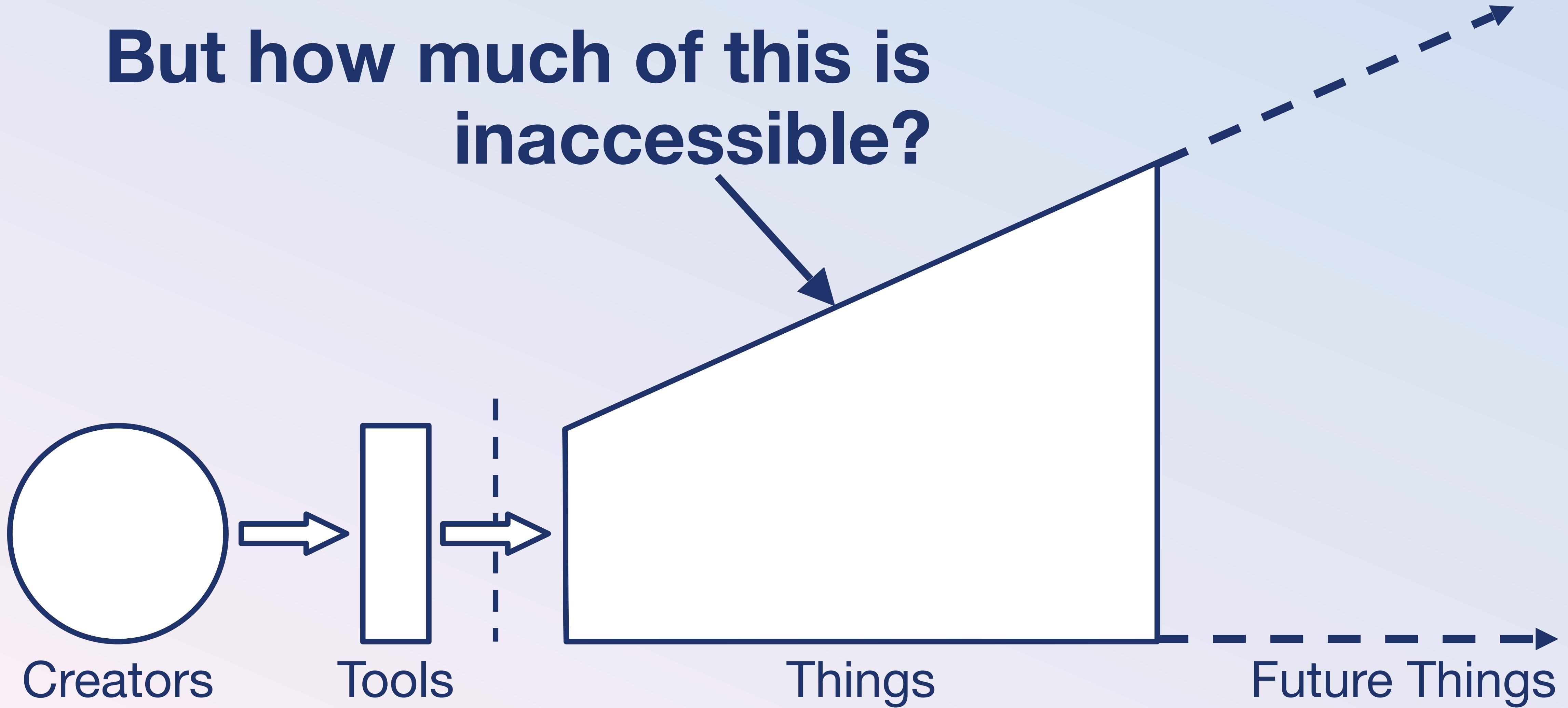
Creators

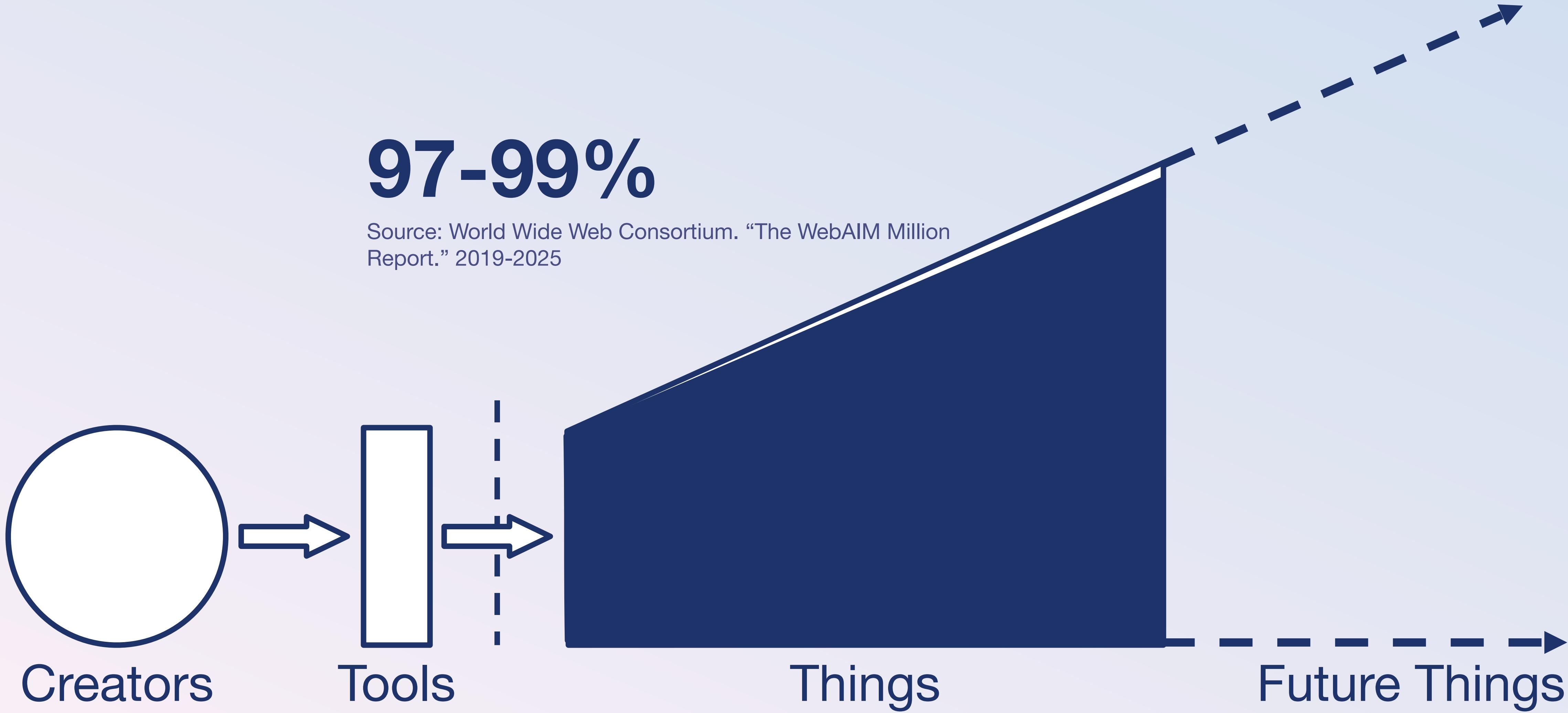






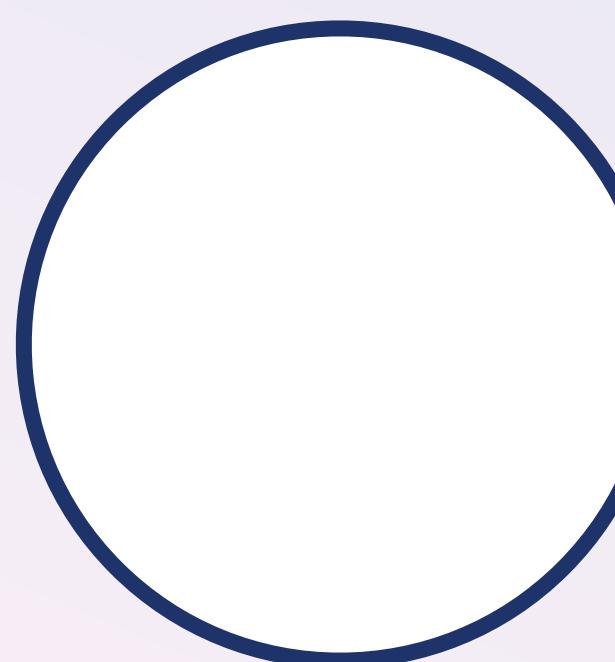
# But how much of this is inaccessible?



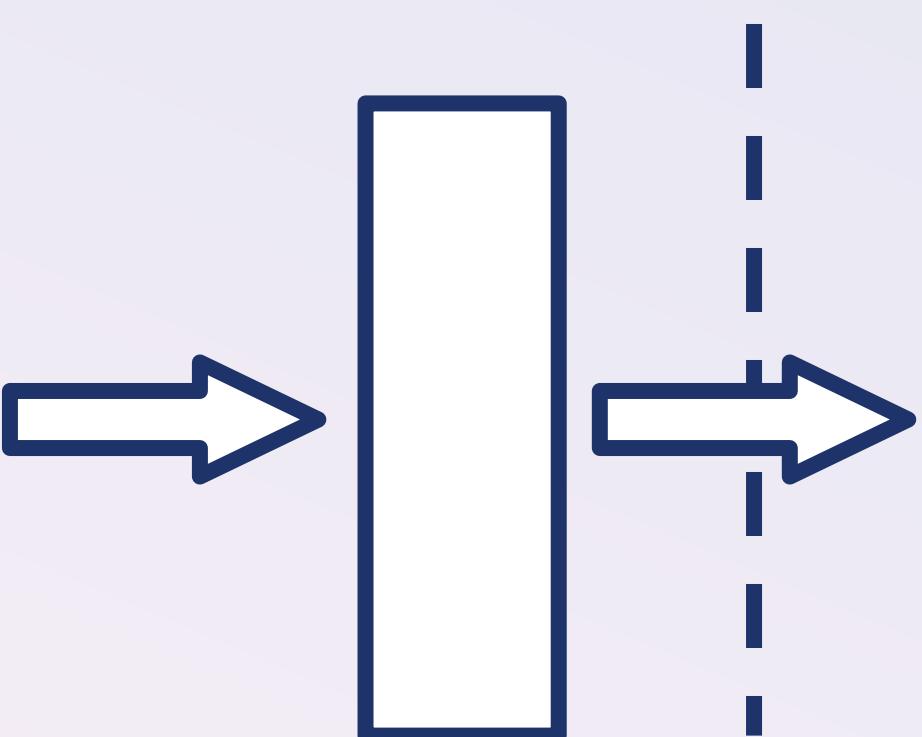


**97-99%**

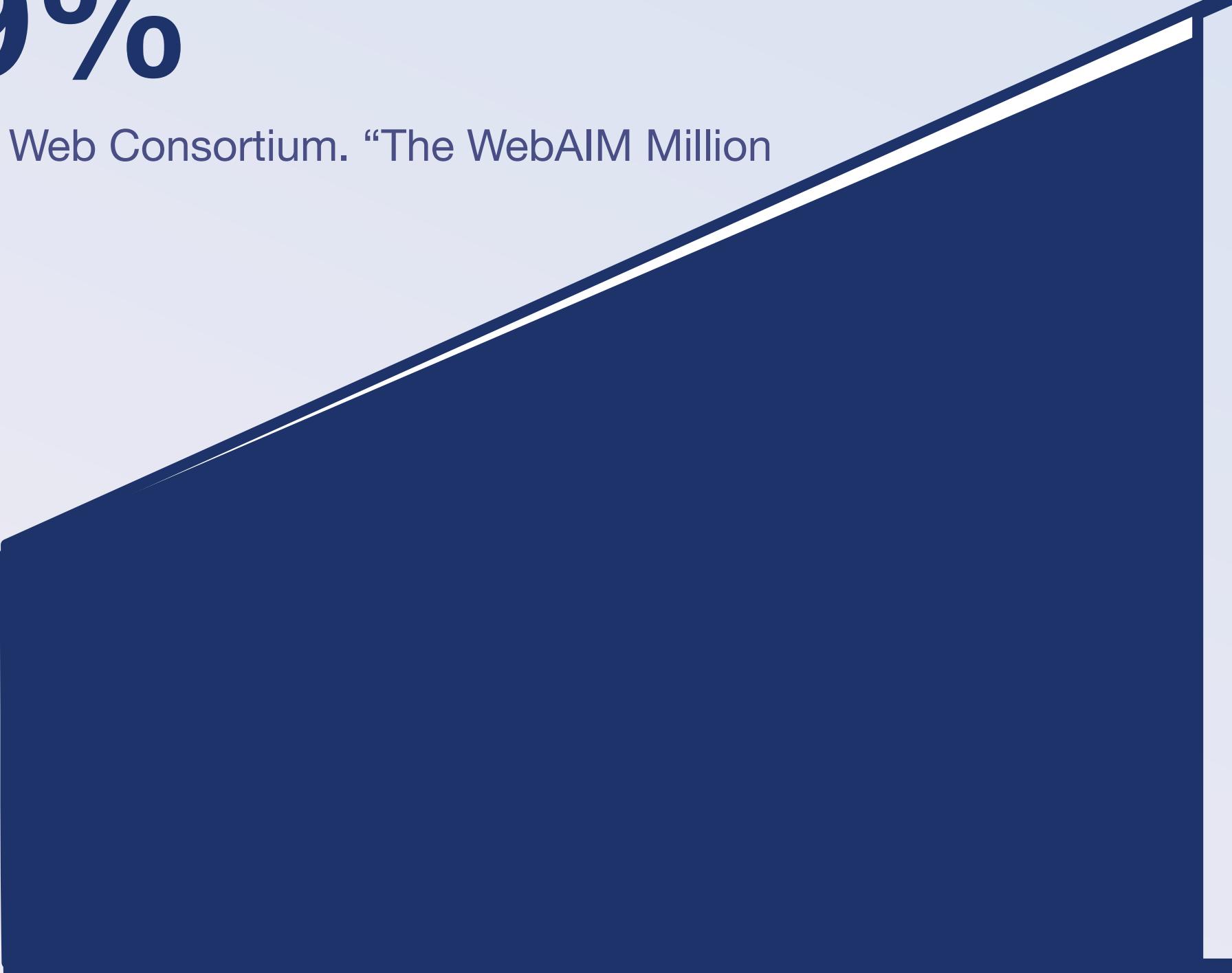
Source: World Wide Web Consortium. "The WebAIM Million Report." 2019-2025



Creators



Tools

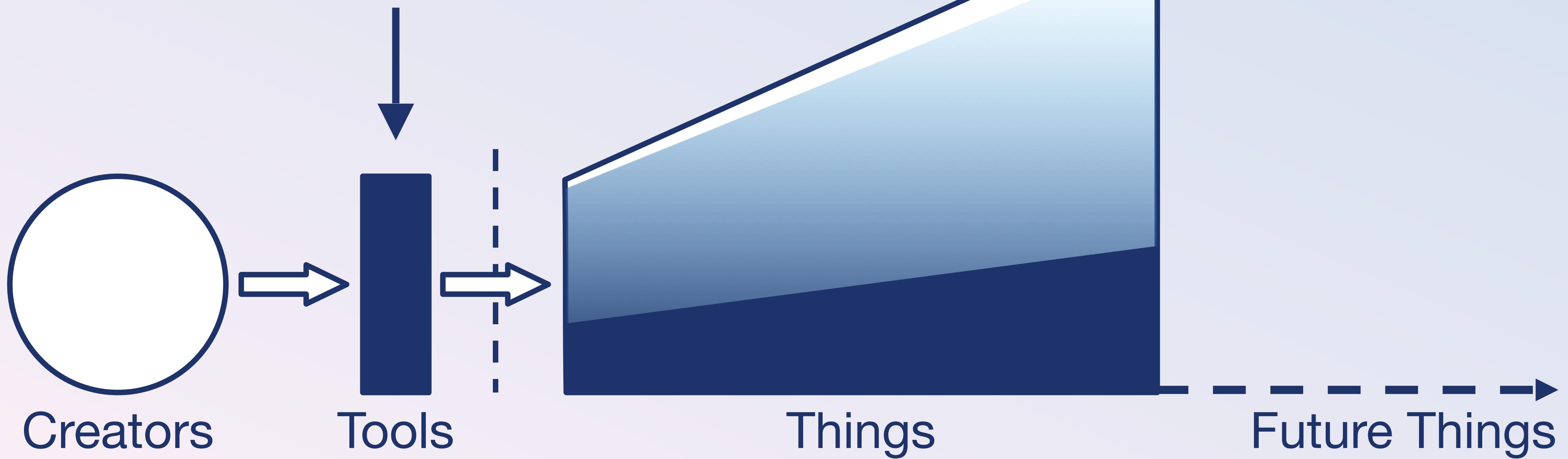


Things

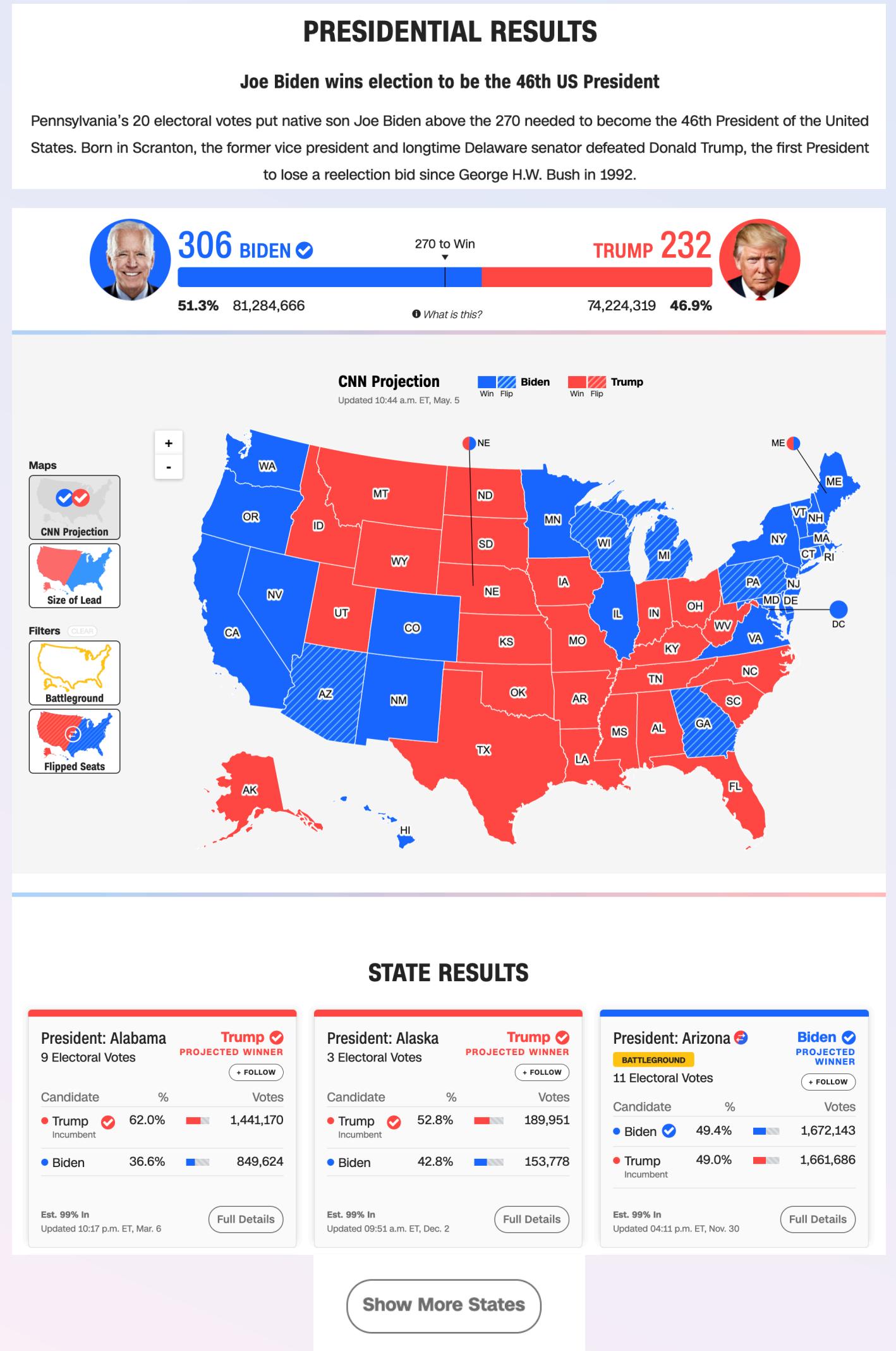
Future Things

The builders and the makers (*that's us*) are responsible for access.

# Can better tools reduce inaccessibility?

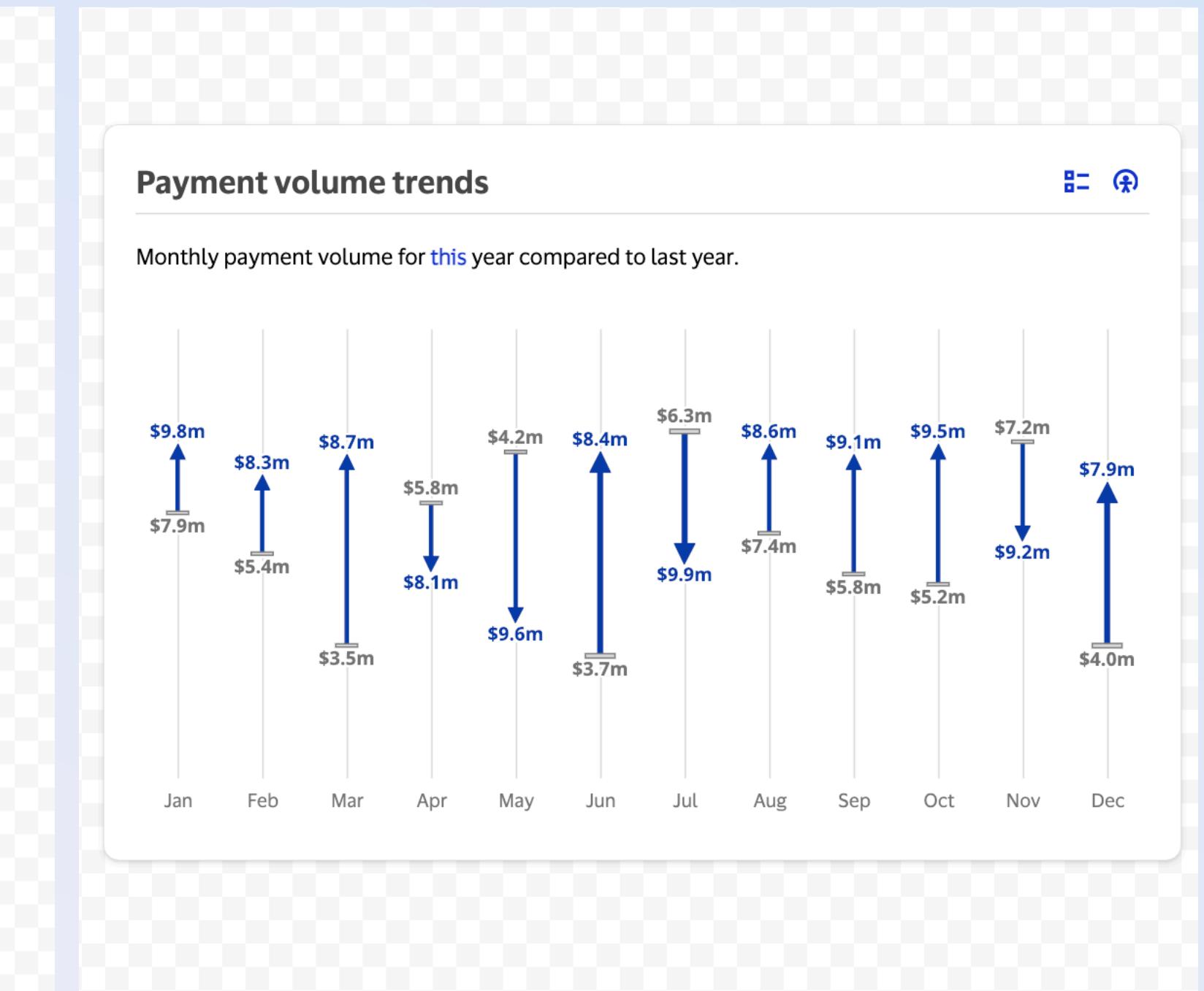
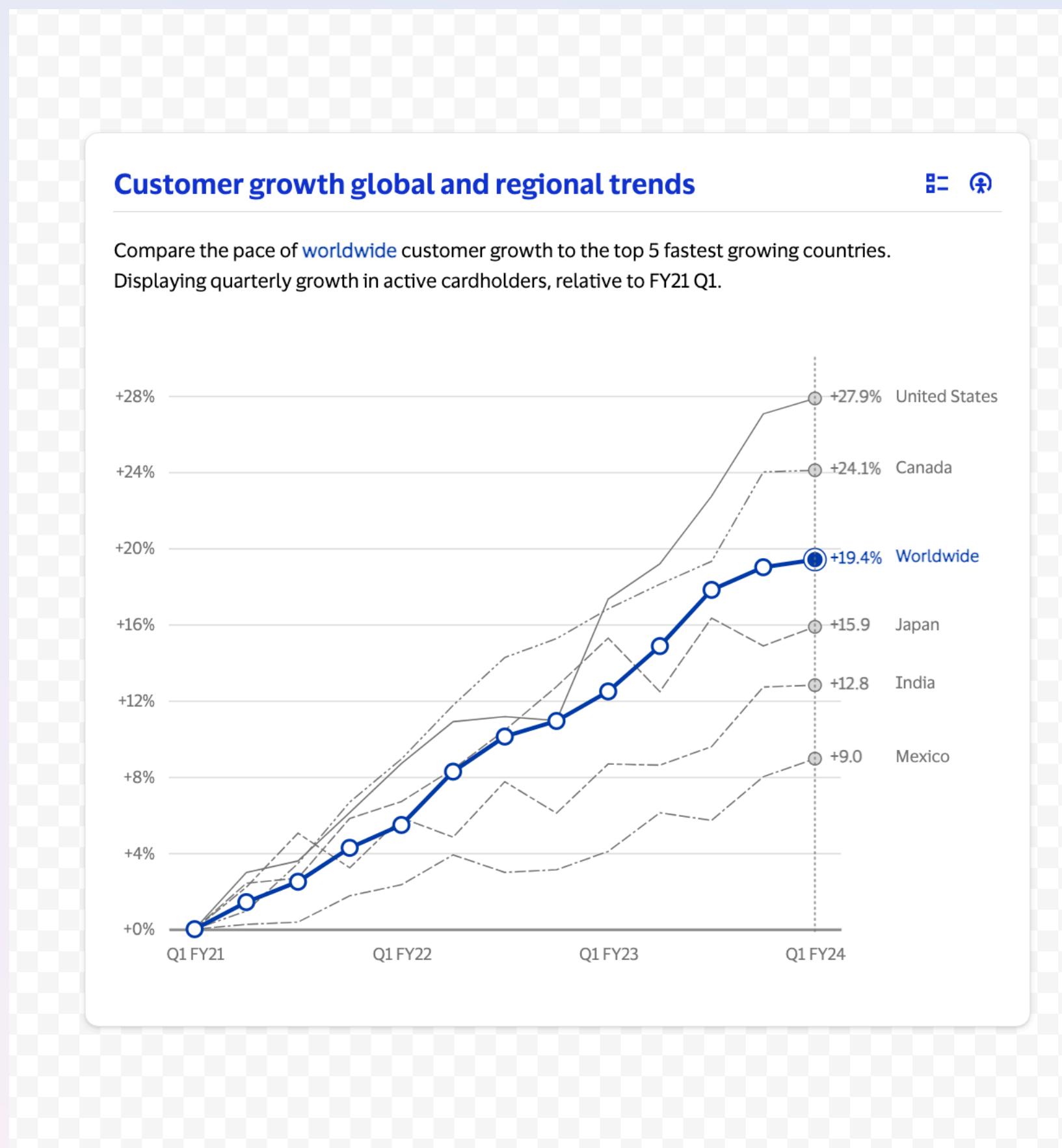


# Section 1: Helping practitioners consider accessibility

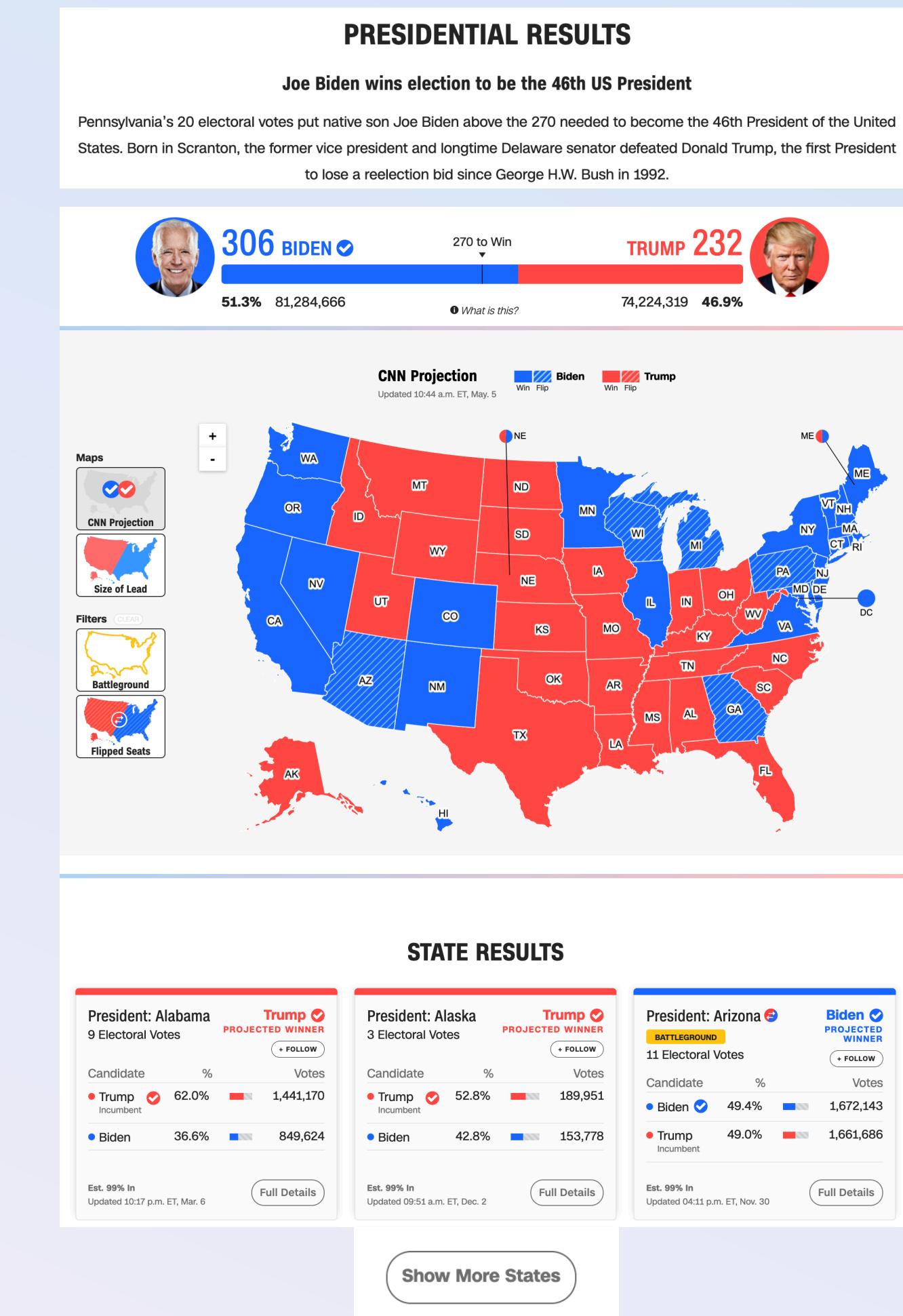
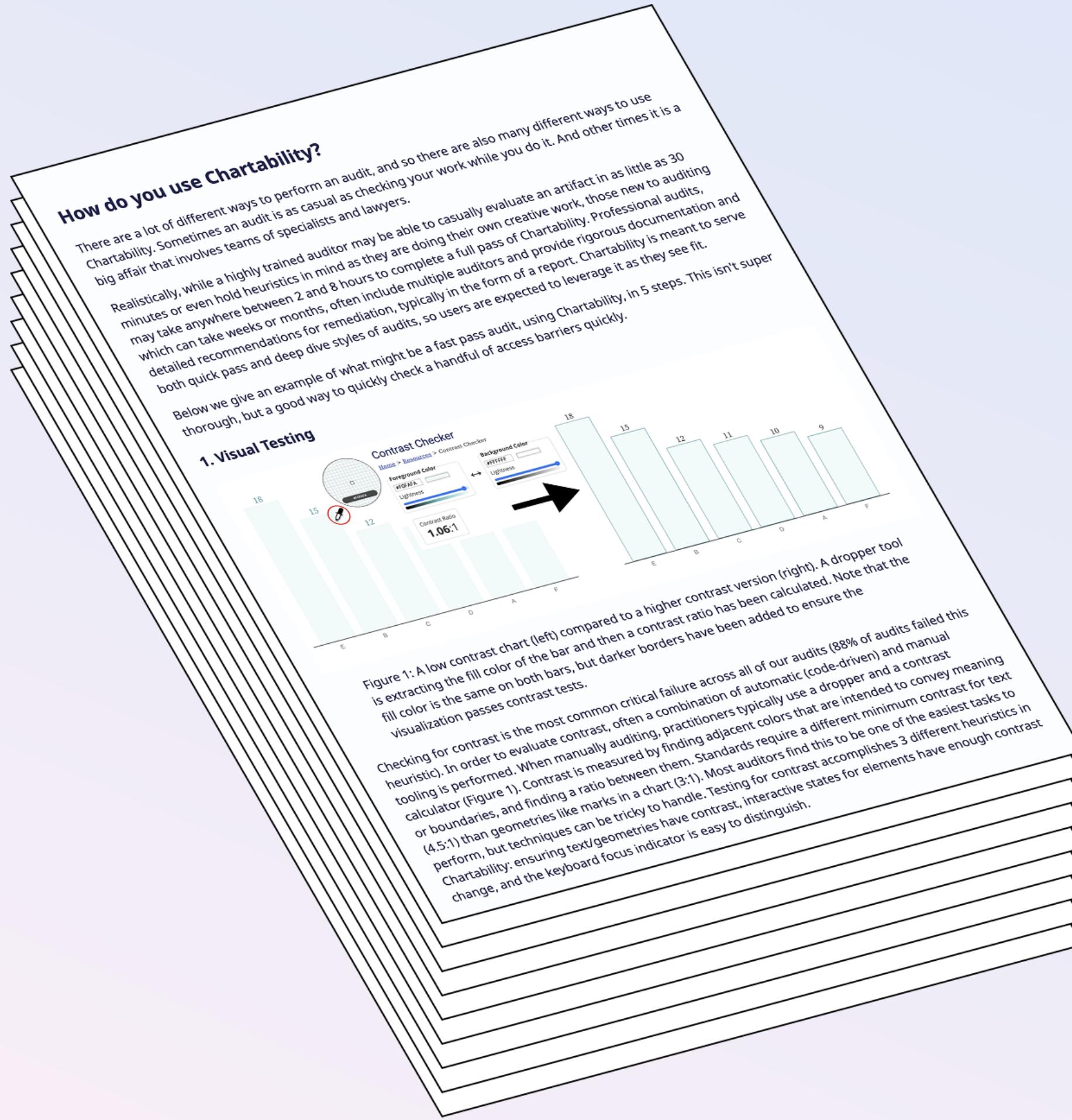


# Research problem: How do you find and evaluate access barriers in interactive visualizations?

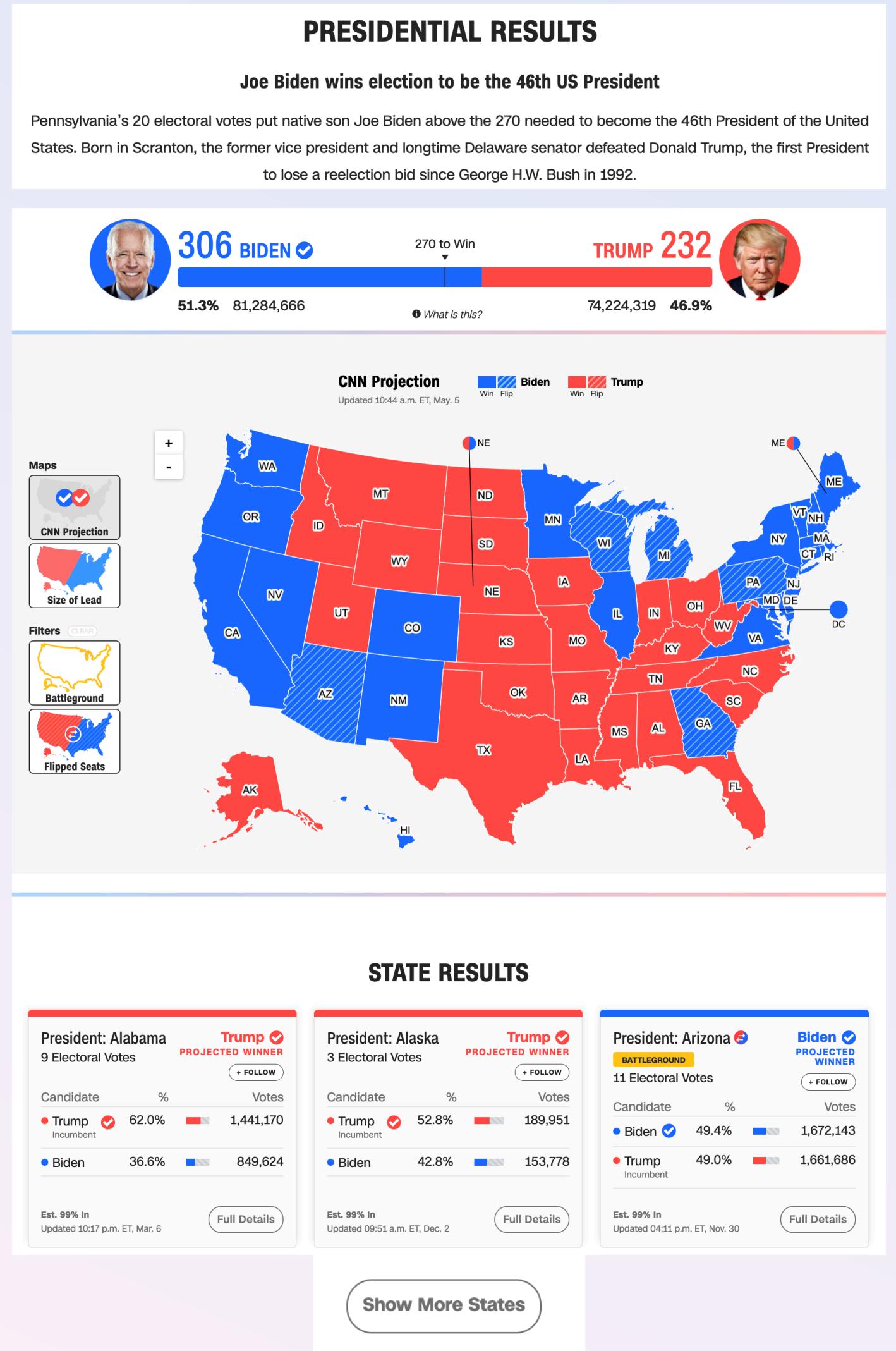
# Prior work: Staff-level engineer making a visualization library



# Chartability is a workbook of tests, tools, and principles



F. Elavsky, C. Bennett, and D. Moritz, “How accessible is my visualization? Evaluating visualization accessibility with *Chartability*,” Computer Graphics Forum, 2022.



# Let's evaluate this map from CNN with Chartability.

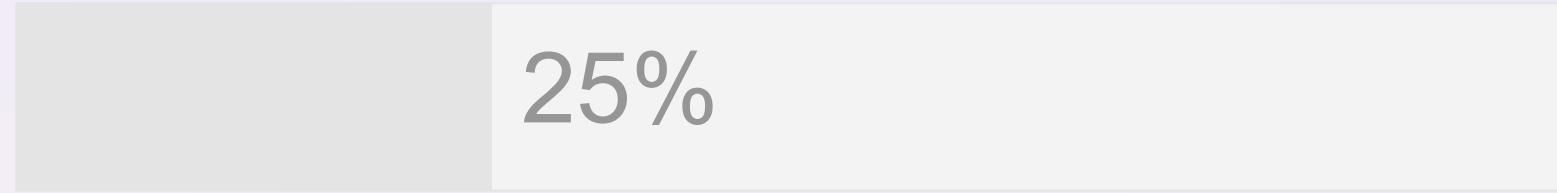
# Design with high contrast

**Colorblindness Disproportionately Overrepresented in A11y Resources**

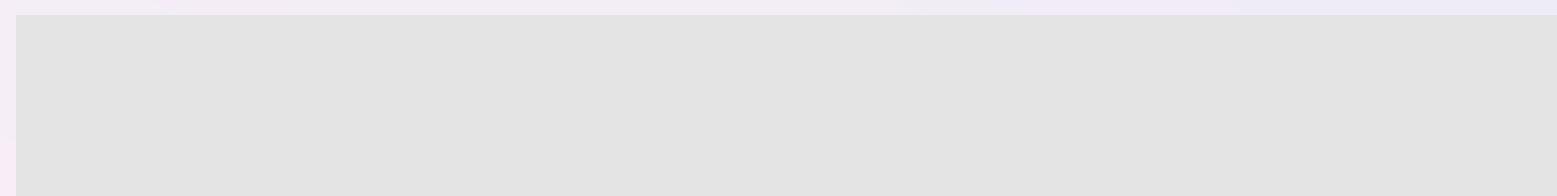
Colorblindness: % of People



Low Vision: % of People



Colorblindness: # of Resources



Low Vision: # of Resources

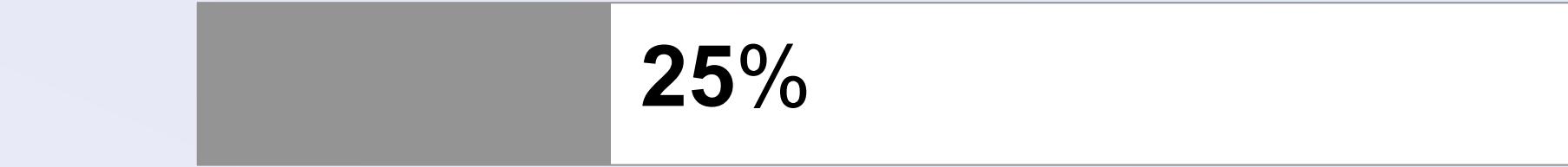


**Colorblindness Disproportionately Overrepresented in A11y Resources**

Colorblindness: % of People



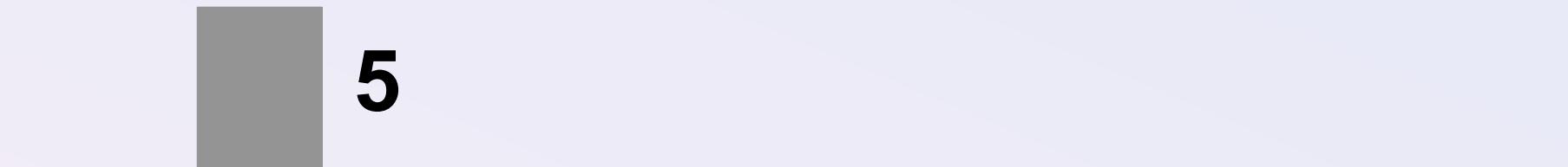
Low Vision: % of People



Colorblindness: # of Resources



Low Vision: # of Resources



# Use High Contrast Text

Text needs at least 4.5:1 contrast against its background.

Large text (bold and 16pt or larger) can be 3:1 or higher.

## Contrast Checker

[Home](#) > [Resources](#) > Contrast Checker

Foreground Color  
#969696 

Lightness 

Background Color  
#FFFFFF 

Lightness 

Contrast Ratio  
**2.95:1**

[permalink](#)

### Normal Text

WCAG AA: **Fail**

WCAG AAA: **Fail**

The five boxing wizards jump quickly.

### Large Text

WCAG AA: **Fail**

WCAG AAA: **Fail**

The five boxing wizards jump quickly.

# Use High Contrast Geometries

Chart elements need at least 3:1 contrast against their background.

## Contrast Checker

[Home](#) > [Resources](#) > Contrast Checker

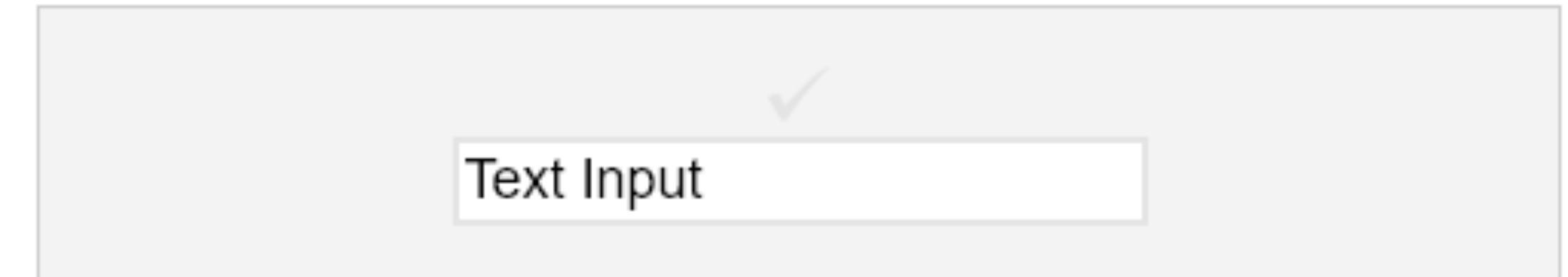
Foreground Color  
#E4E4E4   
Lightness 

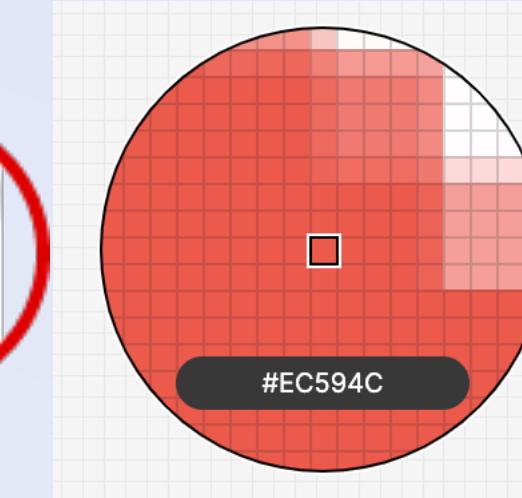
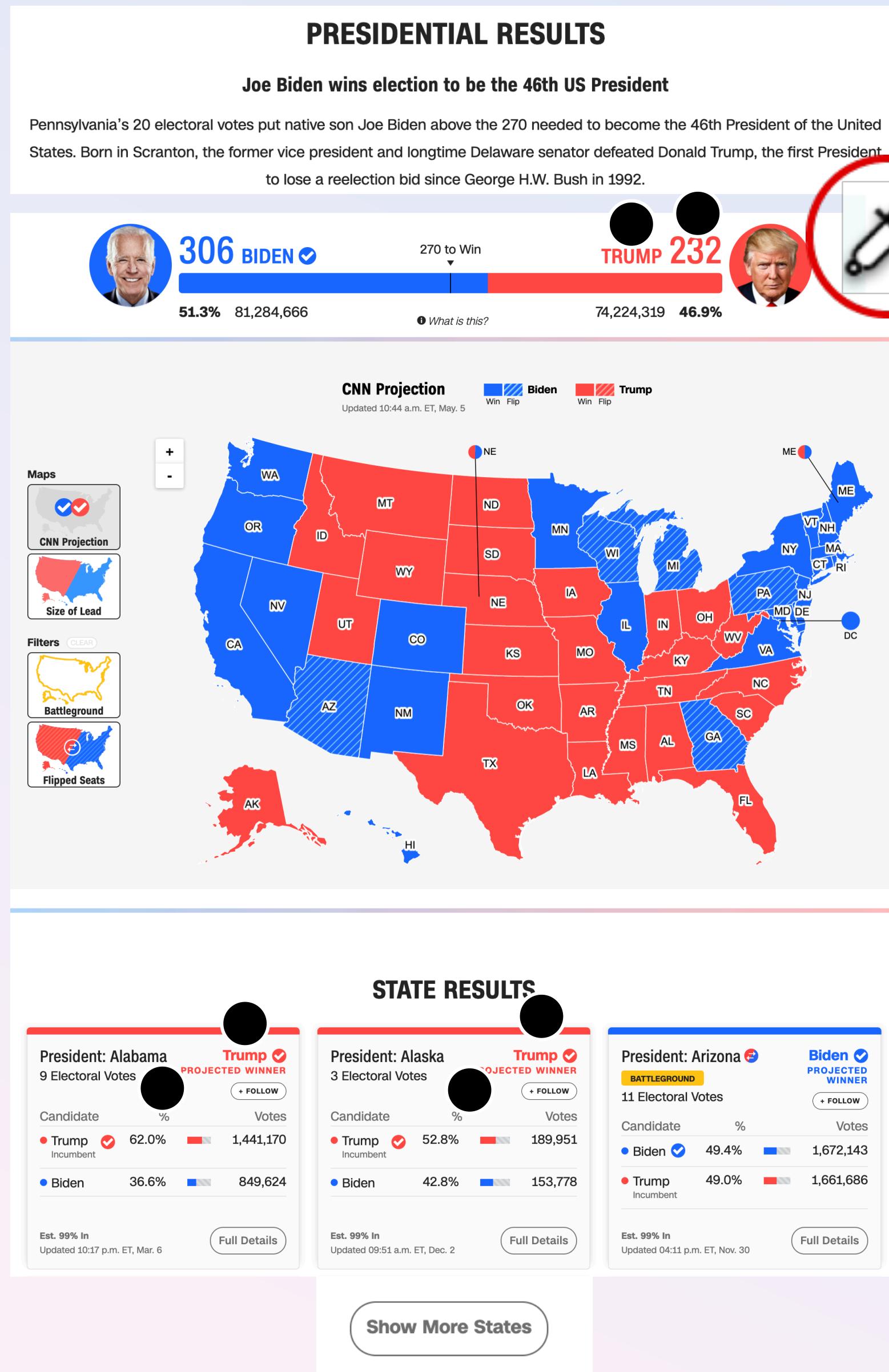
Background Color  
#F3F3F3   
Lightness 

Contrast Ratio  
**1.14:1**  
[permalink](#)

## Graphical Objects and User Interface Components

WCAG AA: **Fail**





# Contrast Checker

[Home](#) > [Resources](#) > Contrast Checker

## Foreground Color

#EC594C



Lightness



## Background Color

#FFFFFF



Lightness



## Contrast Ratio

**3.44:1**

[permalink](#)

## Normal Text

WCAG AA: **Fail**

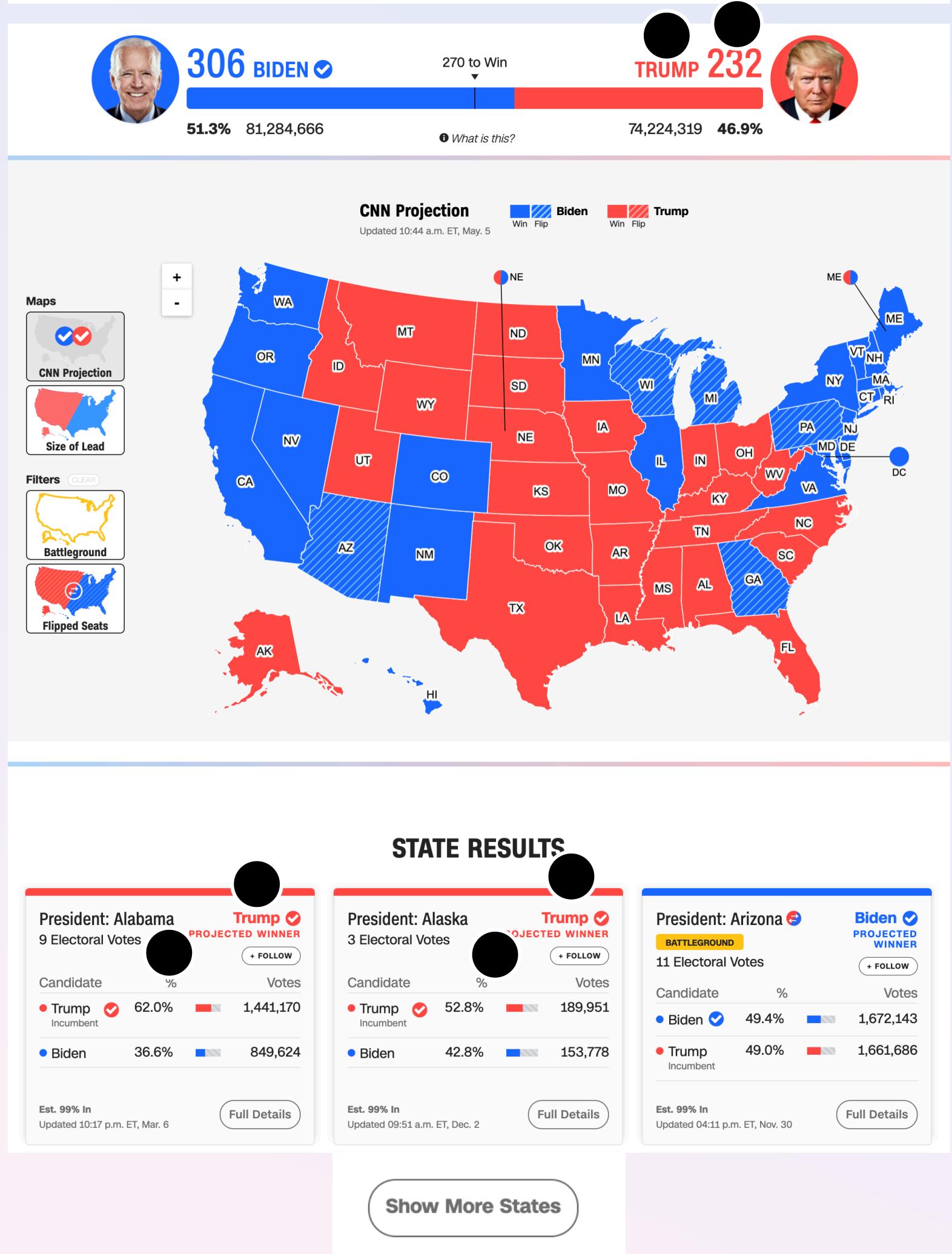
WCAG AAA: **Fail**

The five boxing wizards jump quickly.

## PRESIDENTIAL RESULTS

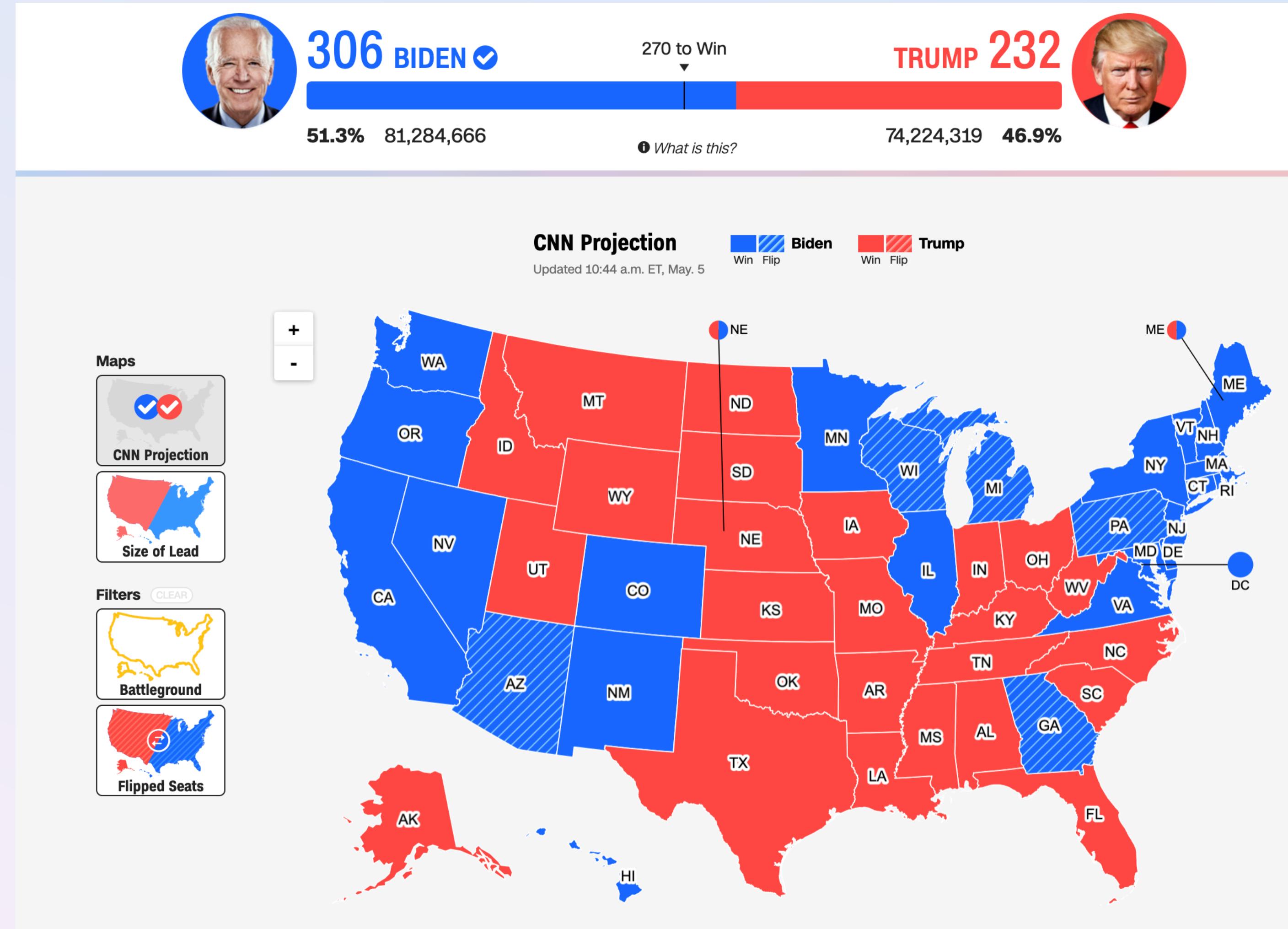
Joe Biden wins election to be the 46th US President

Pennsylvania's 20 electoral votes put native son Joe Biden above the 270 needed to become the 46th President of the United States. Born in Scranton, the former vice president and longtime Delaware senator defeated Donald Trump, the first President to lose a reelection bid since George H.W. Bush in 1992.

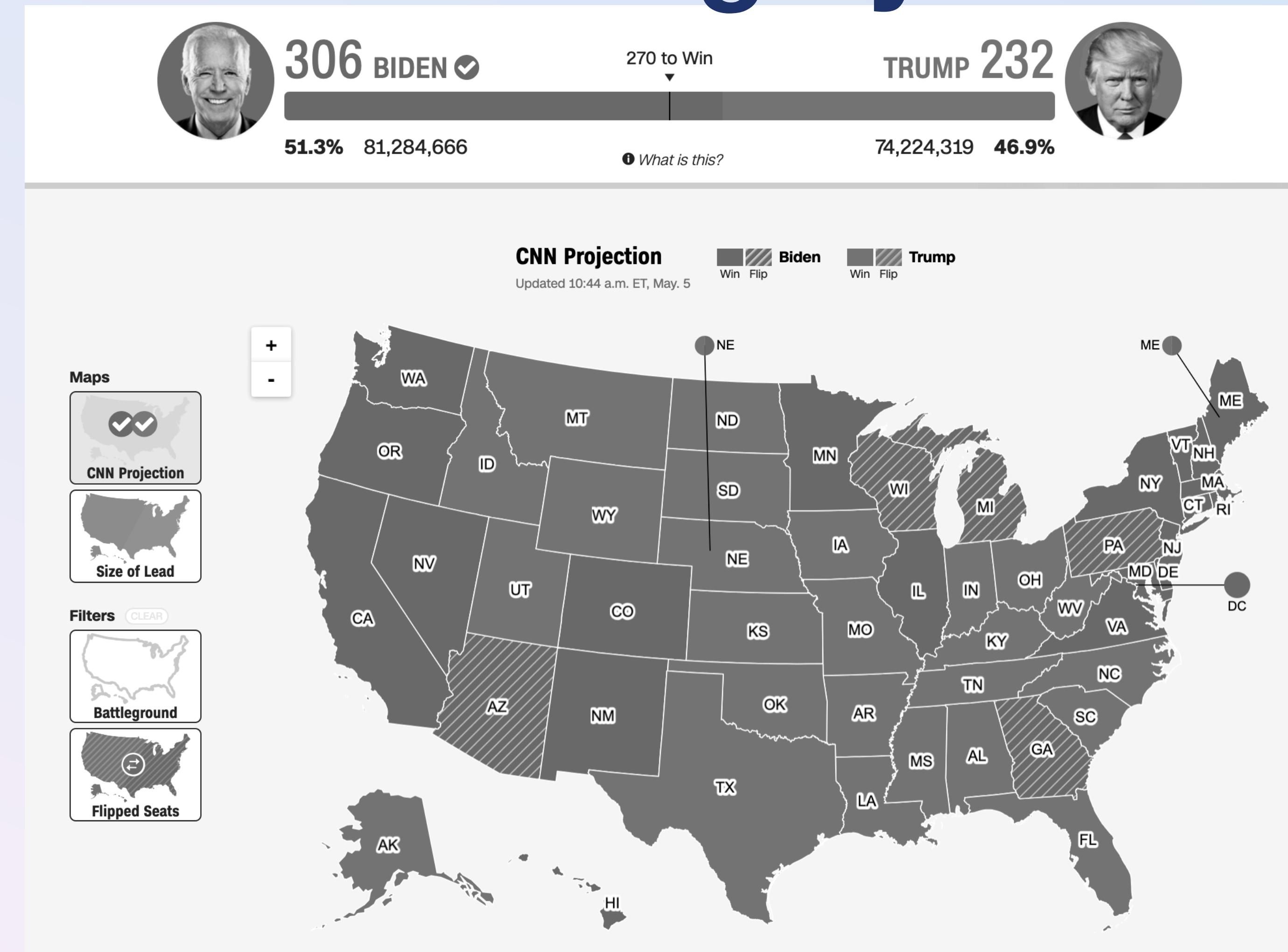


# 6 instances of low contrast

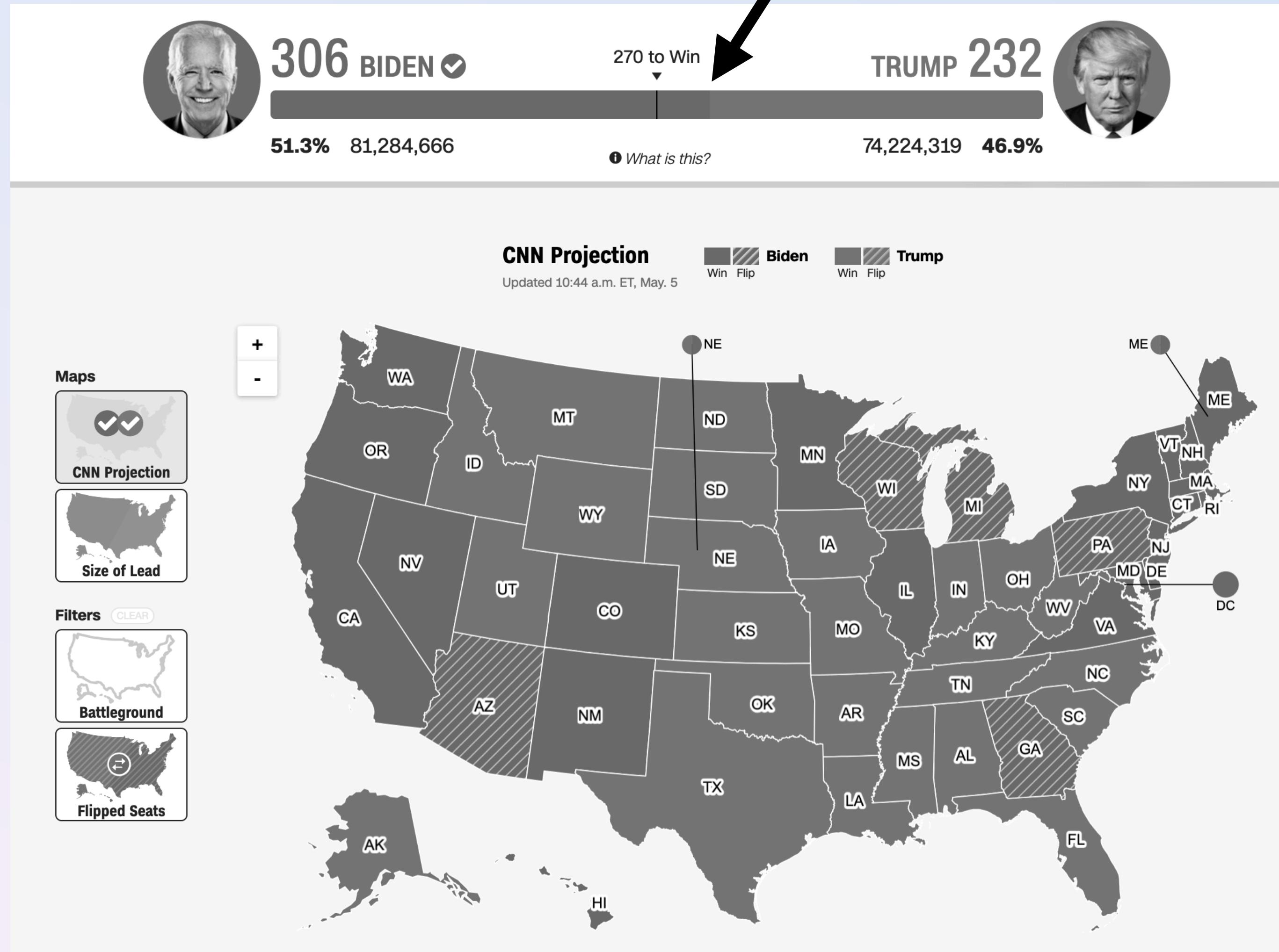
# How can we fix this?



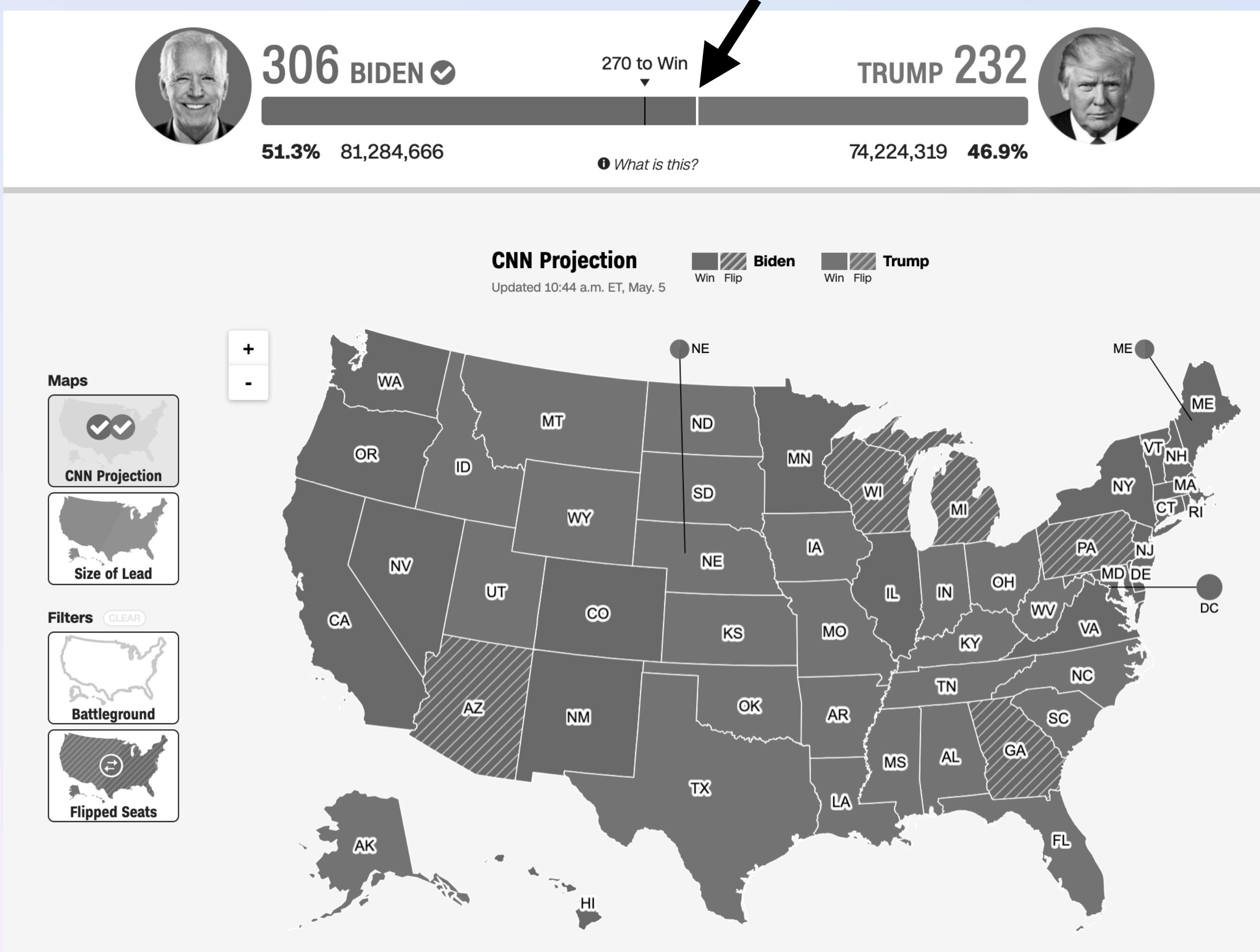
# This map is trouble in greyscale



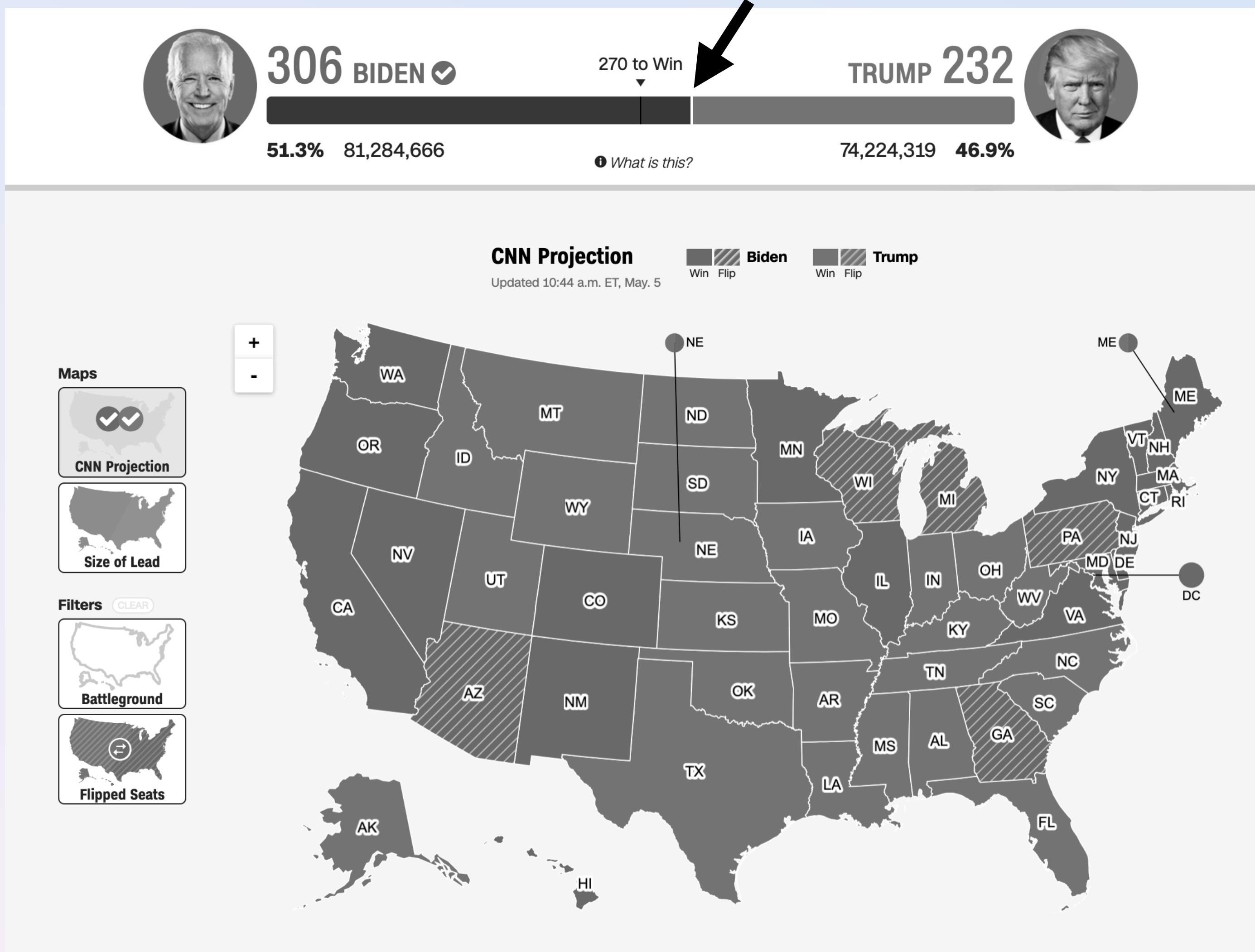
The division here matters!



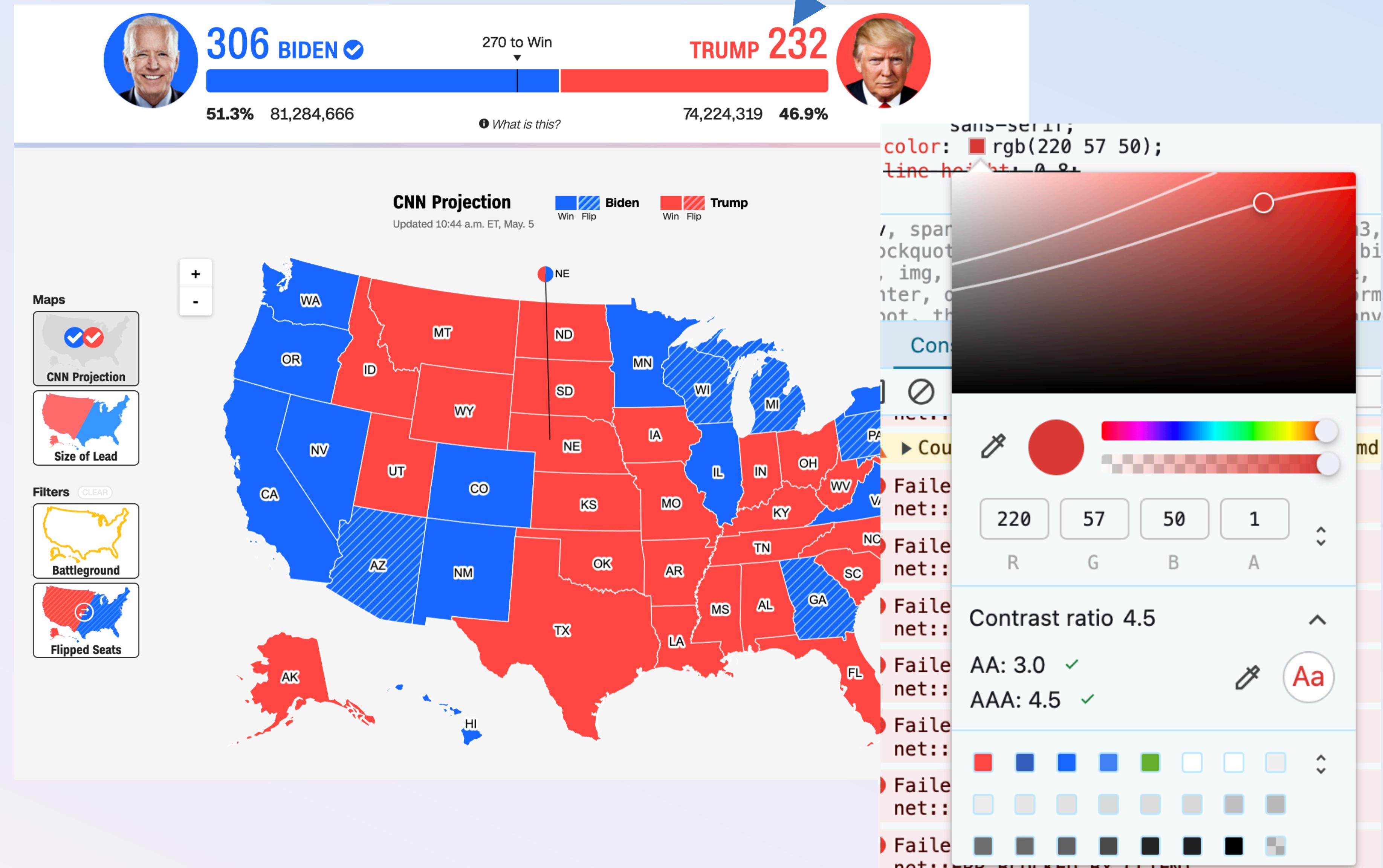
**Maybe a small white divider, like the states?**



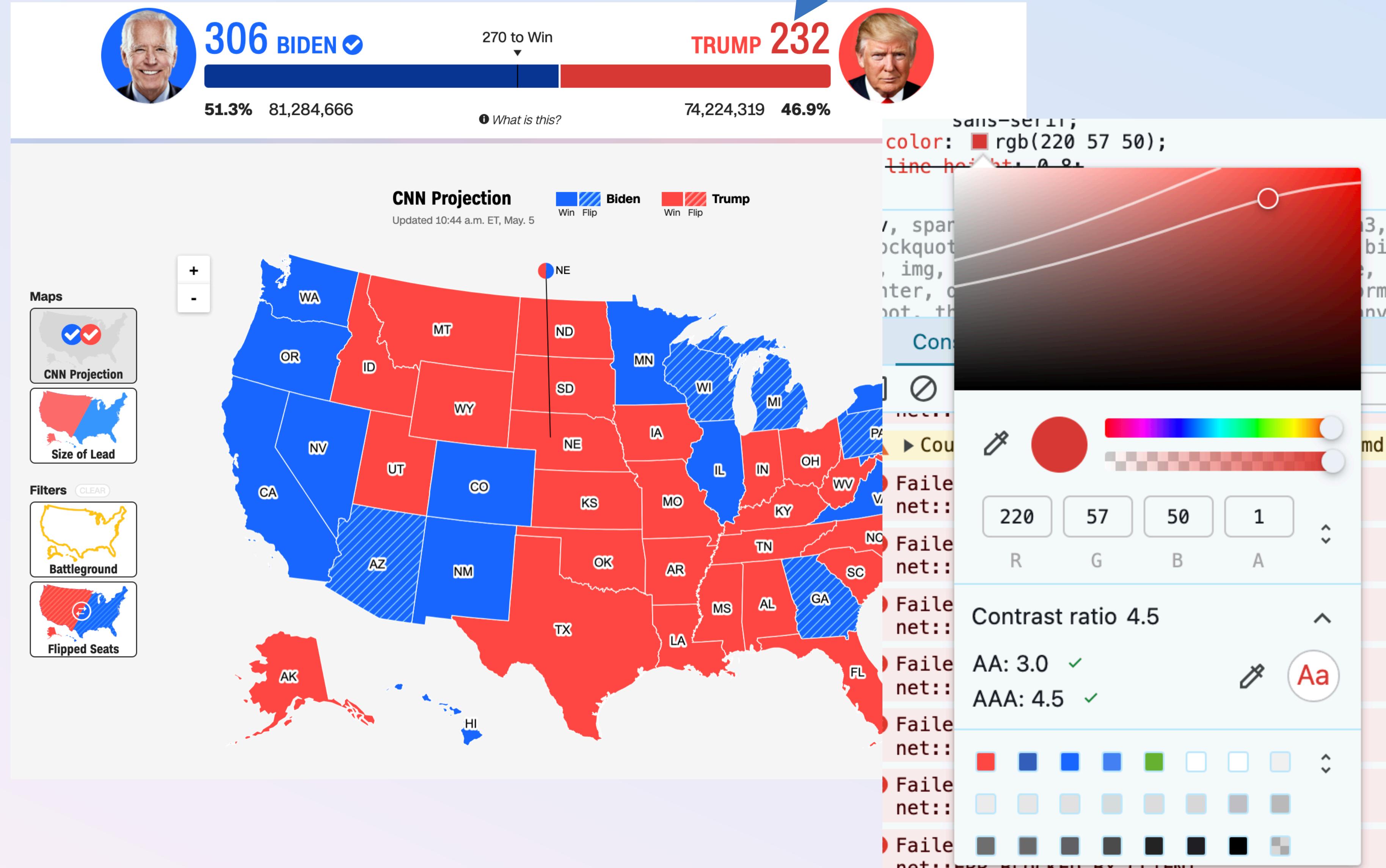
Perhaps test a darker blue too?



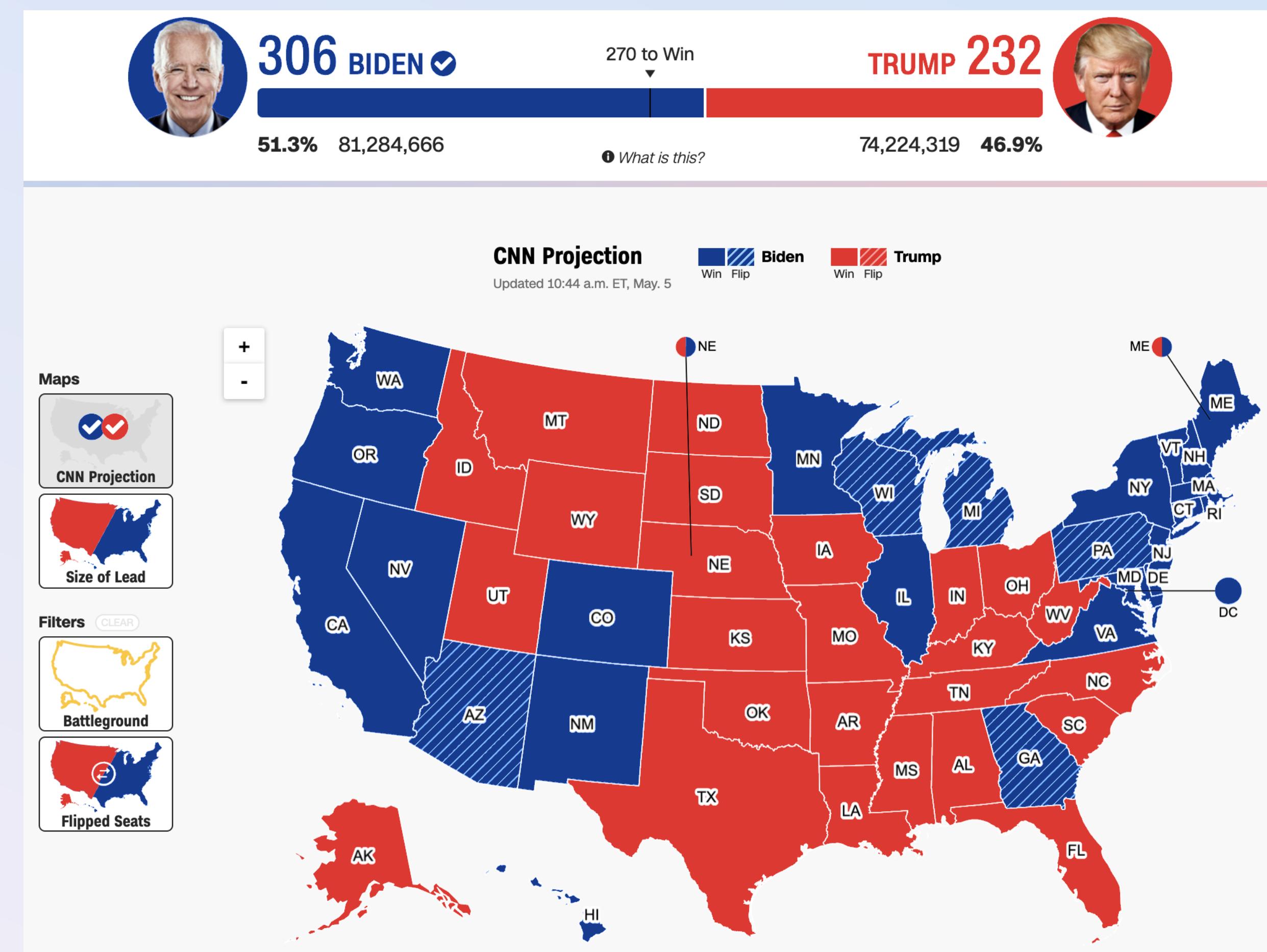
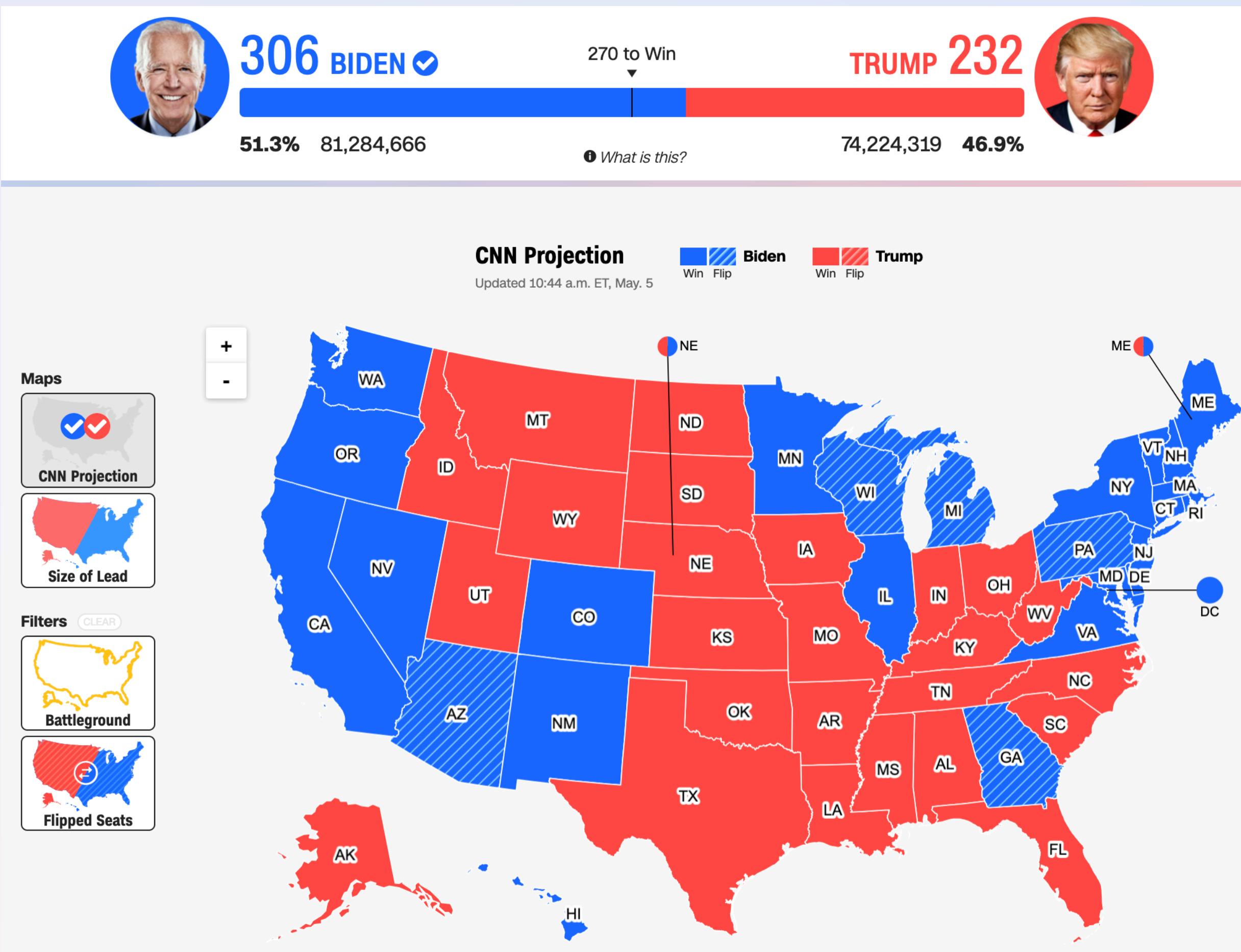
# What if we fix the contrast failures at the same time?



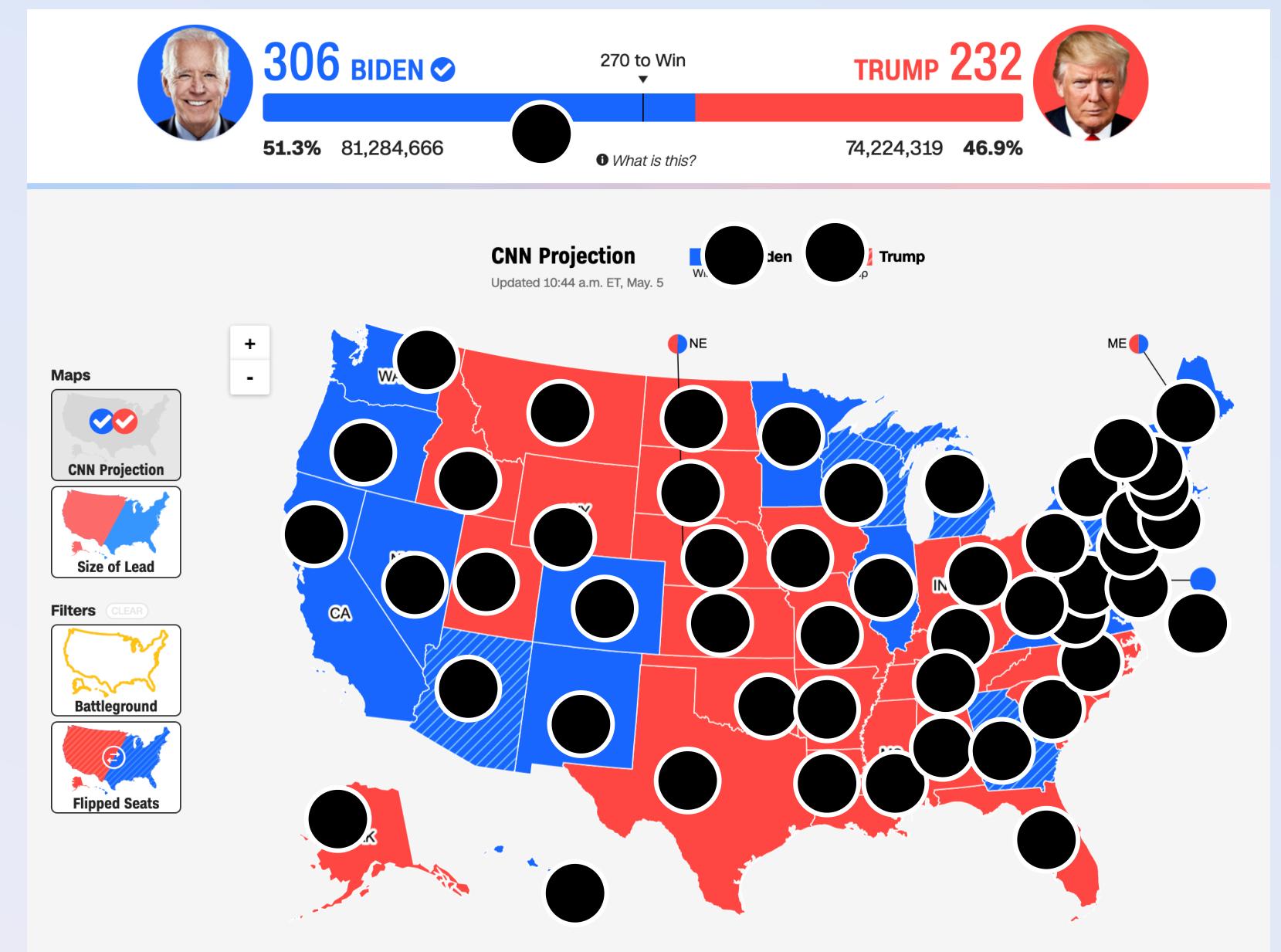
# This text now passes!



# Sufficient contrast can help folks differentiate

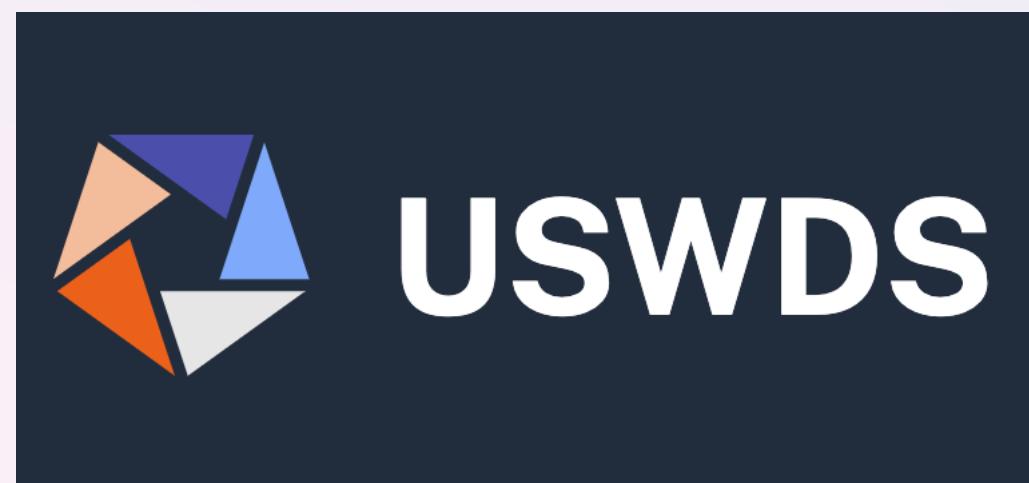


(repeat for 49  
other heuristics)



# Chartability is used in:

**15+** Policy orgs and governments worldwide



**110+** Tech, news, and non-profit companies/orgs

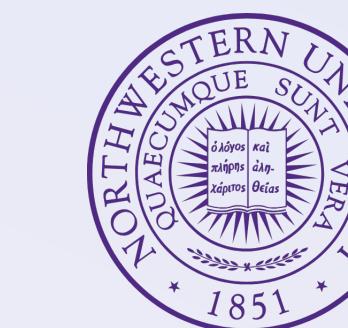


**20+** Undergraduate and graduate courses

Carnegie Mellon University



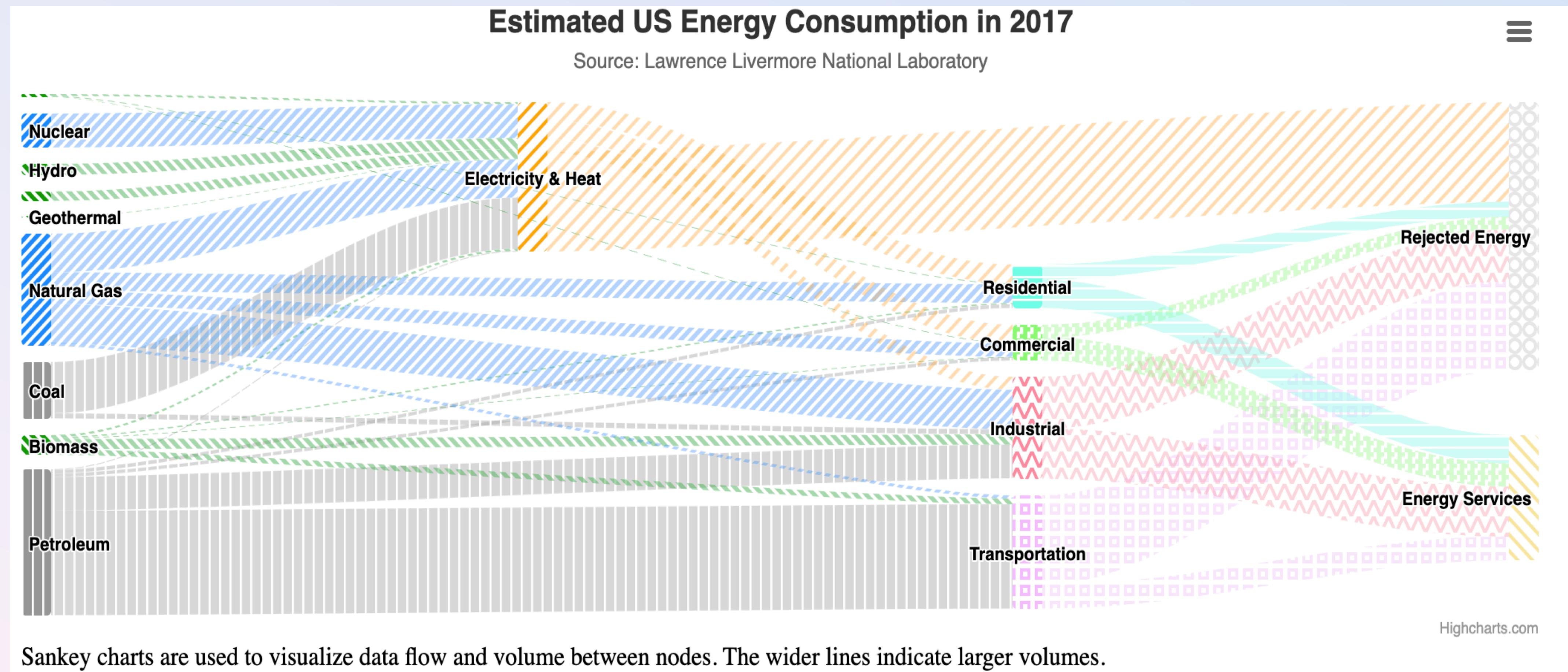
UNIVERSITY *of* WASHINGTON



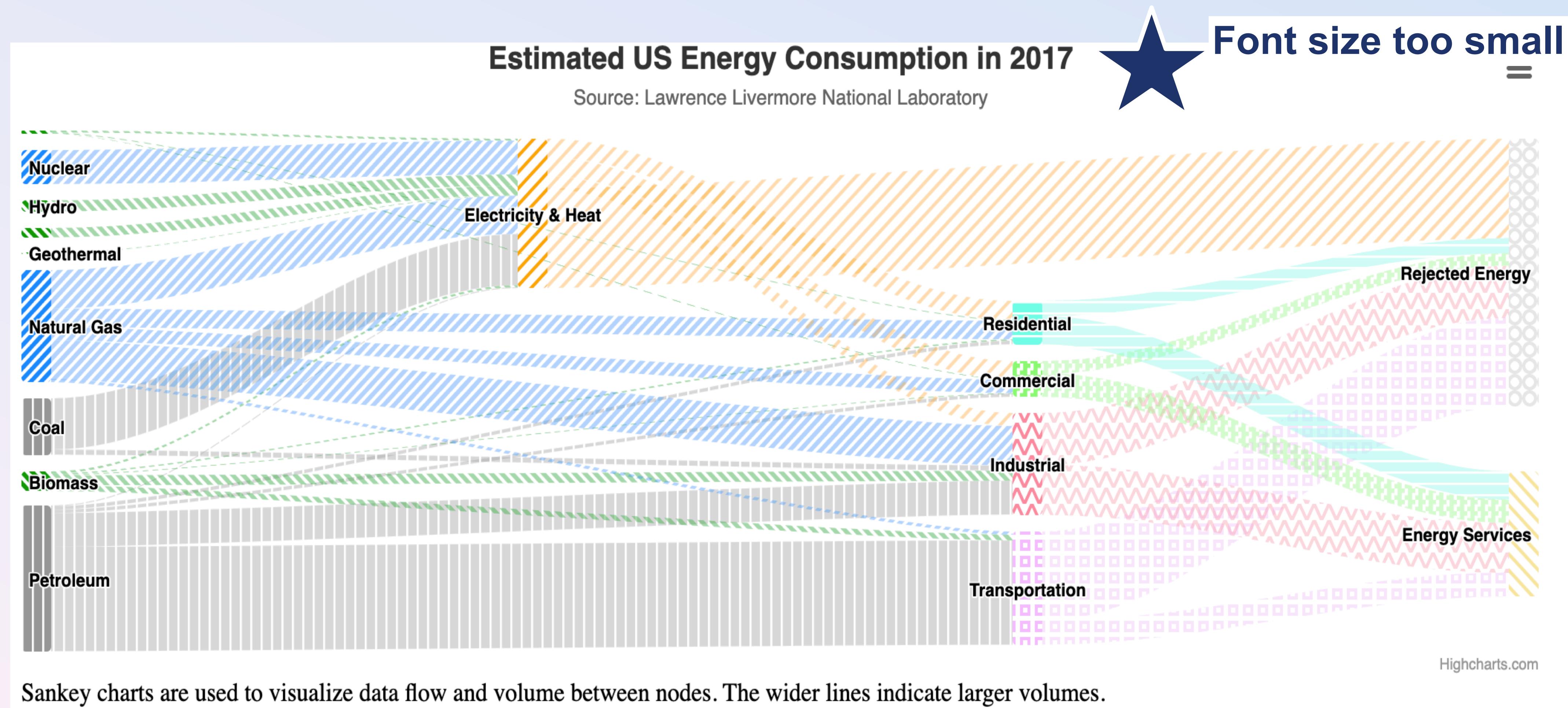
Northwestern University

COLUMBIA UNIVERSITY  
IN THE CITY OF NEW YORK

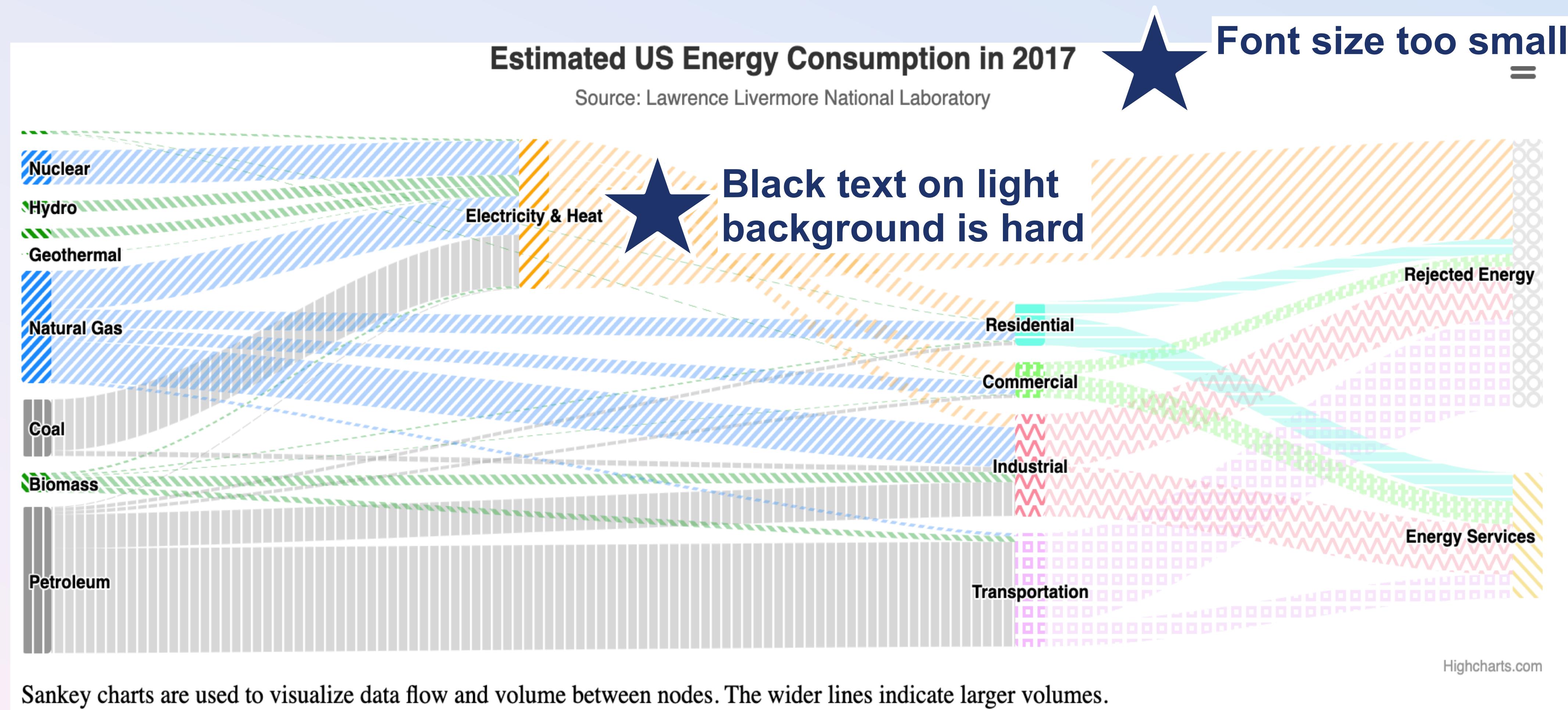
# What about this visualization might be a barrier?



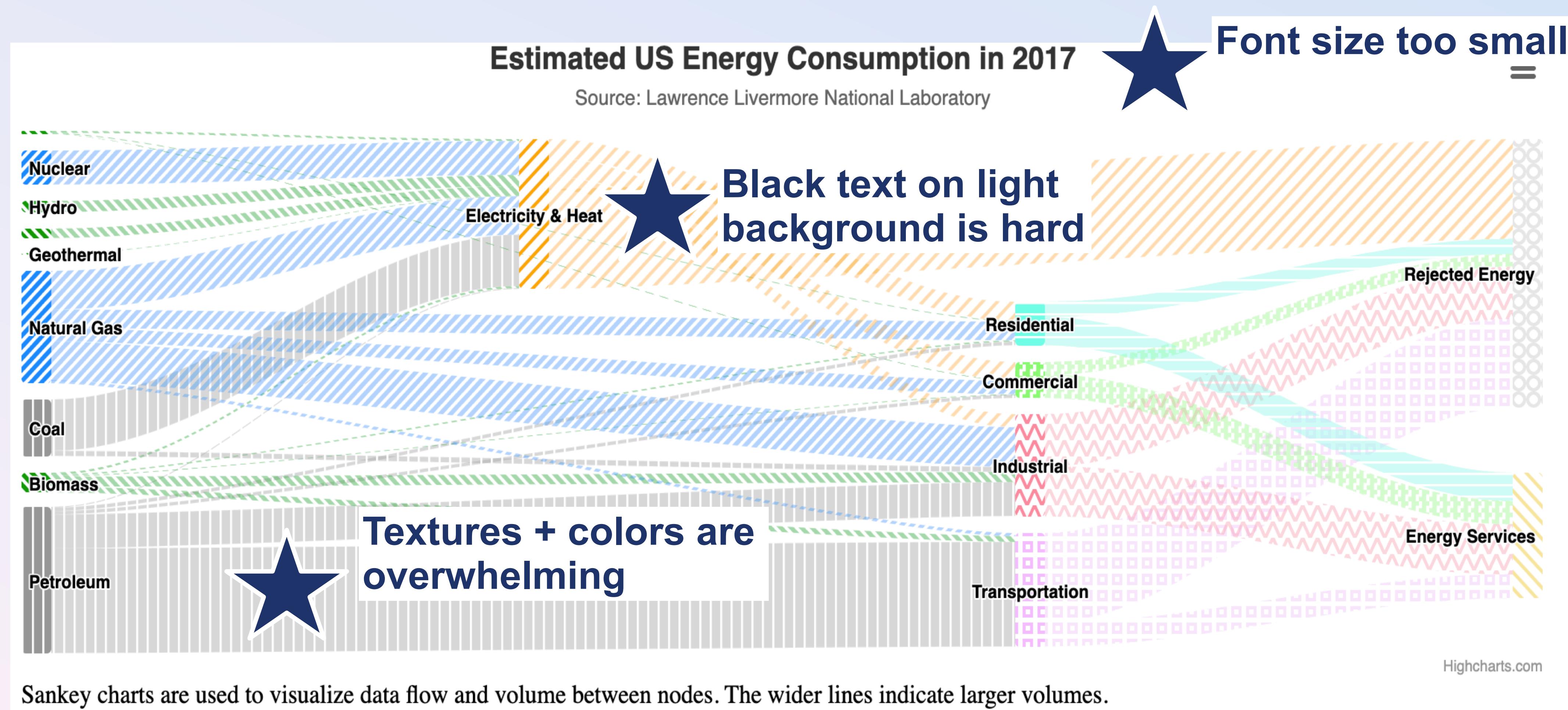
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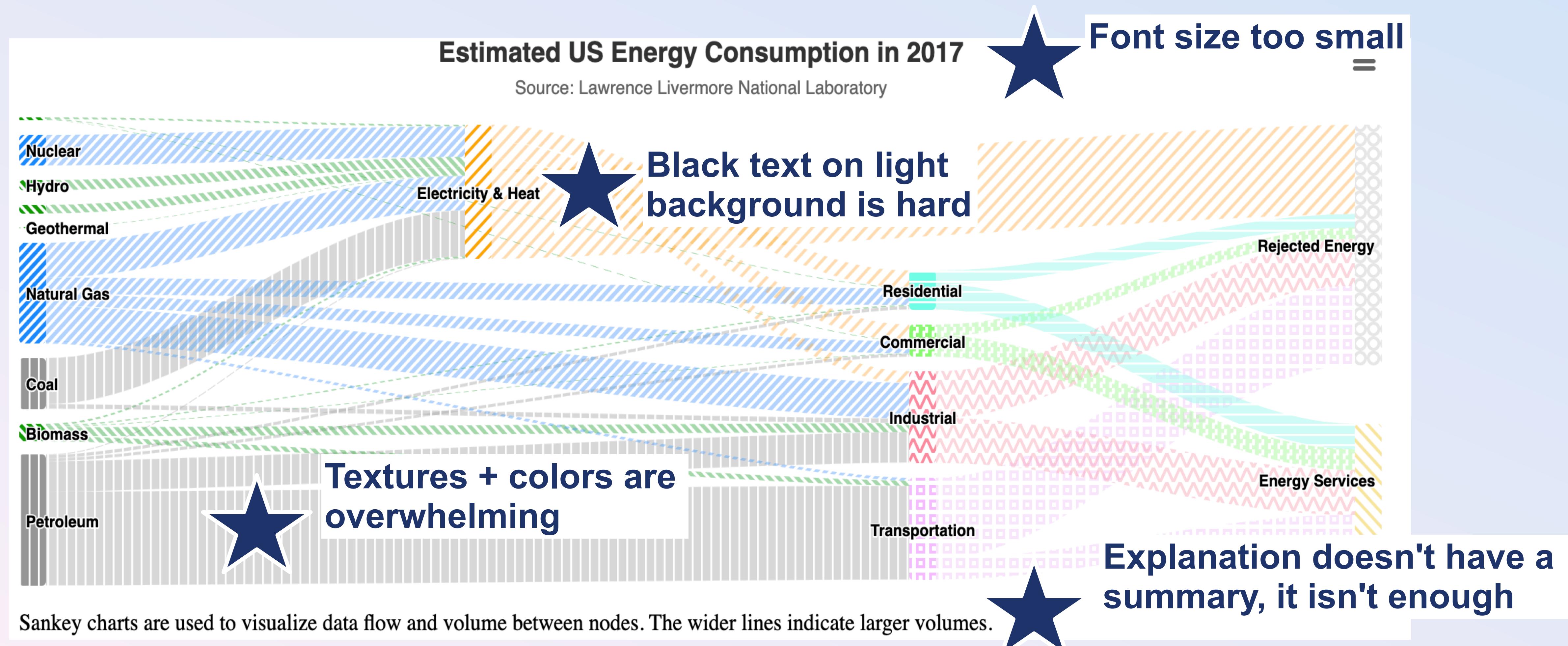
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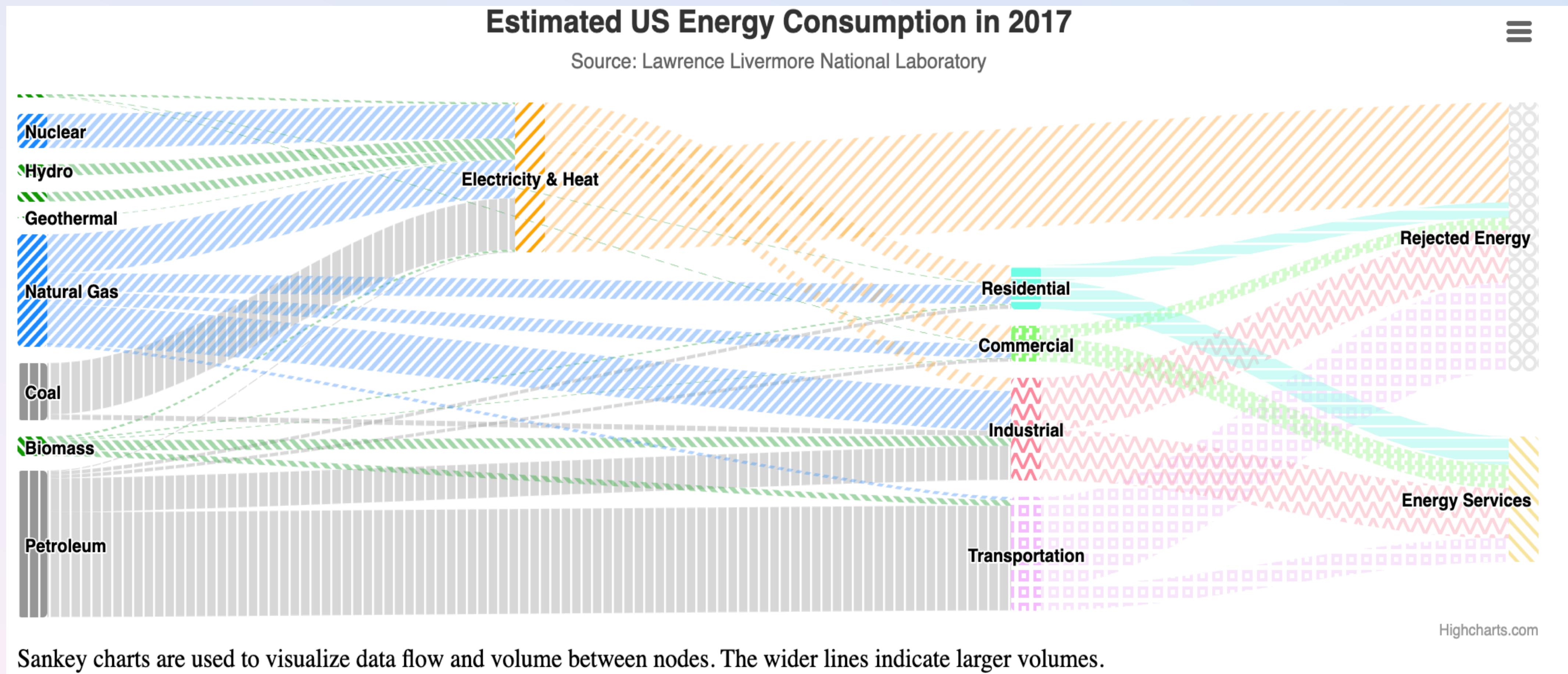
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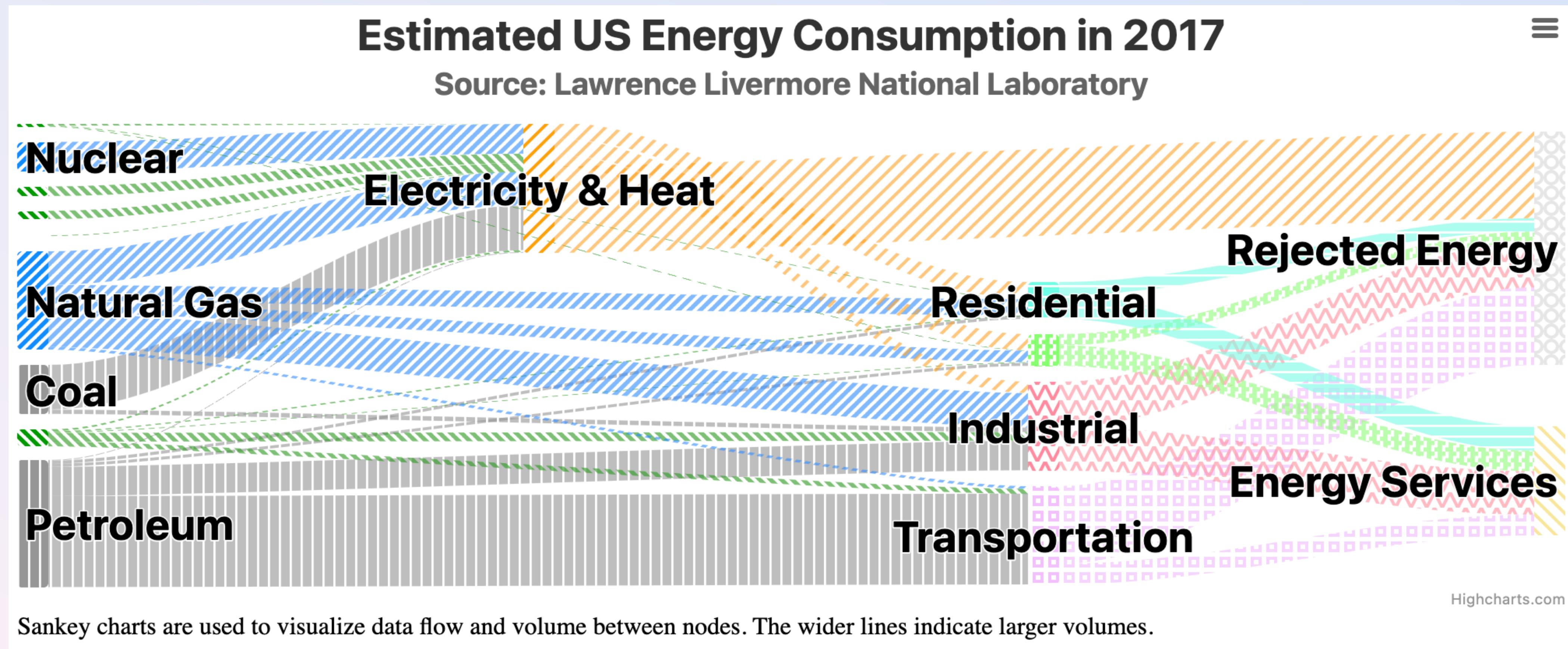
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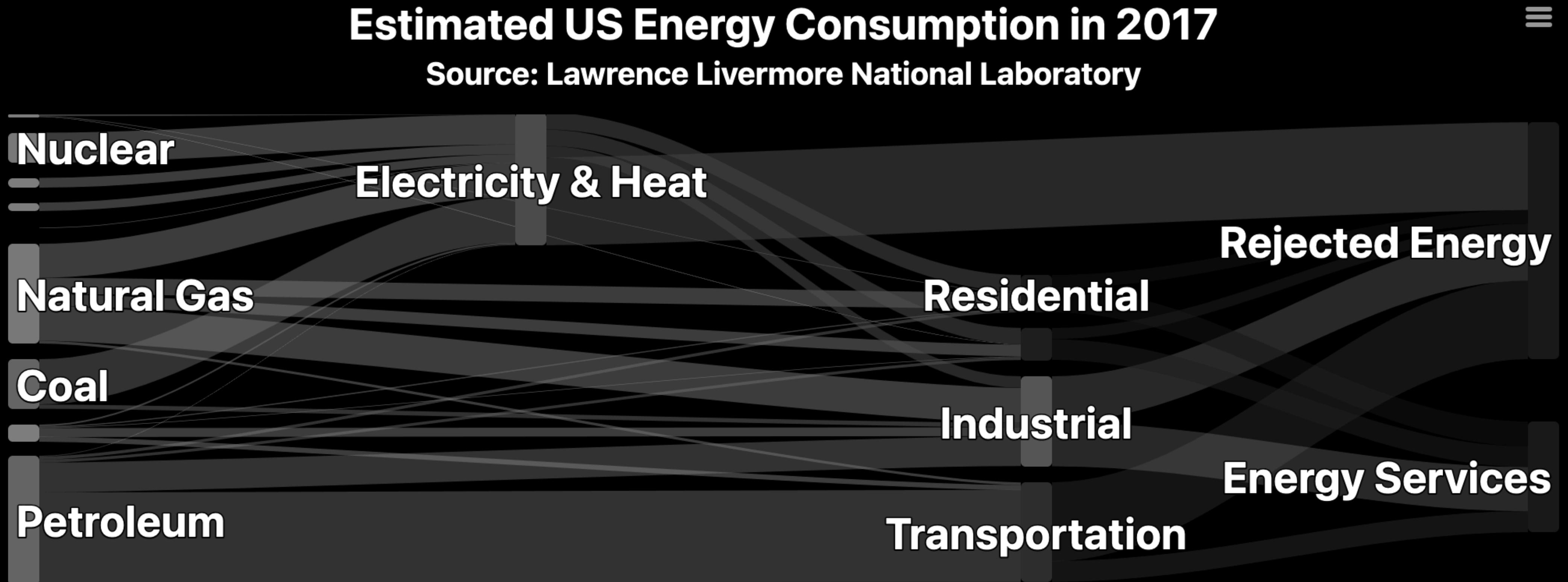
# Can we fix this?



# Maybe we can bump up the text size



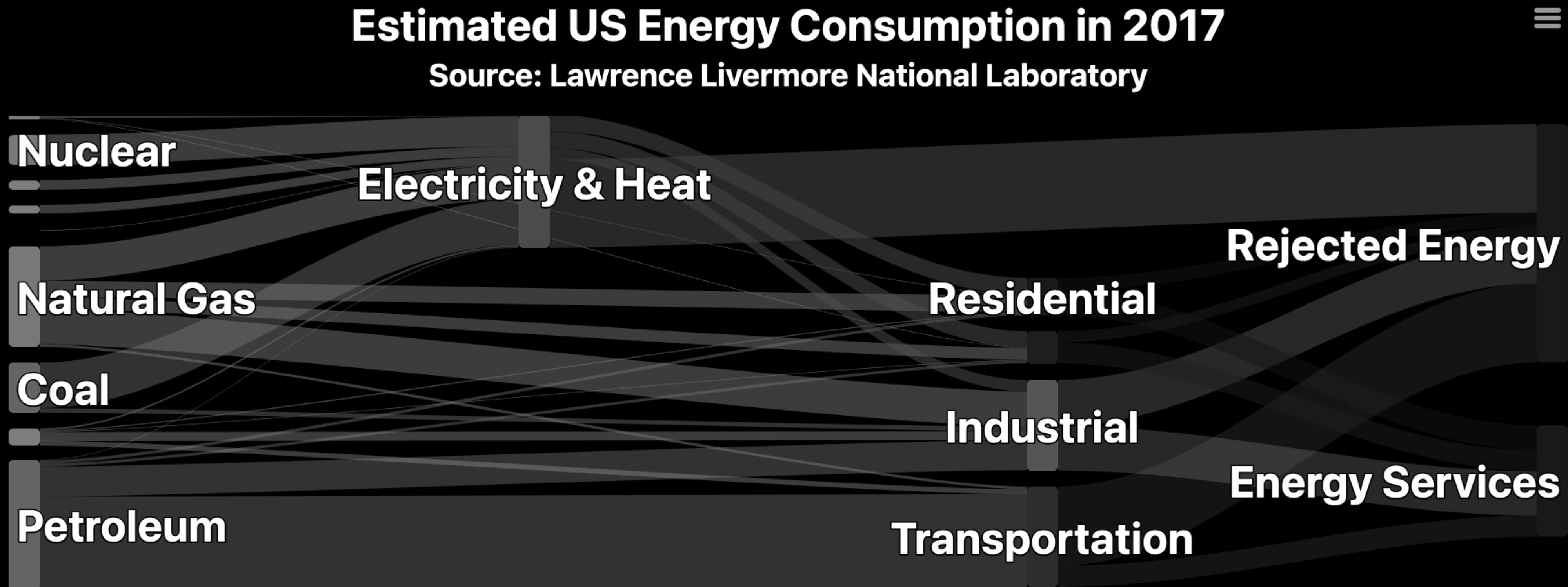
# We can reduce visual complexity too



Sankey charts are used to visualize data flow and volume between nodes. The wider lines indicate larger volumes.

Highcharts.com

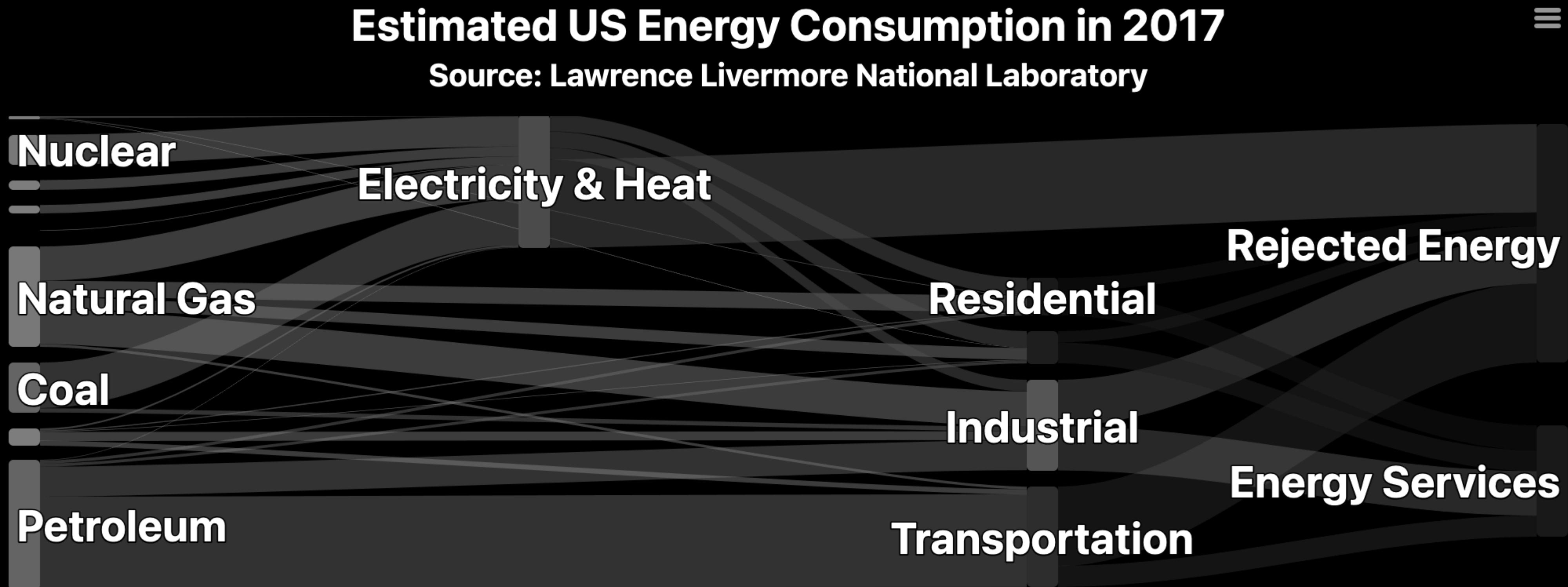
# We can add a more descriptive explanation



Highcharts.com

Sankey charts are used to visualize data flow and volume between nodes. Visually wider lines indicate larger volumes. This chart is showing energy consumption and types. Interacting with this chart by selecting a node or flow (such as with a click) will update the stacked bar chart below.

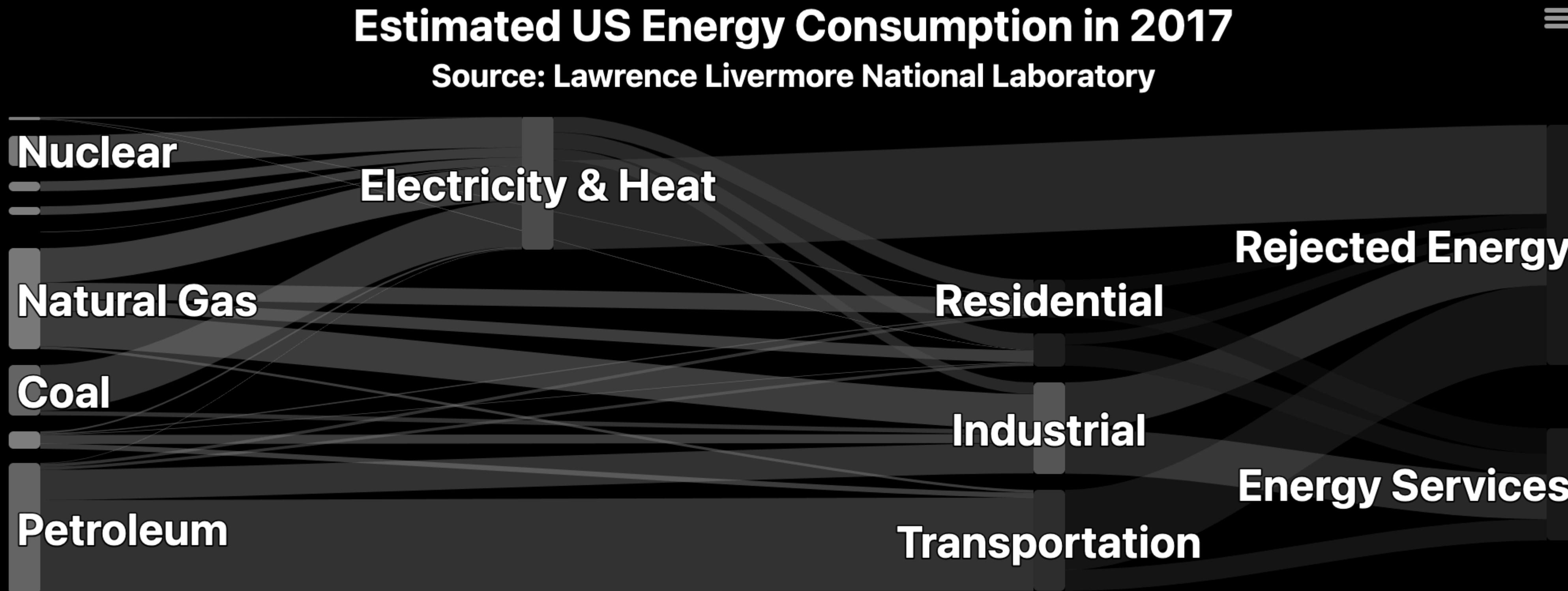
# Is this the perfect, most accessible design?



Highcharts.com

Sankey charts are used to visualize data flow and volume between nodes. Visually wider lines indicate larger volumes. This chart is showing energy consumption and types. Interacting with this chart by selecting a node or flow (such as with a click) will update the stacked bar chart below.

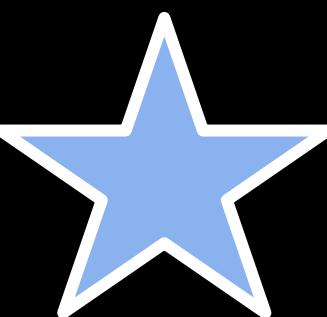
# Bad news...



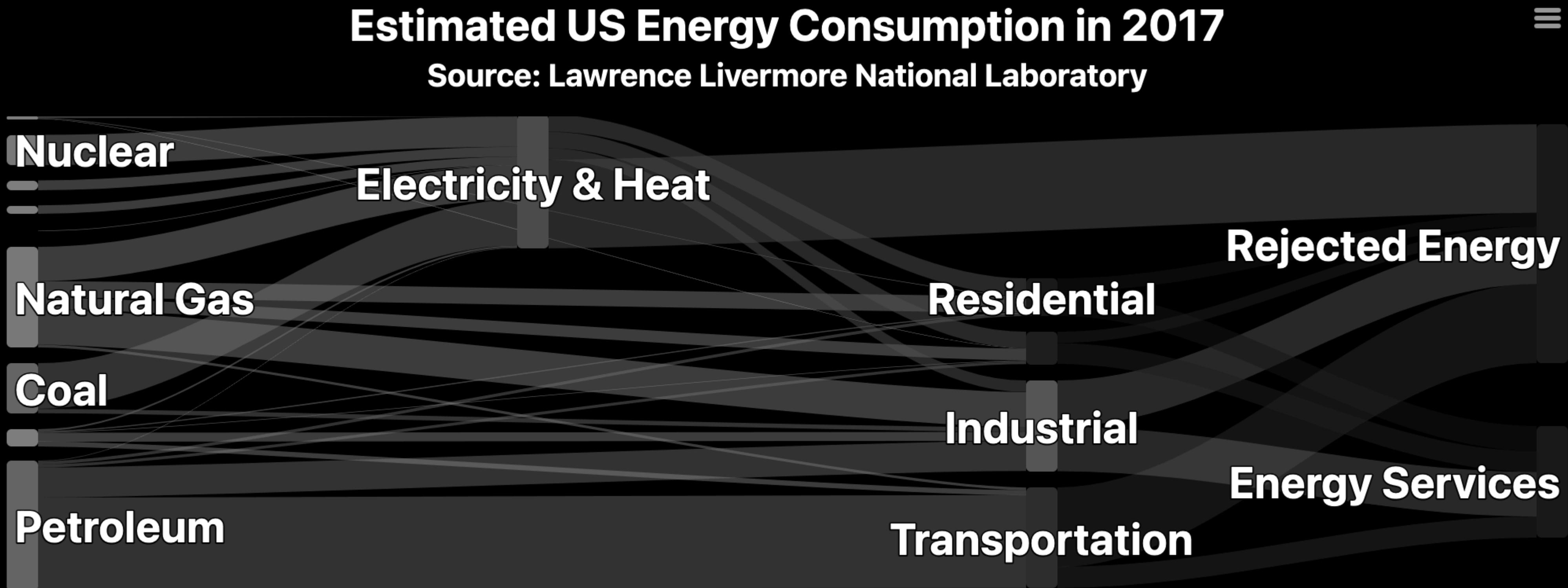
Highcharts.com

Sankey charts are used to visualize data flow and volume between nodes. Visually wider lines indicate larger volumes. This chart is showing energy consumption and types. Interacting with this chart by selecting a node or flow (such as with a click) will update the stacked bar chart below.

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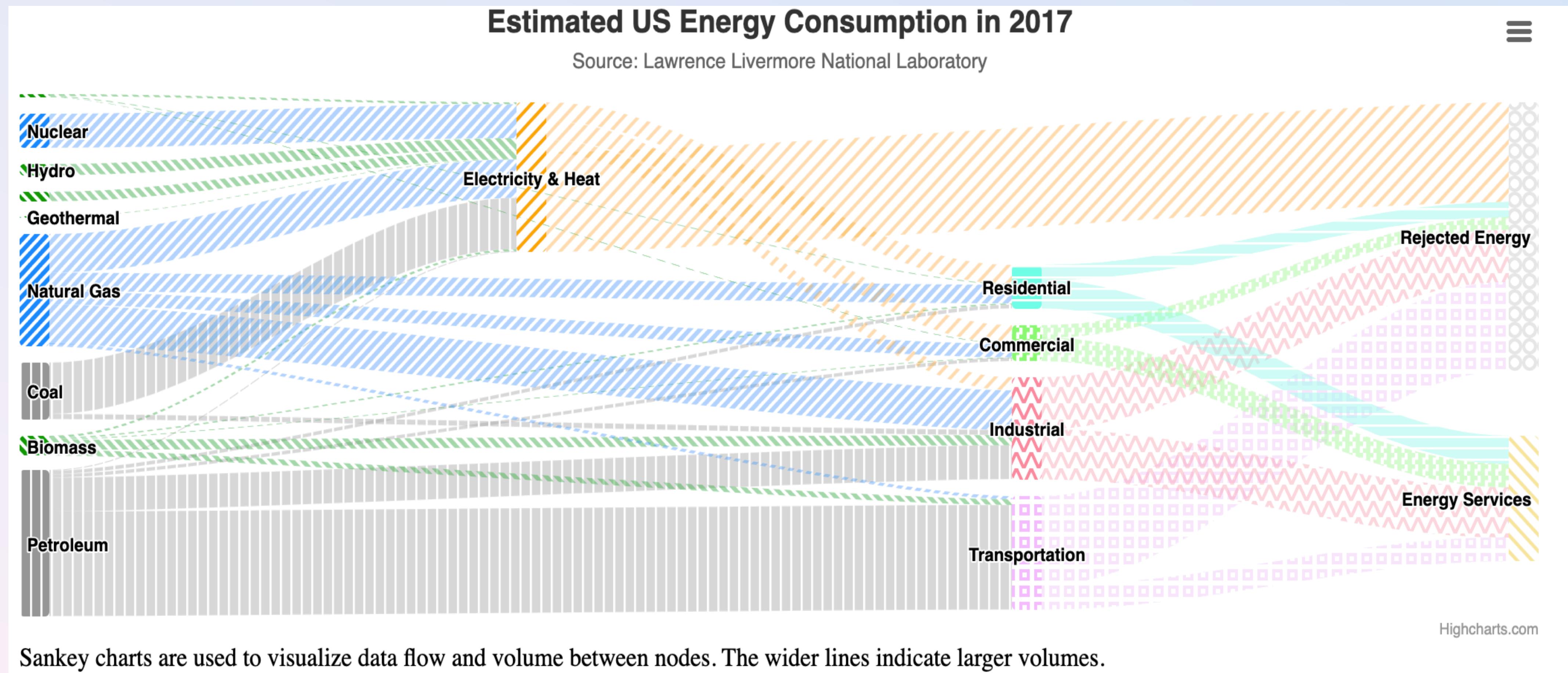
This design has  
accessibility issues too



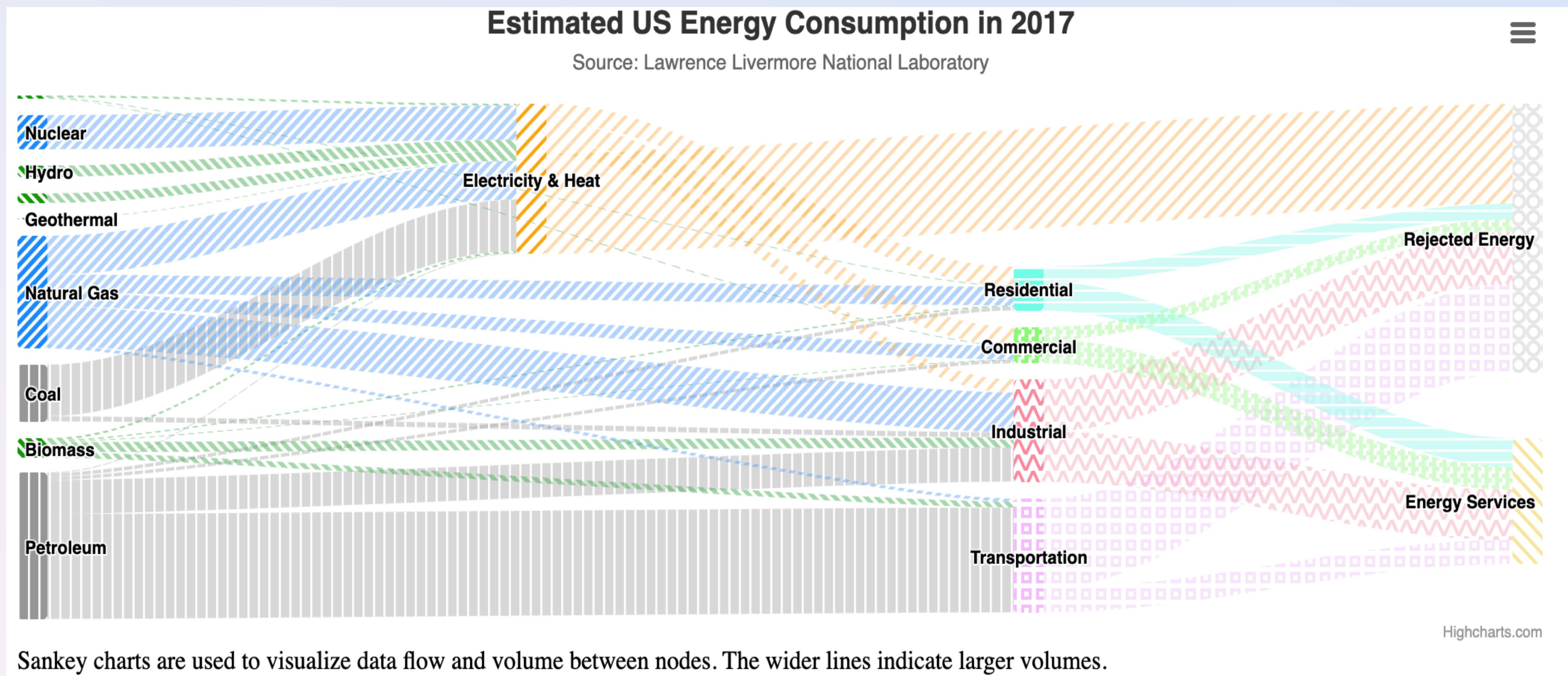
Highcharts.com

Sankey charts are used to visualize data flow and volume between nodes. Visually wider lines indicate larger volumes. This chart is showing energy consumption and types. Interacting with this chart by selecting a node or flow (such as with a click) will update the stacked bar chart below.

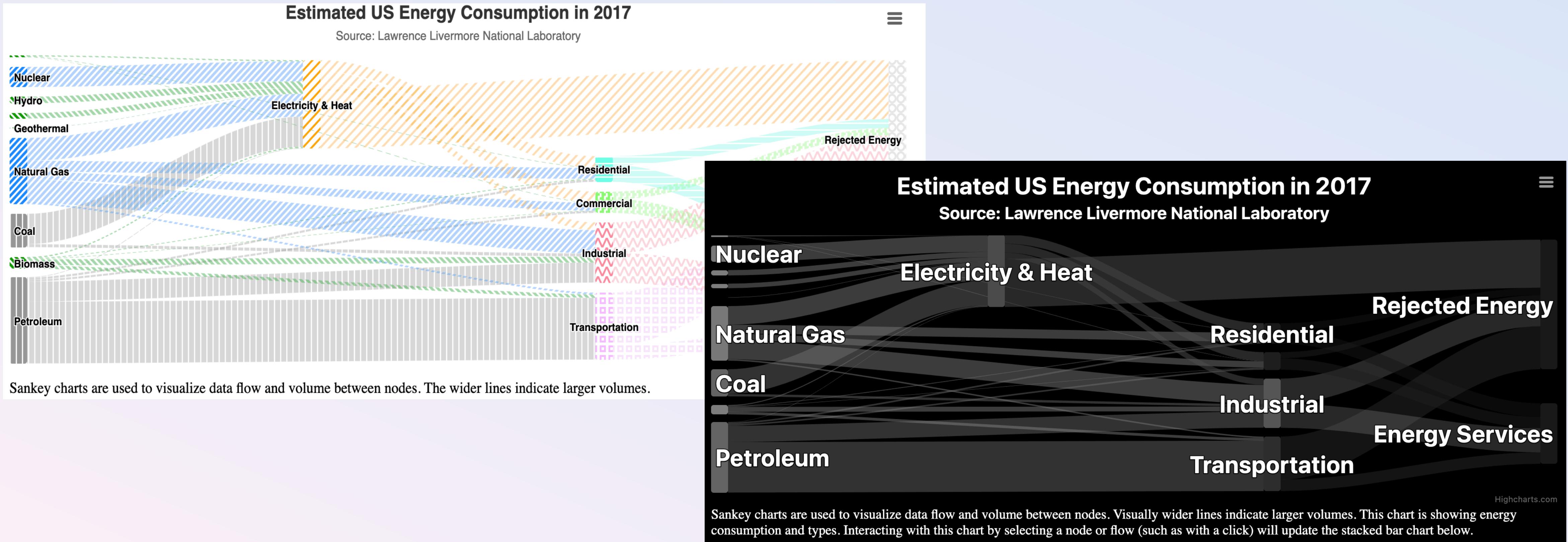
# There is no such thing as a single, perfect design



# One design cannot fit all



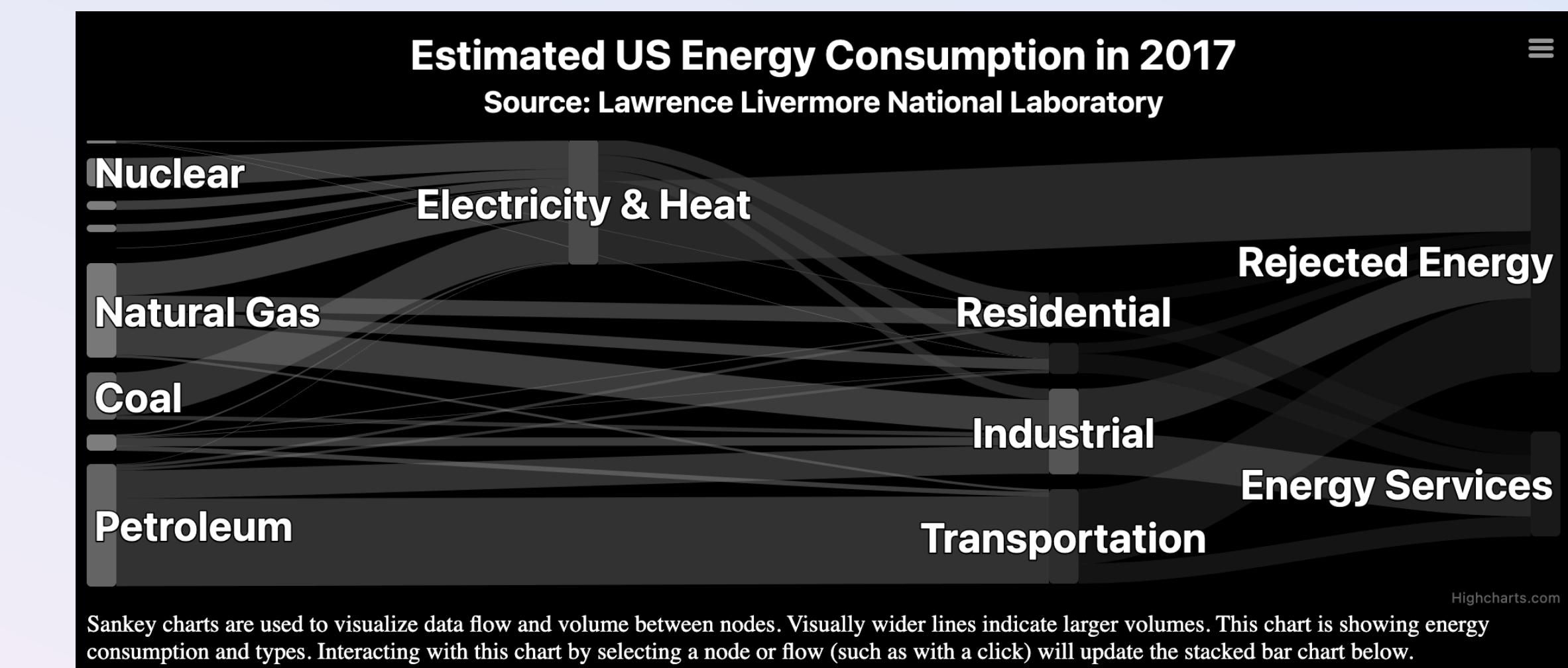
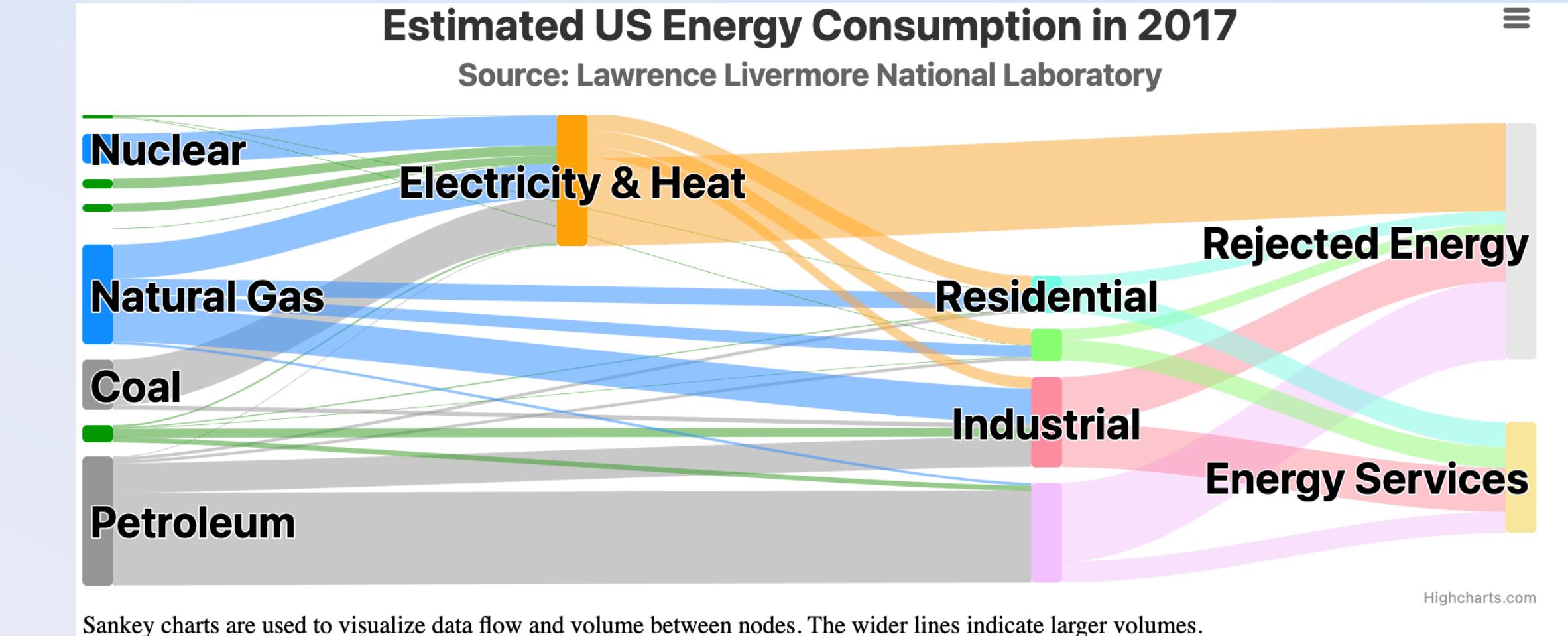
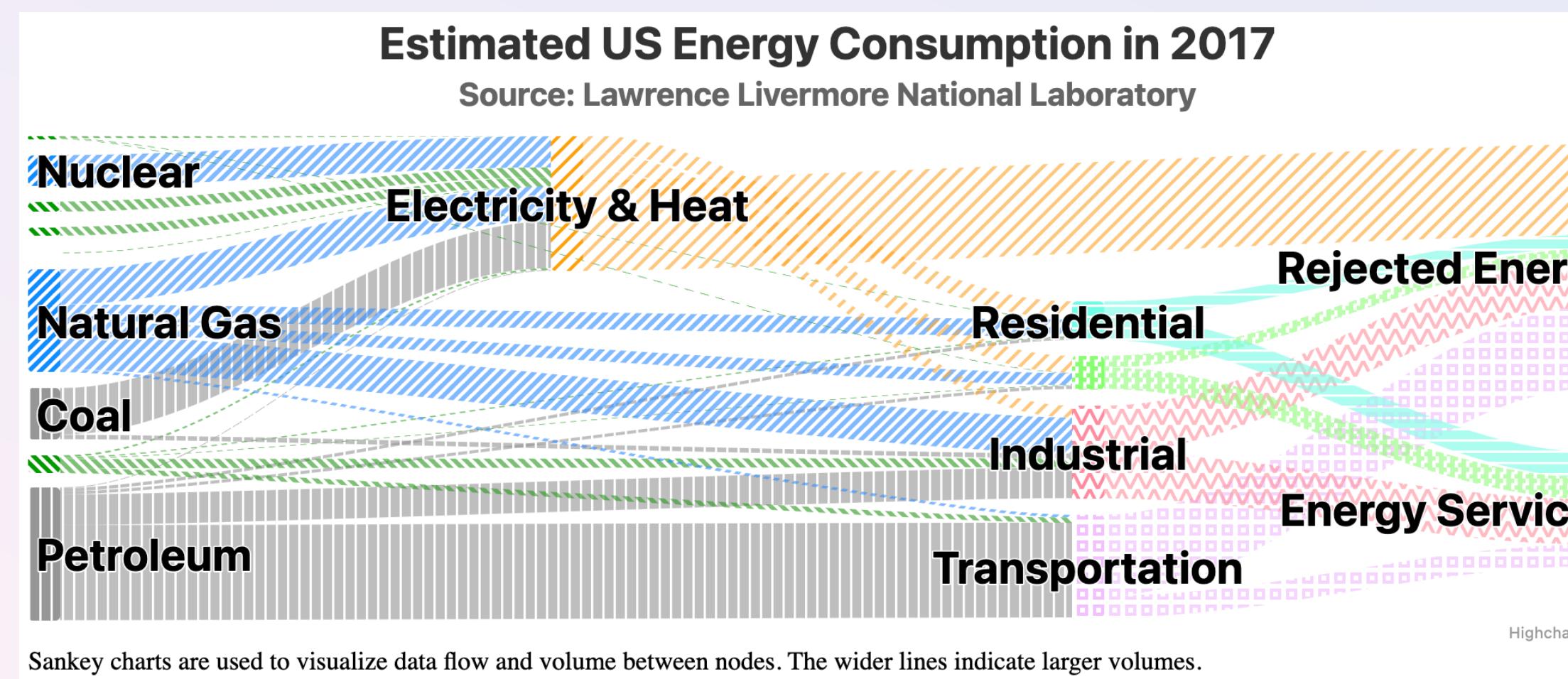
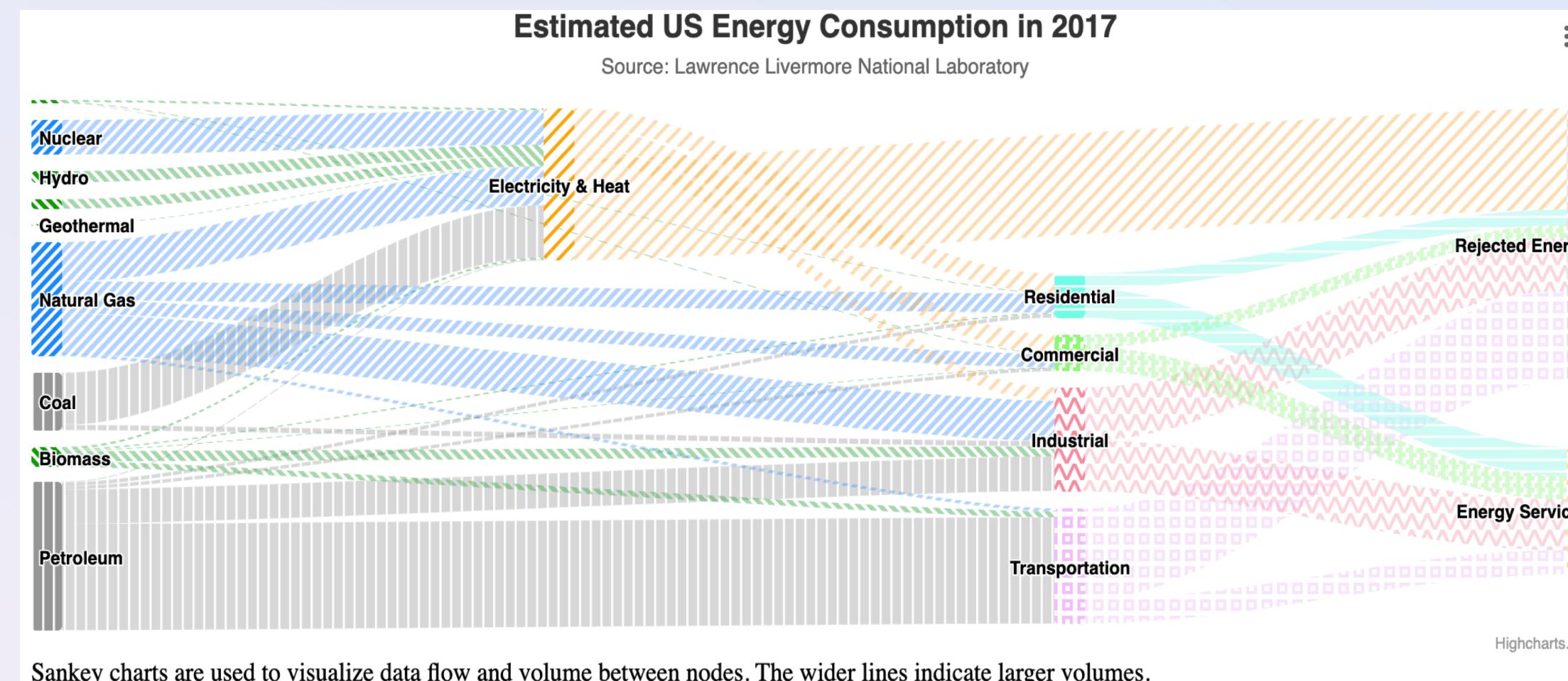
# Research problem: How do we resolve this “access friction”?



# Why should our designs be one-size-fits-all?



# What if we let users personalize?



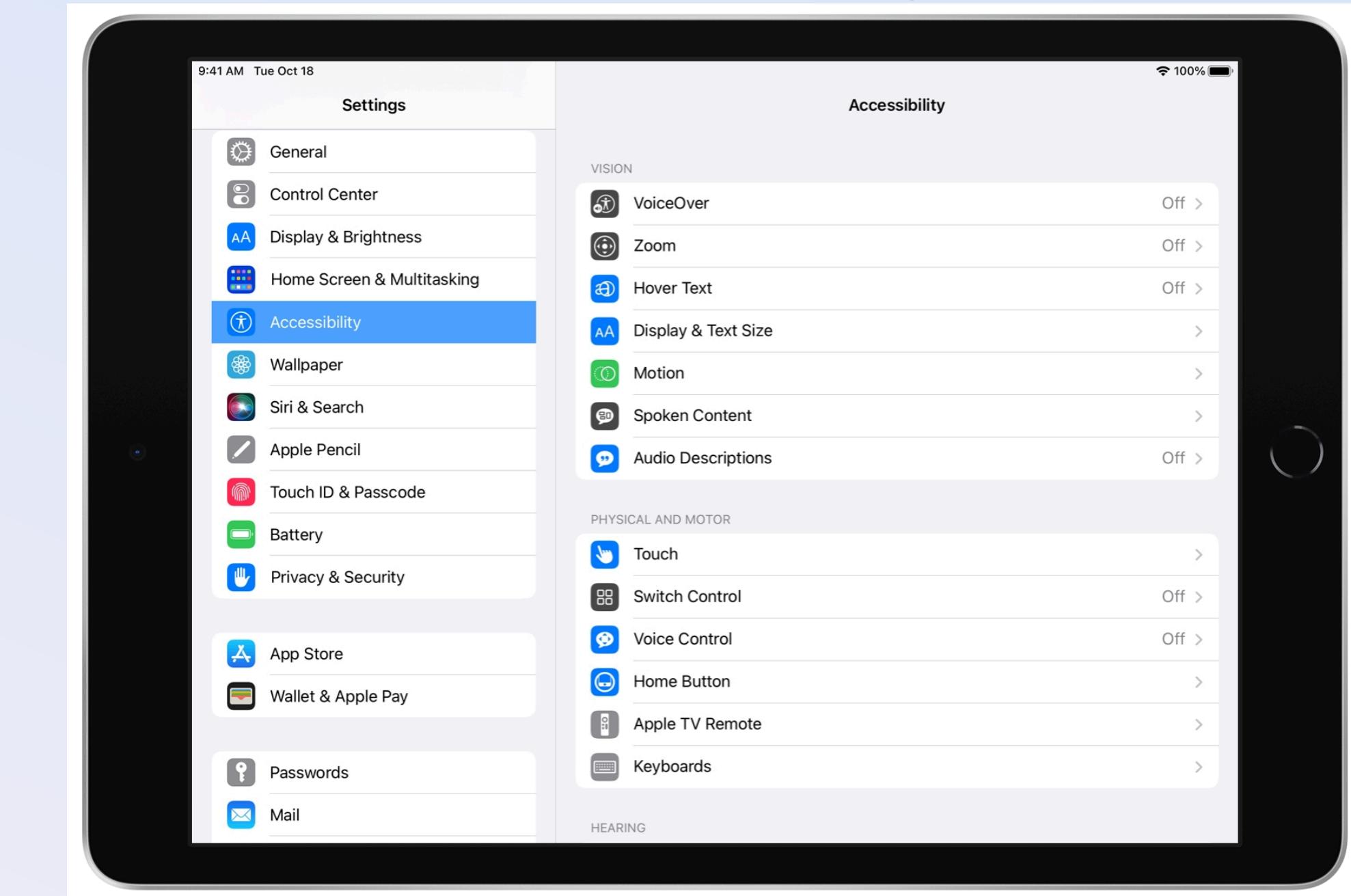
# We have been enabling personalization for years

## Video games



The Last of Us 2 has more than 60 settings

## Devices and operating systems



"Make it yours" is the motto for Apple's accessibility personalization

# We built a preferences menu!

**Preferences**

This menu provides a way to customize charts and graphs. The menu is organized into categories, and adjusting the settings at the category level will adjust all of the settings within that category. Some settings within categories also have sub-settings which will also inherit higher level settings that they belong to. If wording for a category's setting is hard to understand, try changing that setting and then navigating into the menu to see which children settings it affected.

Hide unavailable options

**Comprehension**  
 default    moderate    robust  
       

► Show more comprehension options...

**Text visuals**  
 default    minimalist    moderate    maximalist  
           

▼ Show more text visuals options...

**Font Size**  
 default    small    medium    large  
           

► Show more font size options...

**Font Weight**  
 default    100    400    700  
           

► Show more font weight options...

**Color and contrast**  
 default    minimalist    maximalist  
       

▼ Show more color and contrast options...

**Estimated US Energy Consumption in 2017**  
 Source: Lawrence Livermore National Laboratory

Sankey charts are used to visualize data flow and volume between nodes. The wider lines indicate larger volumes.

**Energy Sources**

Source	Value (Total Quads)
Geothermal	0.77
Solar	2.76
Wind	8.42
Hydro	13.96
Biomass	36.2
Nuclear	
Coal	
Natural Gas	
Petroleum	

Total Quads

**Monthly Energy Consumption**

Line chart for comparing change in data across categories. Line charts are often used to visualize change in data over time, showing important trends. Sonification will play all values selected in legend.

Play chart sonification

**What do people with disabilities want to personalize with visualizations?  
And how does personalization change how we design visualization libraries, systems, and tools?**

# We gave 9 BLV users and 4 developers some levers to pull

## Preferences

This menu provides a way to customize charts and graphs. The menu is organized into categories, and adjusting the settings at the category level will adjust all of the settings within that category. Some settings within categories also have sub-settings which will also inherit higher level settings that they belong to. If wording for a category's setting is hard to understand, try changing that setting and then navigating into the menu to see which children settings it affected.

Hide unavailable options

## Comprehension

default    moderate    robust

► Show more comprehension options...

## Text visuals

default    minimalist    moderate    maximalist

▼ Show more text visuals options...

## Font Size

default    small    medium    large

► Show more font size options...

## Font Weight

default    100    400    700

► Show more font weight options...

## Color and contrast

default    minimalist    maximalist

▼ Show more color and contrast options...

### Estimated US Energy Consumption in 2017

Source: Lawrence Livermore National Laboratory

The Sankey diagram illustrates the flow of energy in the United States in 2017. It starts with primary energy sources: Nuclear, Natural Gas, Coal, Petroleum, and Electricity & Heat. These feed into various sectors: Residential, Industrial, Energy Services, Transportation, and Rejected Energy. The width of the arrows represents the volume of energy flow between nodes.

Highcharts.com

Sankey charts are used to visualize data flow and volume between nodes. The wider lines indicate larger volumes.

### Energy Sources

A stacked bar chart showing the total energy consumption by source in quads. The sources and their contributions are:

Source	Contribution (Quads)
Geothermal	0.77
Solar	0.77
Wind	2.76
Hydro	2.76
Biomass	8.42
Nuclear	13.96
Coal	36.2
Natural Gas	
Petroleum	

Total Quads

Highcharts.com

Chart showing stacked columns for comparing quantities. Stacked charts are often used to visualize data that accumulates to a sum.

### Monthly Energy Consumption

A line chart showing monthly energy consumption across several categories. The categories and their trends are:

- Solar: Blue line with circles, decreasing from ~3.5 to ~2.5
- Nuclear: Blue line with triangles, decreasing from ~3.0 to ~2.0
- Hydro: Green line with squares, increasing from ~0.5 to ~1.5
- Geothermal: Green line with diamonds, increasing from ~0.5 to ~1.0
- Natural Gas: Blue line with crosses, increasing from ~0.5 to ~1.0
- Natural Gas: Blue line with crosses, increasing from ~0.5 to ~1.0
- Coal: Grey line with diamonds, increasing from ~0.5 to ~1.0
- Petroleum: Grey line with triangles, increasing from ~0.5 to ~1.0

Highcharts.com

Line chart for comparing change in data across categories. Line charts are often used to visualize change in data over time, showing important trends. Sonification will play all values selected in legend.

Play chart sonification

(What is accessible for one...)

“If anything has dark mode? That’s great. I wish everything used dark mode.”

Participant #4

(...might be a barrier for another.)

“Oh, I can’t use dark mode at all. I hate when websites have [dark mode] because it can be virtually impossible to use.”

Participant #7



## Malleable interfaces need guardrails

- It is possible to design harmful visualizations, so system designers should anticipate ways to help users personalize safely.

# Results

F. Elavsky, M. Vindedal, T. Gies, P. Carrington, D. Moritz, and Ø. Mousing, “Towards Softerware: Enabling personalization of interactive data representations for users with disabilities,” *Computer Graphics and Applications*, 2025.

# Results



## Malleable interfaces need guardrails

- It is possible to design harmful visualizations, so system designers should anticipate ways to help users personalize safely.



## Our ethical responsibility: Accessible defaults first

- Some users won't want to personalize or manipulate interfaces at all, so they will still rely on smart, effective defaults.

F. Elavsky, M. Vindedal, T. Gies, P. Carrington, D. Moritz, and Ø. Mousing, “Towards Softerware: Enabling personalization of interactive data representations for users with disabilities,” *Computer Graphics and Applications*, 2025.

# Results



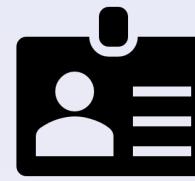
## Malleable interfaces need guardrails

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## Persistence, profiles, and "effort-to-usage" ratio

- Everything about malleable interfaces should save users time and energy. Let them save, reuse, and share their personalization.

F. Elavsky, M. Vindedal, T. Gies, P. Carrington, D. Moritz, and Ø. Mousing, “Towards Softerware: Enabling personalization of interactive data representations for users with disabilities,” *Computer Graphics and Applications*, 2025.

# Results



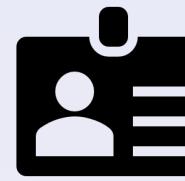
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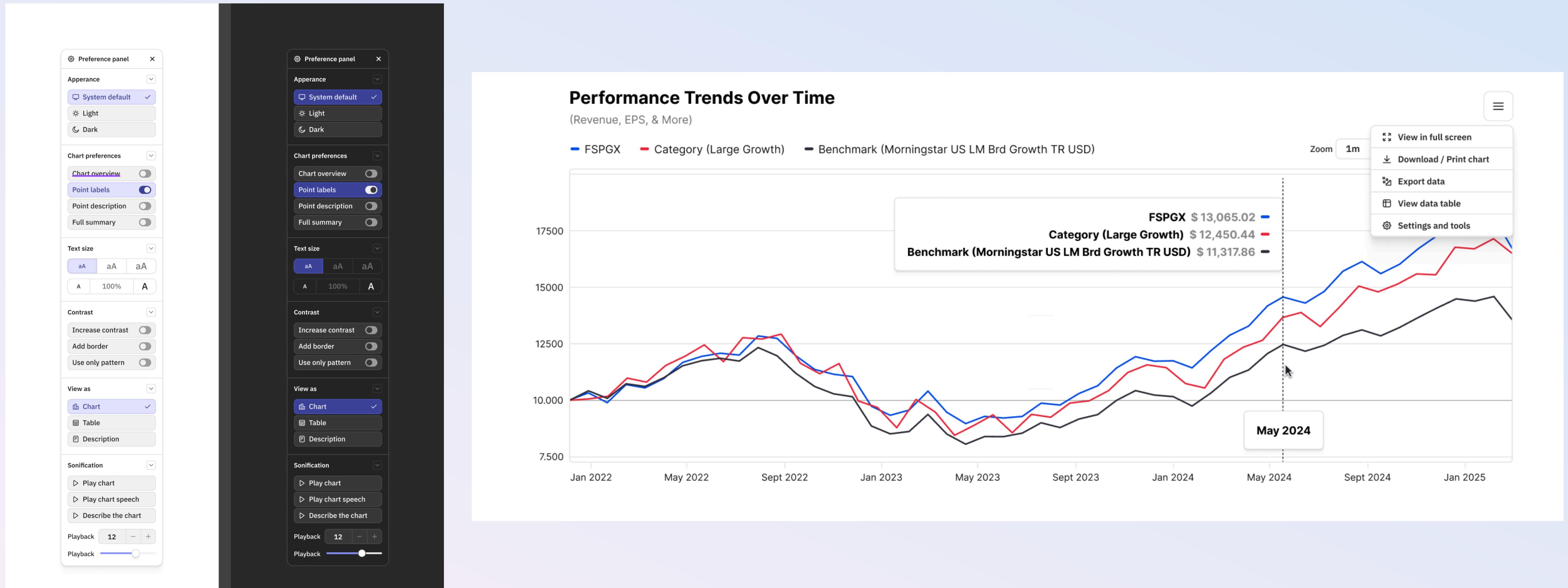


## Interoperability: everyone's job

- One visualization library isn't enough: the way users personalize a chart in one place should carry over to other platforms and tools.

F. Elavsky, M. Vindedal, T. Gies, P. Carrington, D. Moritz, and Ø. Mousing, “Towards Softerware: Enabling personalization of interactive data representations for users with disabilities,” *Computer Graphics and Applications*, 2025.

# Deployment in Highcharts, >6m downloads/month



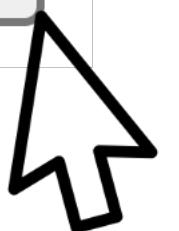
F. Elavsky, M. Vindedal, T. Gies, P. Carrington, D. Moritz, and Ø. Mousing, “Towards Softerware: Enabling personalization of interactive data representations for users with disabilities,” *Computer Graphics and Applications*, 2025.

# Section 2: Low-level building blocks

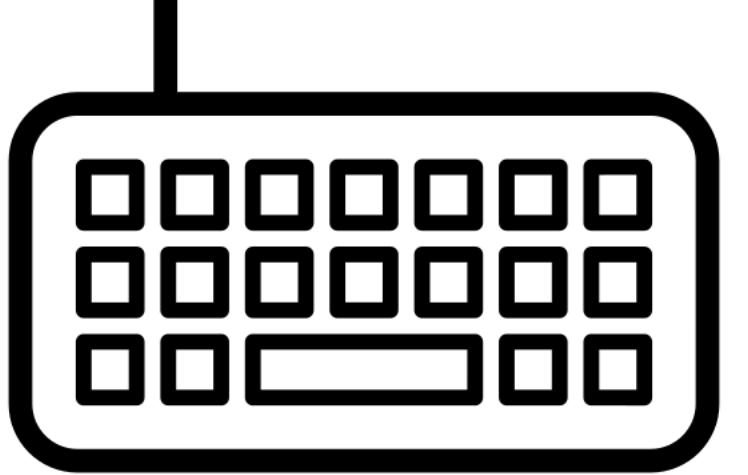
Research problem: How can we enable people to *build* accessible visualizations?

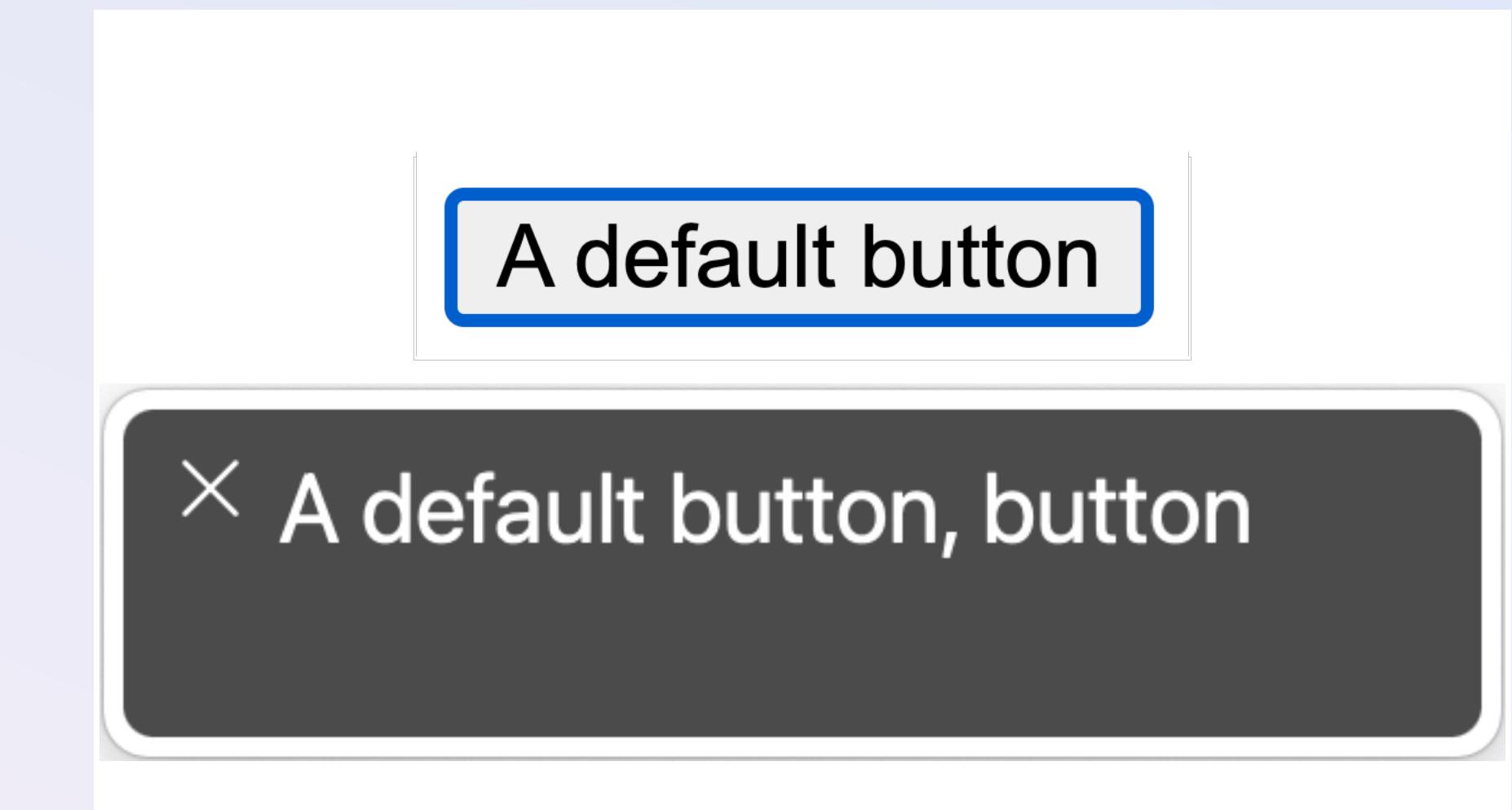
A default button

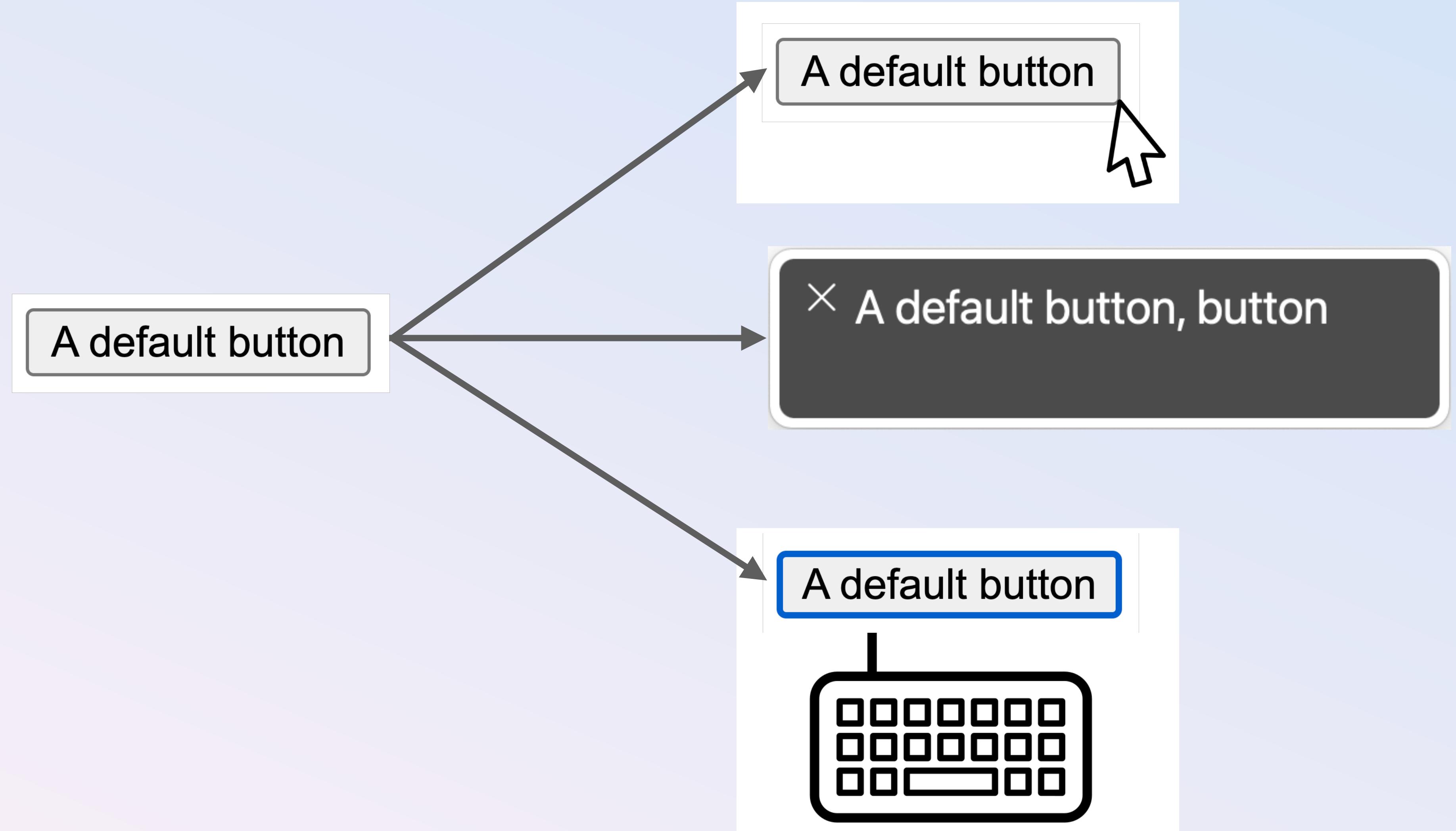
A default button

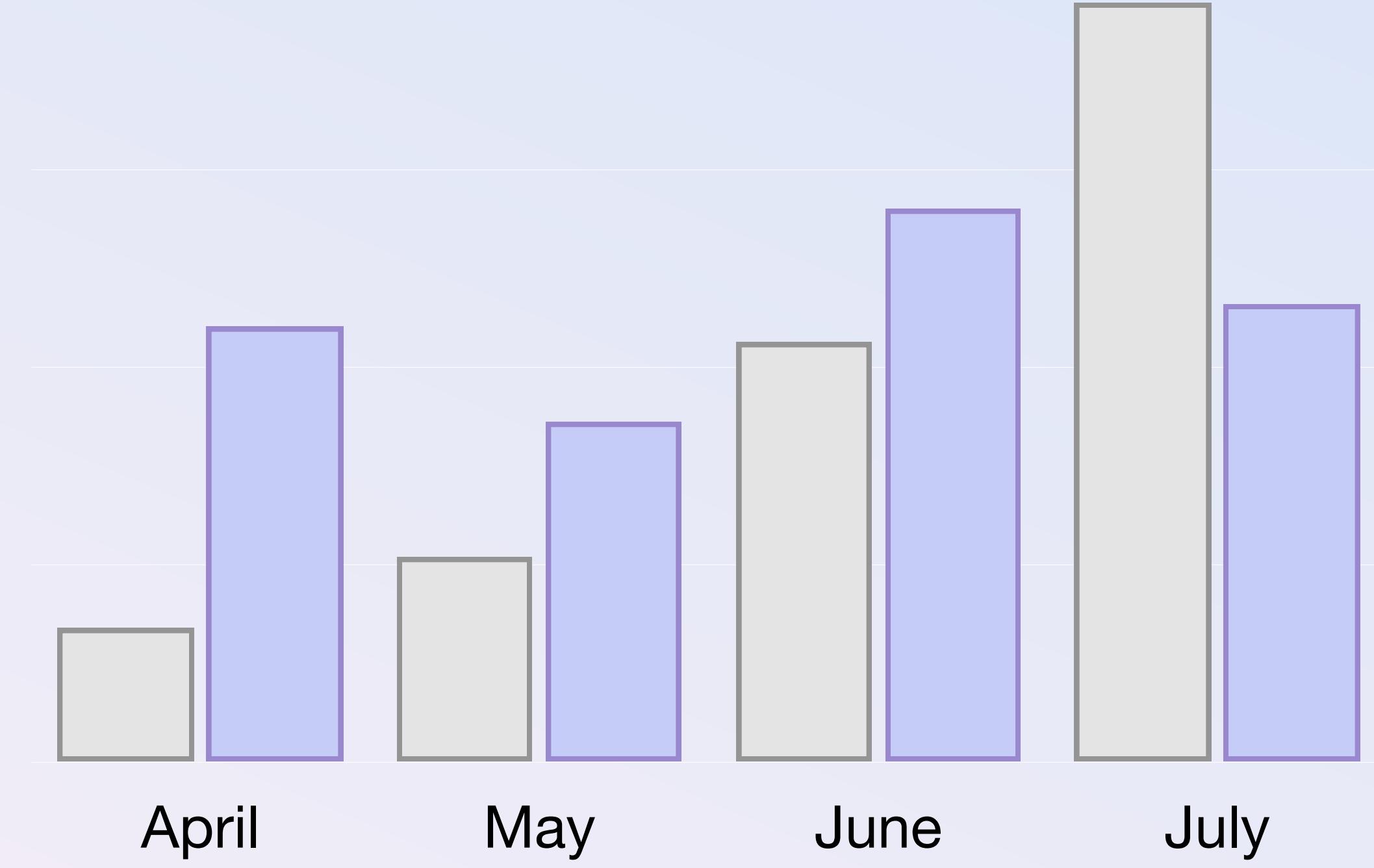


A default button





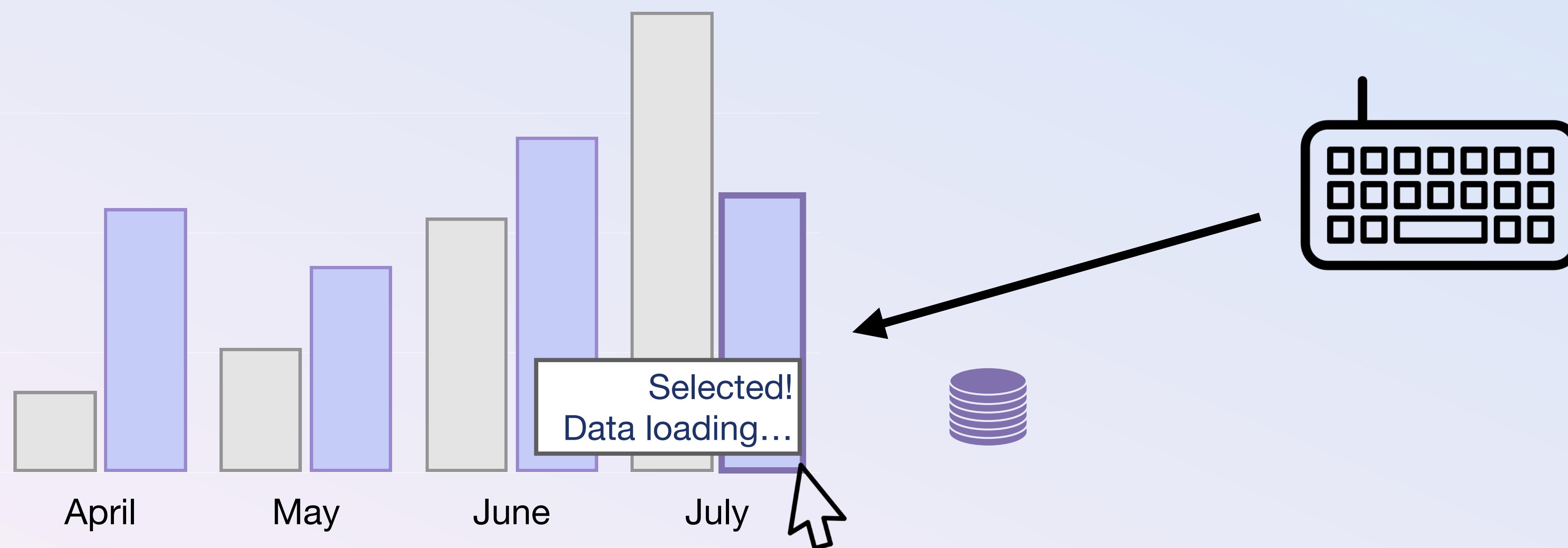




# The mouse rules all



# A keyboard should be able to do everything a mouse can



WAI. “Understanding success criterion 2.1.1: keyboard.” *WCAG standard*, W3C, 2017.

# Discrete and direct navigation face more barriers

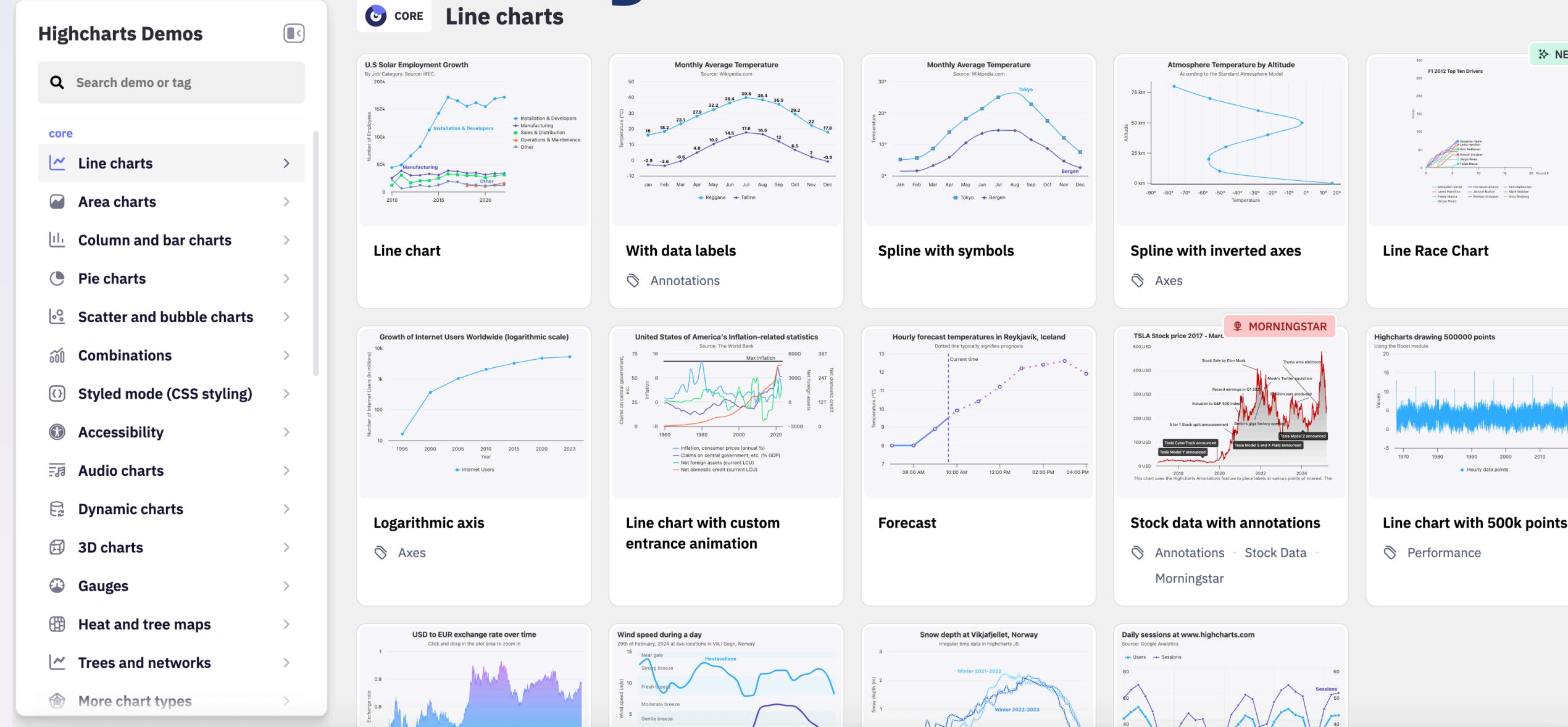


A person in a wheelchair operating an old computer using a desk-mounted sip and puff device called the POSSUM.

Image credit: [Wikipedia](#), Public Domain, 1960. Photographer: Possum Ltd.

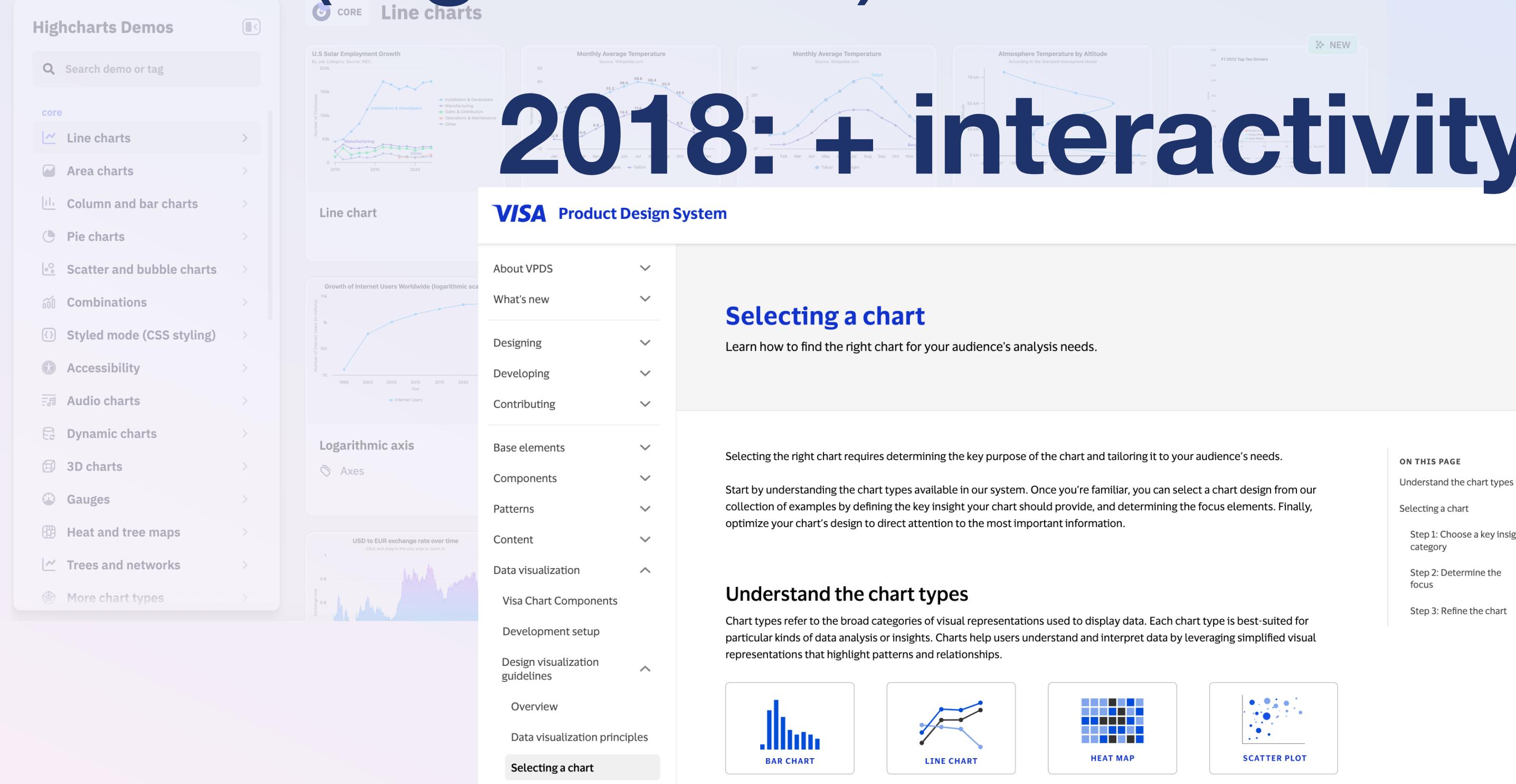
# Rich navigation (a short history)

## 2015: “beyond the table” (highcharts)



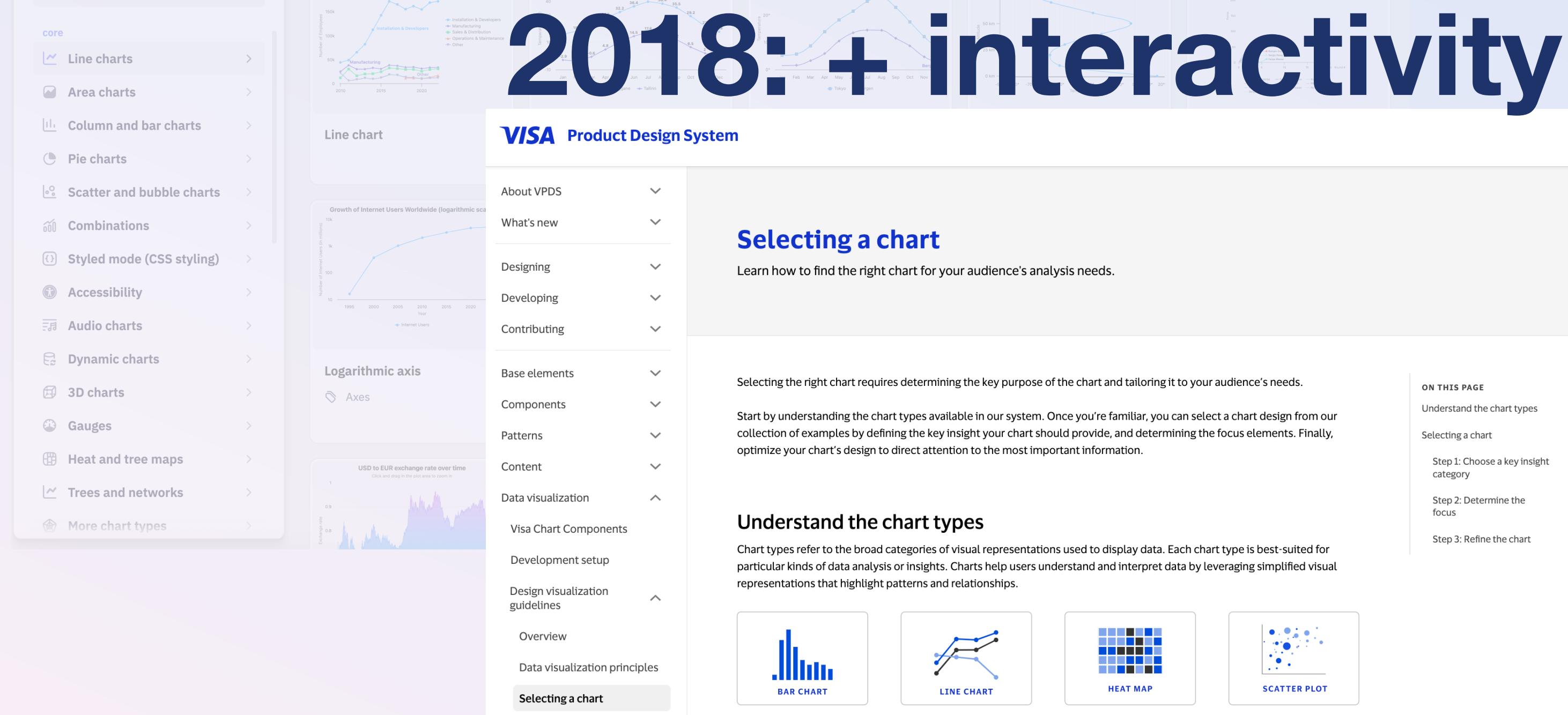
# Rich navigation (a short history)

## 2015 (highcharts)



The screenshot shows the Highcharts Demos website. On the left is a sidebar with a search bar and a list of chart types: core (Line charts, Area charts, Column and bar charts, Pie charts, Scatter and bubble charts, Combinations, Styled mode (CSS styling), Accessibility, Audio charts, Dynamic charts, 3D charts, Gauges, Heat and tree maps, Trees and networks, More chart types). The main area displays several chart examples under the heading "CORE Line charts". These include a line chart for "U.S Solar Employment Growth", a line chart for "Monthly Average Temperature" (with multiple series like Manufacturing & Distribution, Retail & Trade Services, Operations & Maintenance, Other), a line chart for "Atmosphere Temperature by Altitude", and a scatter plot for "F1 2012 Top Ten Drivers".

2018: + interactivity (visa charts)

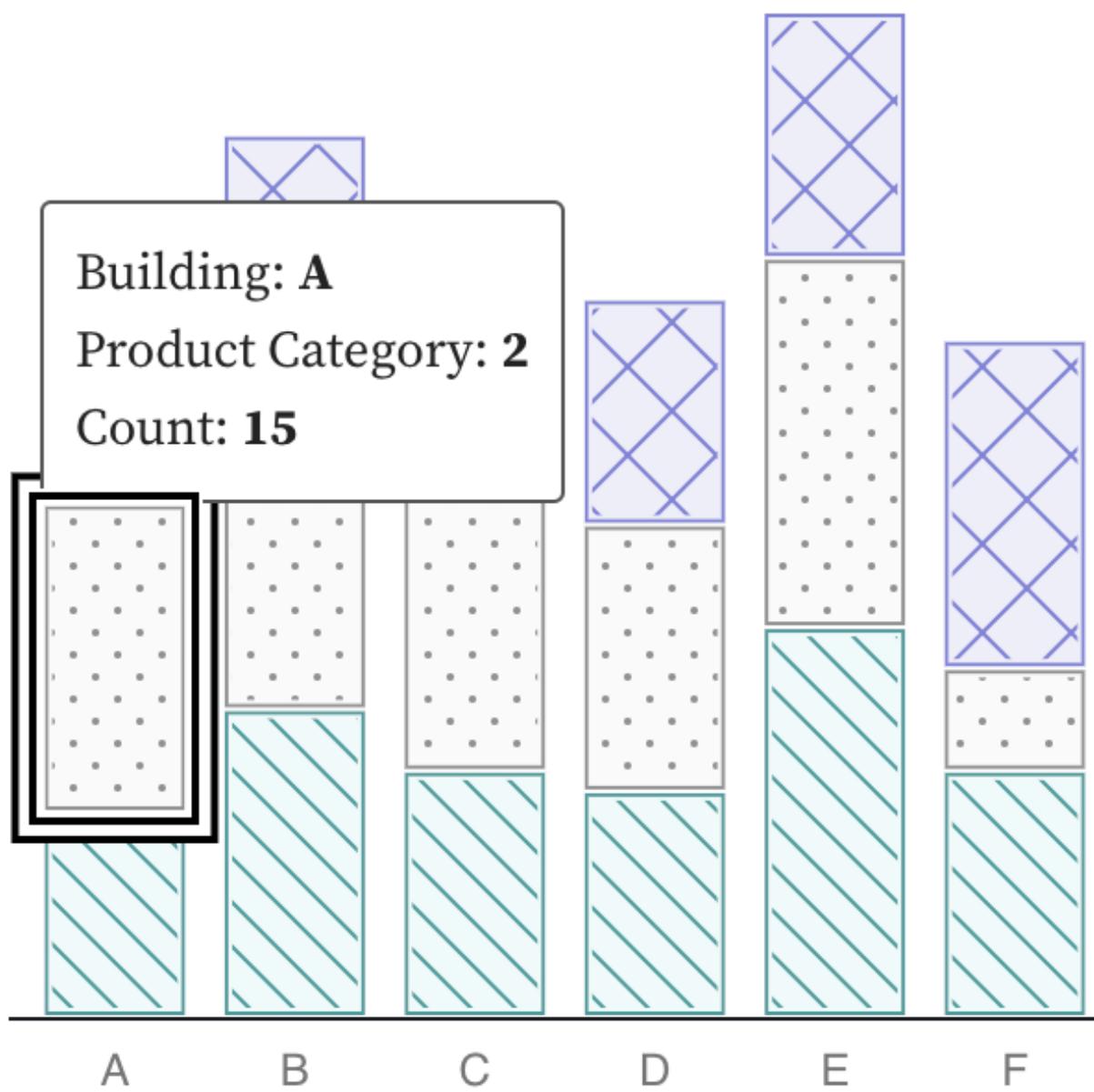


The screenshot shows the VISA Product Design System's "Selecting a chart" page. At the top is a navigation bar with links for "About VPDS", "What's new", "Designing", "Developing", "Contributing", "Logarithmic axis", "Axes", "Components", "Patterns", "Content", "Data visualization", "Visa Chart Components", "Development setup", "Design visualization guidelines", "Overview", "Data visualization principles", and "Selecting a chart". The main content area has a heading "Selecting a chart" with the sub-instruction "Learn how to find the right chart for your audience's analysis needs.". Below this is a section titled "Understand the chart types" with the sub-instruction "Selecting the right chart requires determining the key purpose of the chart and tailoring it to your audience's needs." It also includes a "Start by understanding the chart types available in our system. Once you're familiar, you can select a chart design from our collection of examples by defining the key insight your chart should provide, and determining the focus elements. Finally, optimize your chart's design to direct attention to the most important information." To the right is a sidebar titled "ON THIS PAGE" with links to "Understand the chart types", "Selecting a chart", "Step 1: Choose a key insight category", "Step 2: Determine the focus", and "Step 3: Refine the chart". At the bottom are four icons: BAR CHART, LINE CHART, HEAT MAP, and SCATTER PLOT.

# Alt text should communicate operability

Source: Visa Chart Components, Frank Elavsky (2017-2019)

1 2 3

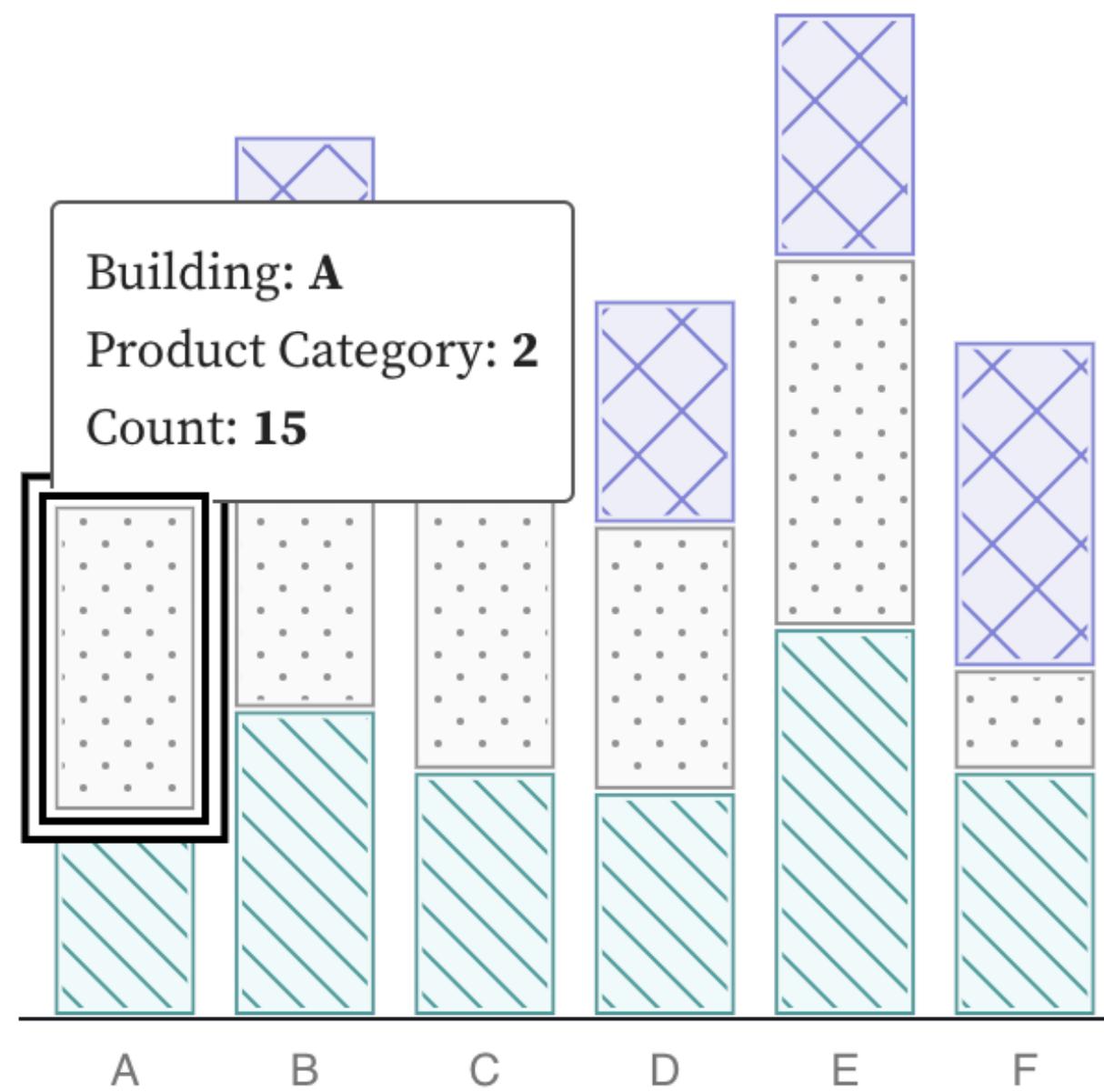


✖ Building A. Product Category 2.  
Count 15. Bar 2 of 3. Image.

# Semantics matter

Source: Visa Chart Components, Frank Elavsky (2017-2019)

1 2 3



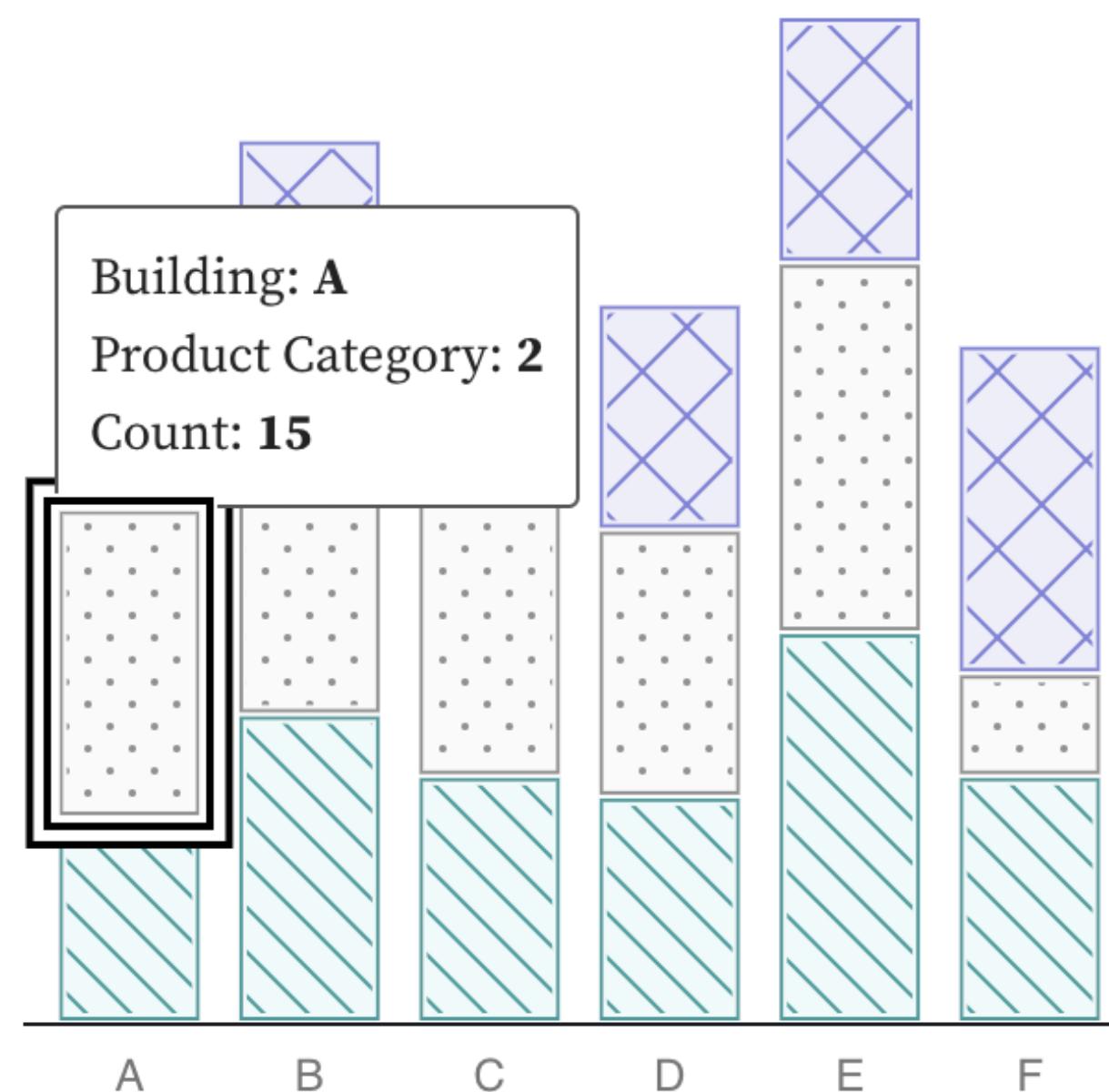
× Building A. Product Category 2.  
Count 15. Bar 2 of 3. Image.

“Image” doesn’t signal interactivity!

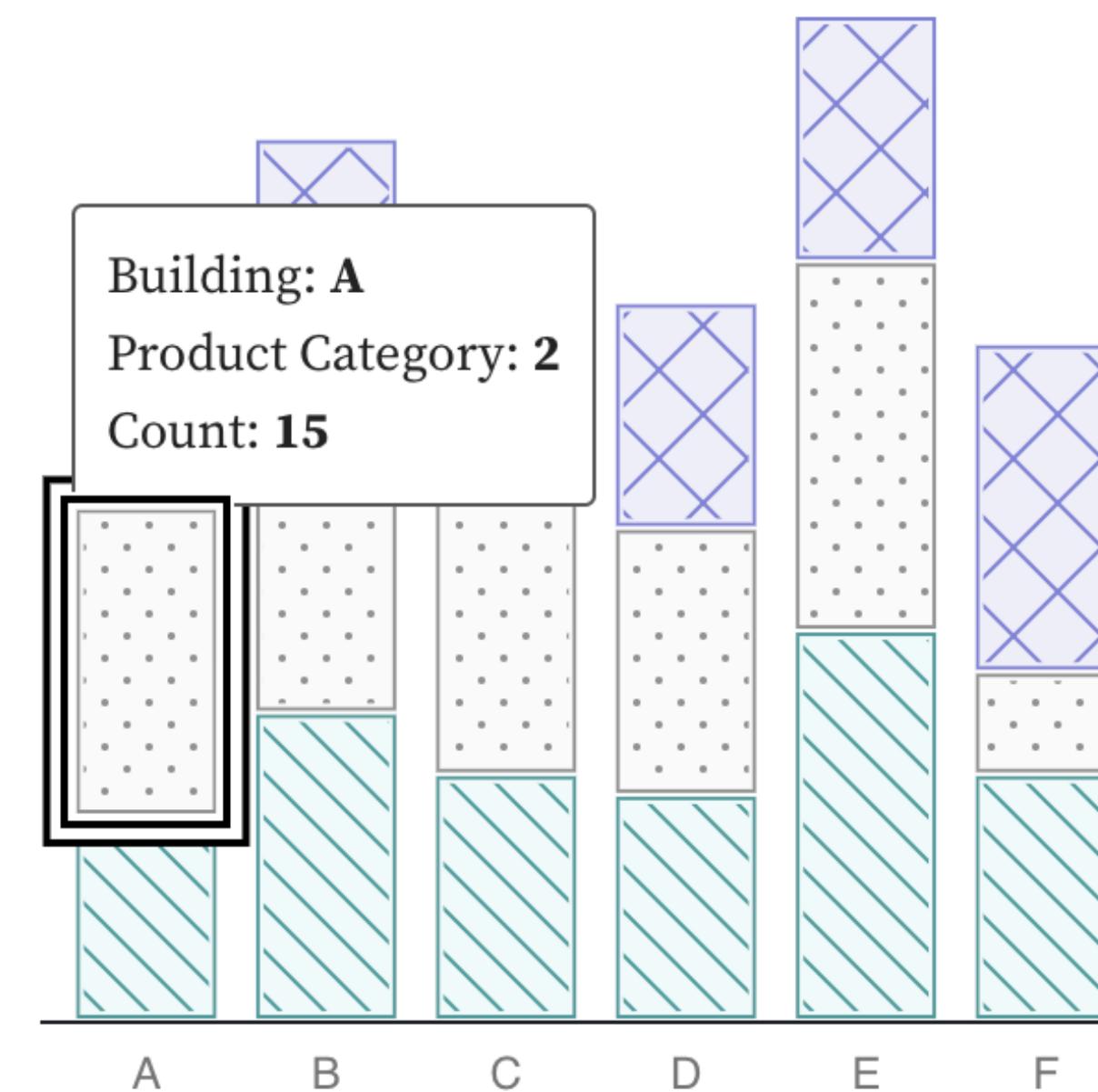
# ARIA semantics are standardized

Source: Visa Chart Components, Frank Elavsky (2017-2019)

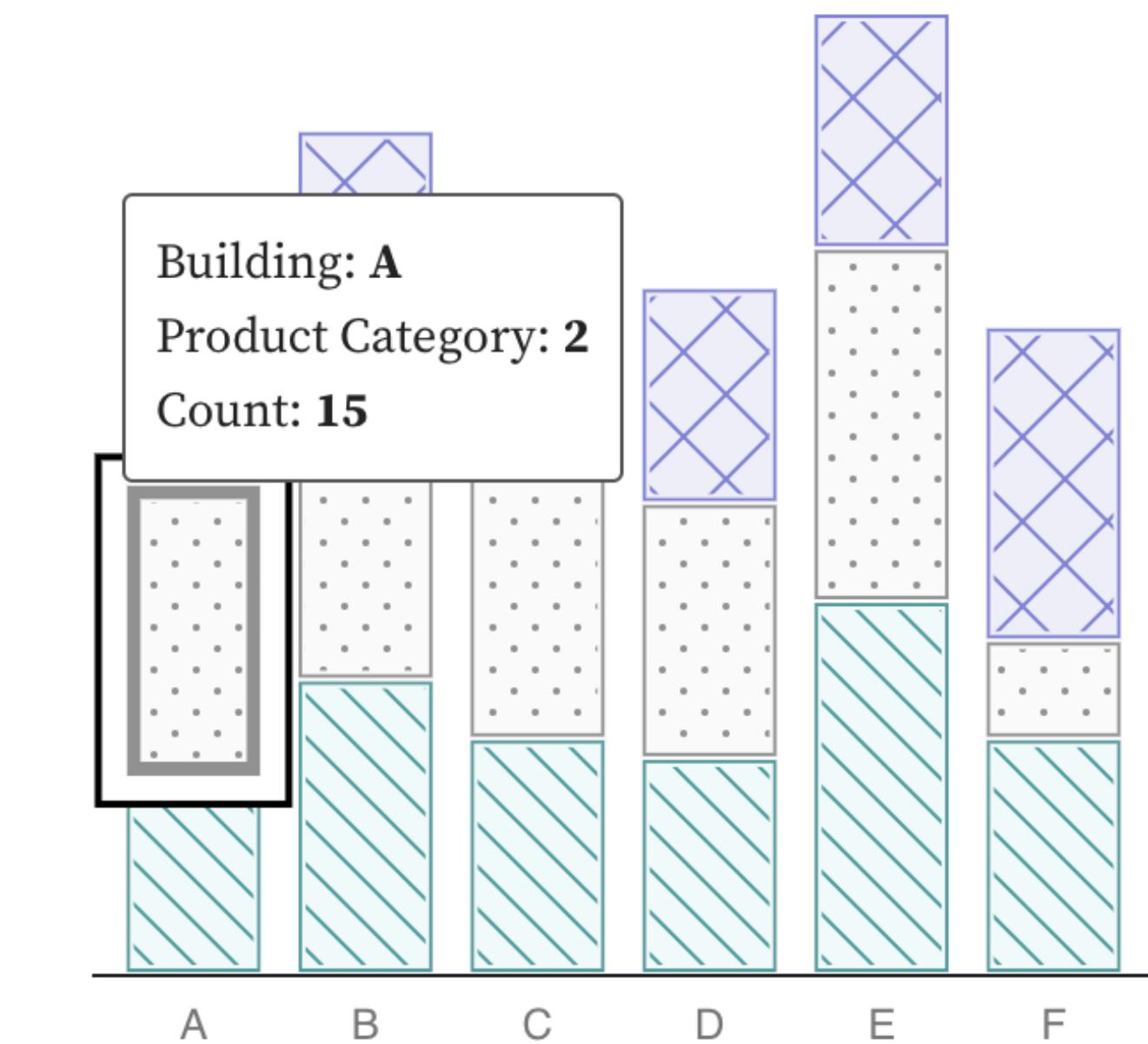
1 2 3



1 2 3



1 2 3



× Building A. Product Category 2.  
Count 15. Bar 2 of 3. Image.

× Building A. Product Category  
2. Count 15. Bar 2 of 3., toggle  
button

× selected, Building A. Product  
Category 2. Count 15. Bar 2 of  
3., toggle button

# Rich navigation (a short history)

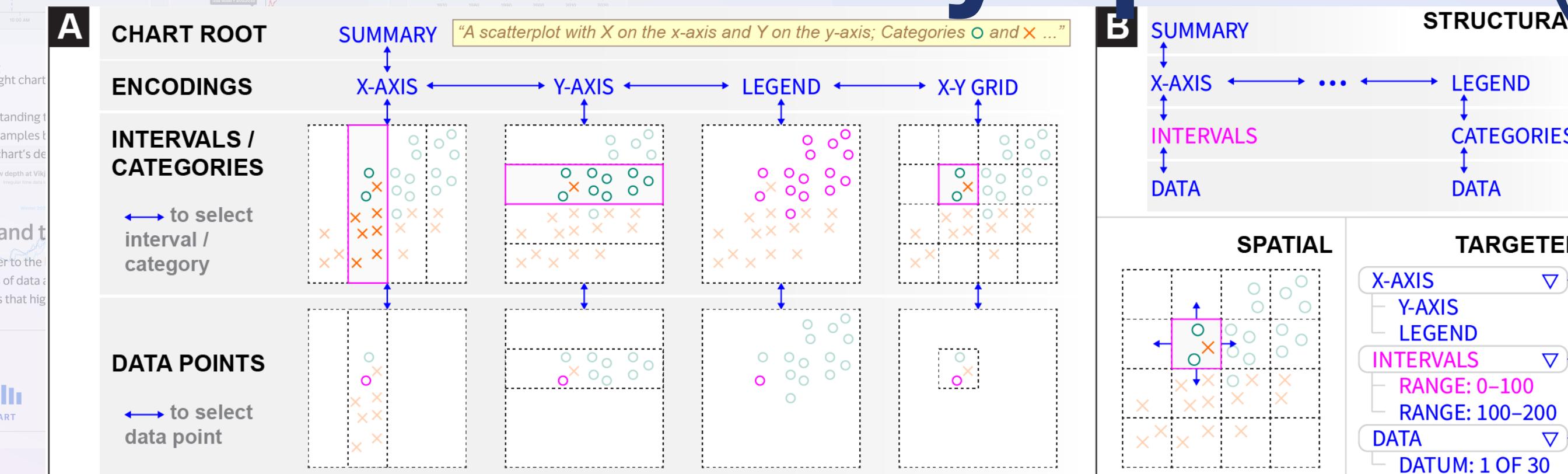
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## 2018 (visa charts)

## 2022: not library specific (olli)



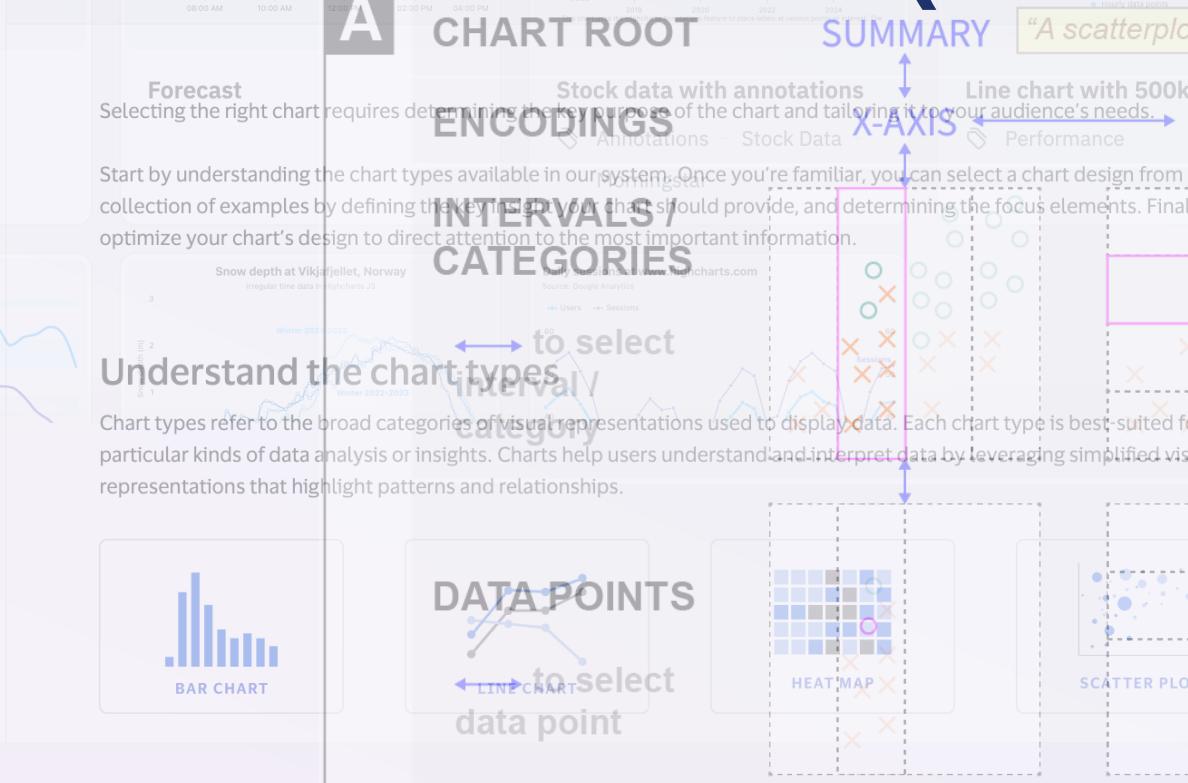
# Rich navigation (a short history)

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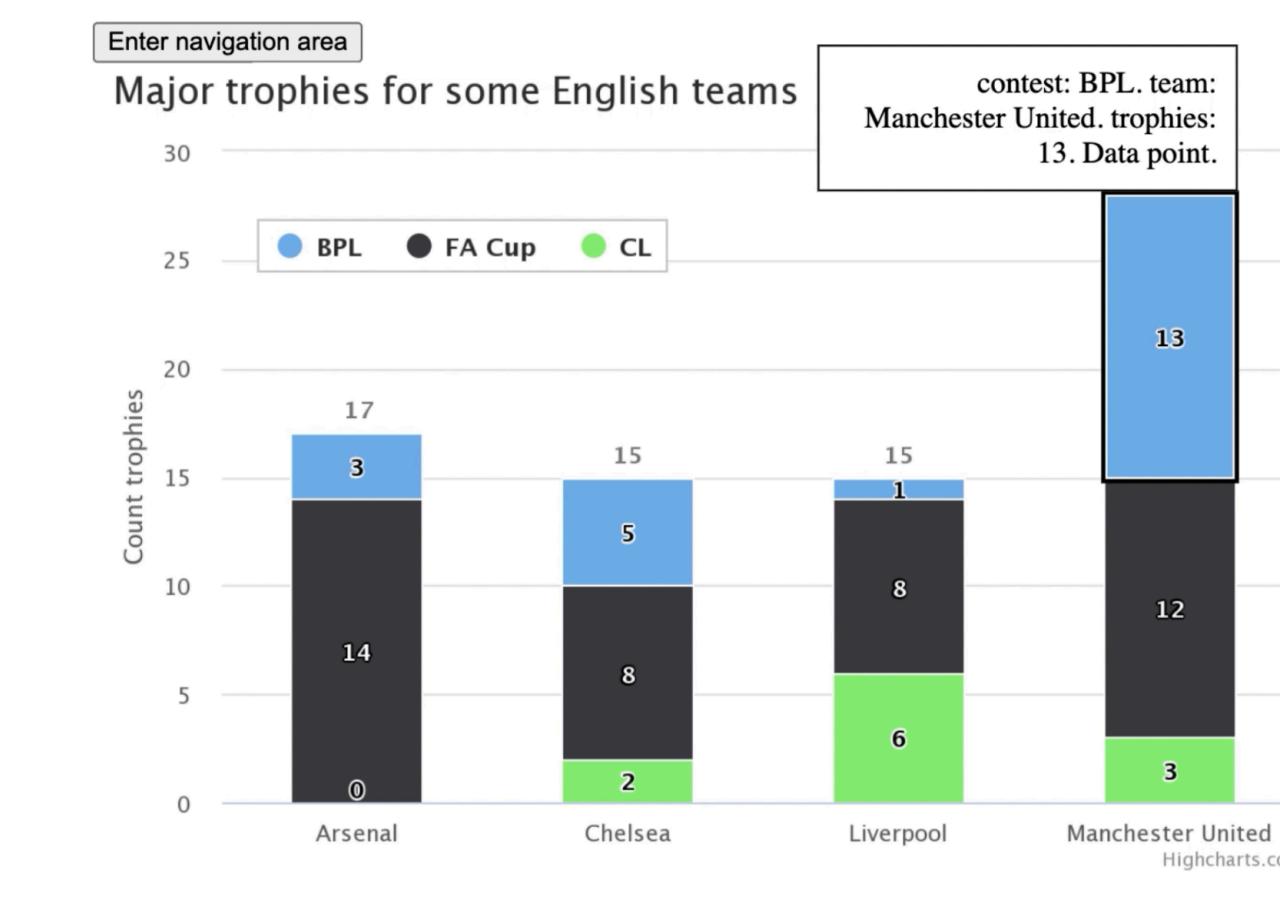


## 2018 (visa charts)

## 2022 (olli)



## 2023 (data navigator)



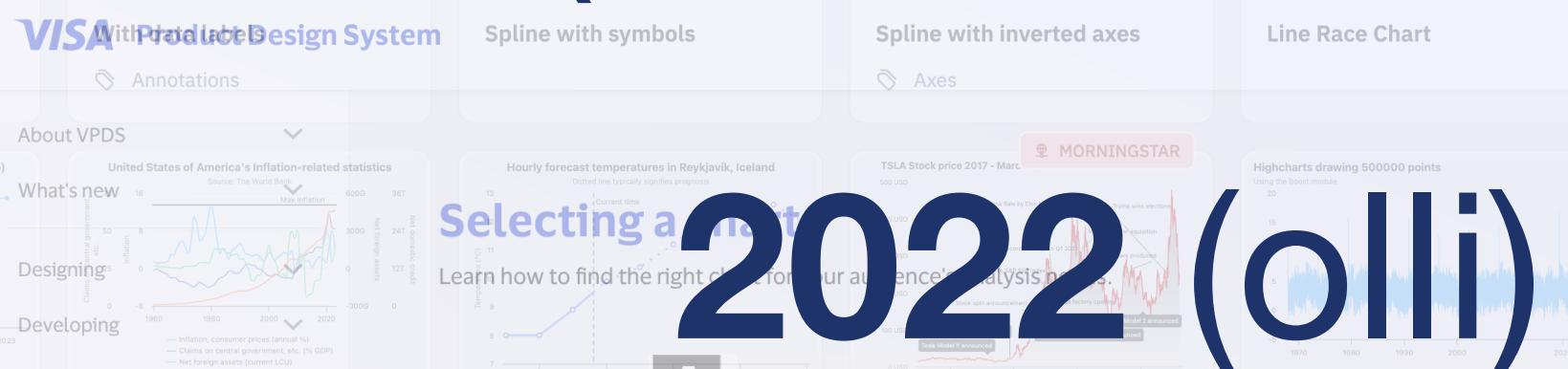
F. Elavsky, L. Nadolskis, and D. Moritz, “*Data Navigator: An Accessibility-Centered Data Navigation Toolkit*,” *IEEE Transactions on Visualization and Computer Graphics*, 2023.

# Rich navigation (a short history)

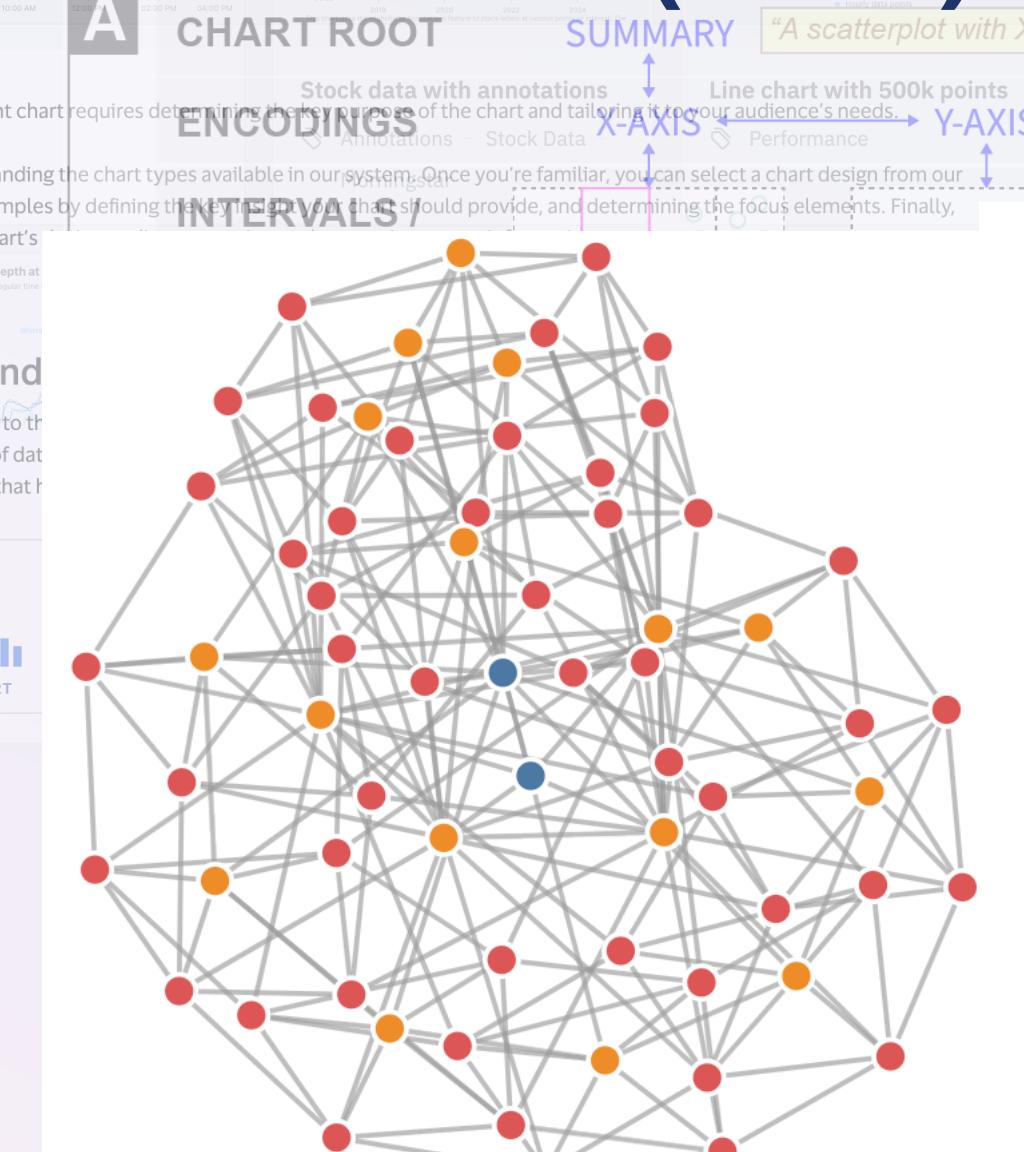
## 2015 (highcharts)



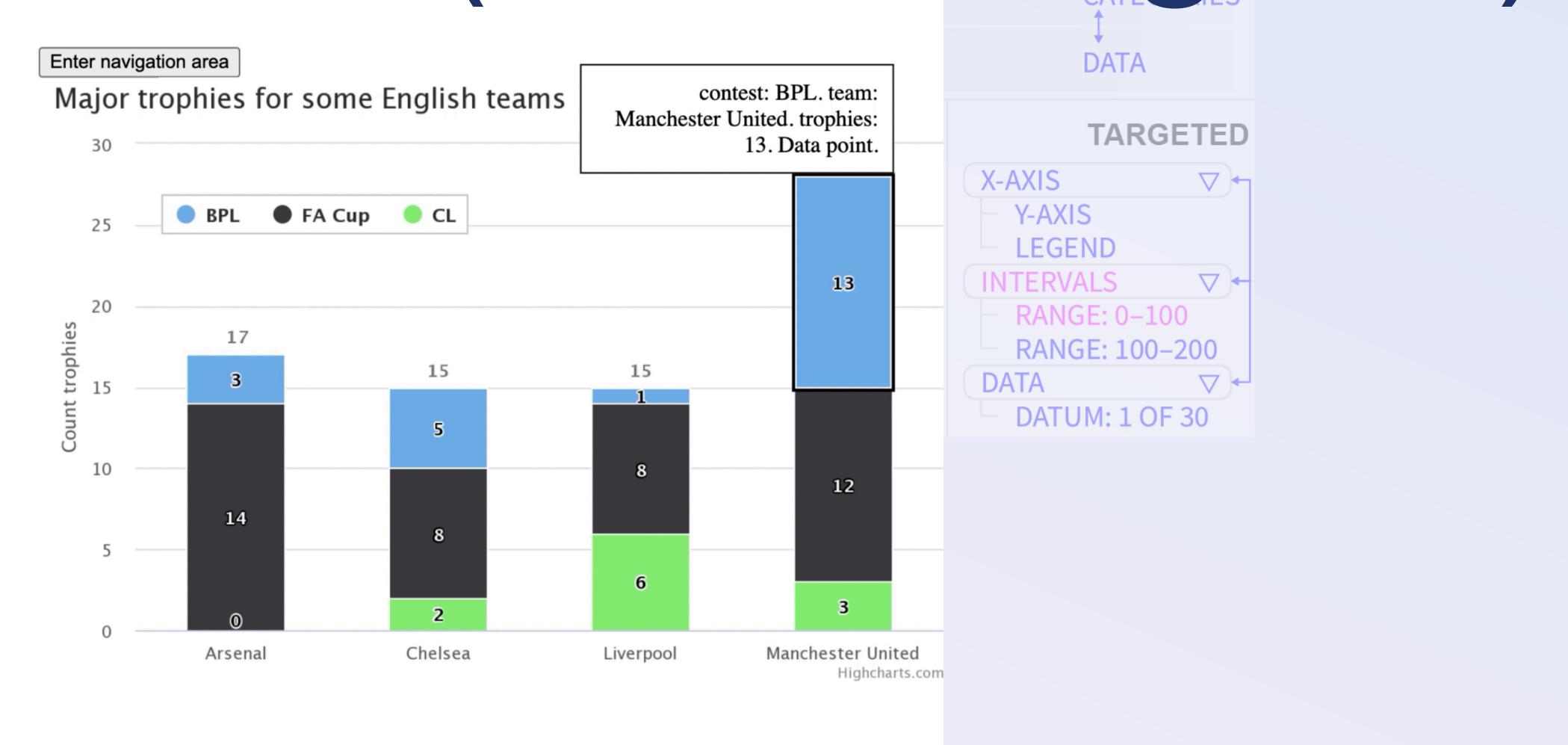
## 2018 (visa charts)



## 2022 (olli)



## 2023 (data navigator)



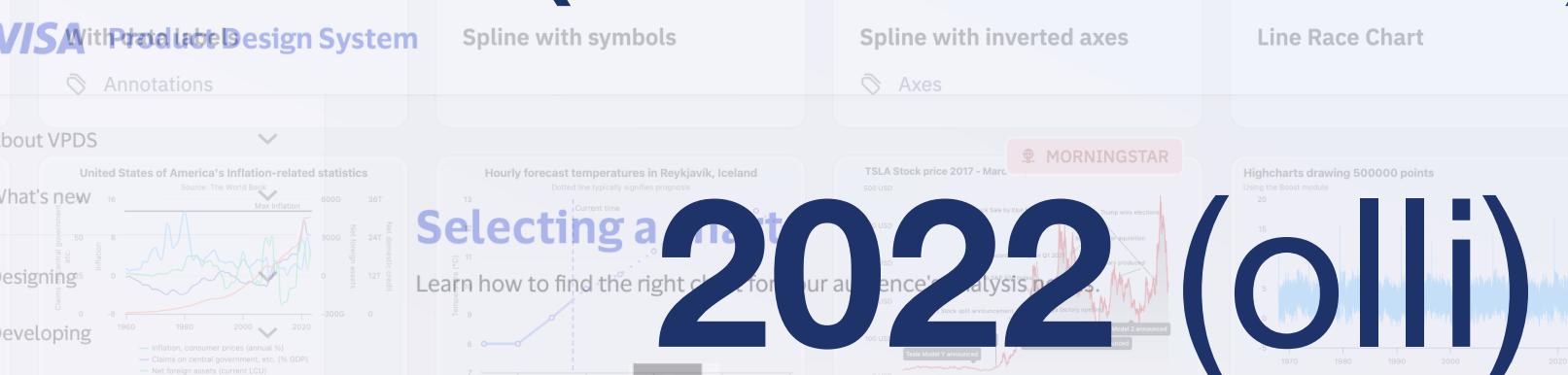
F. Elavsky, L. Nadolskis, and D. Moritz, “*Data Navigator: An Accessibility-Centered Data Navigation Toolkit*,” *IEEE Transactions on Visualization and Computer Graphics*, 2023.

# Rich navigation (a short history)

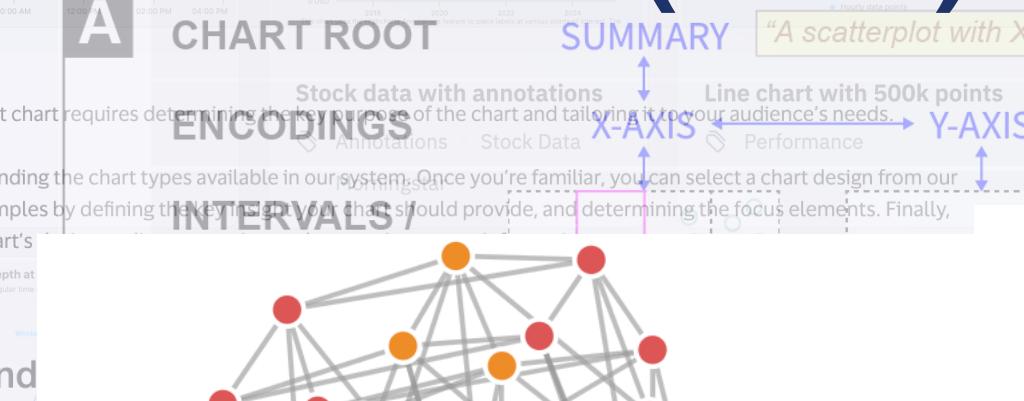
## 2015 (highcharts)



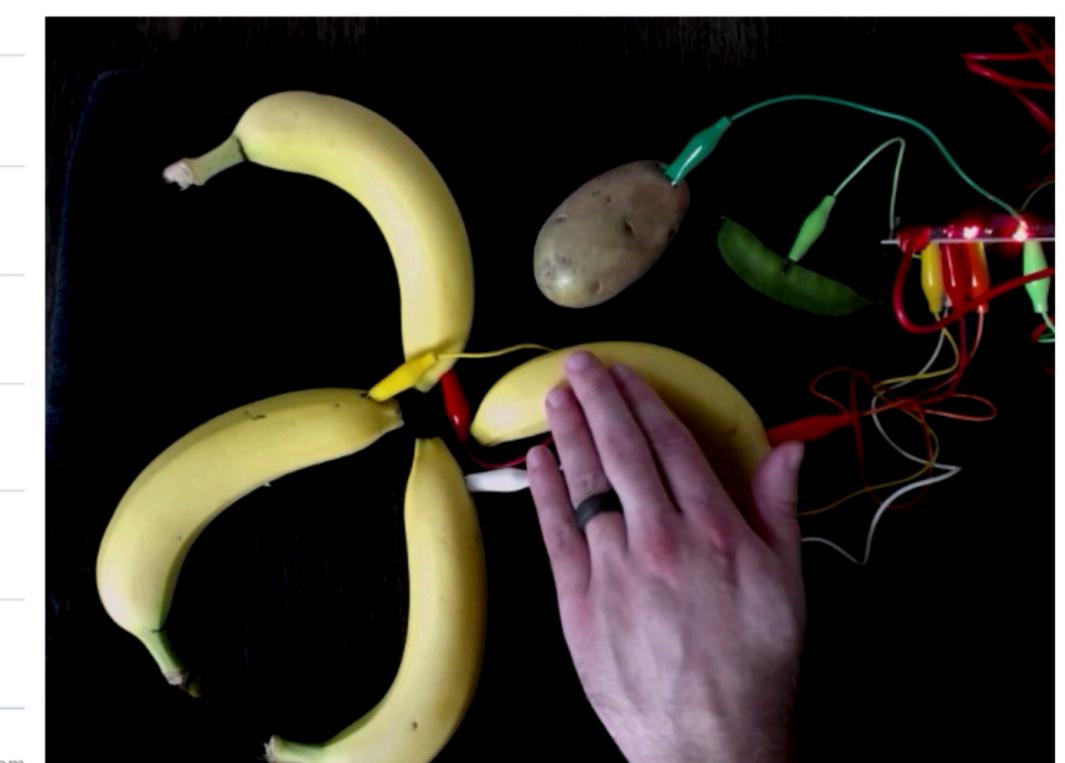
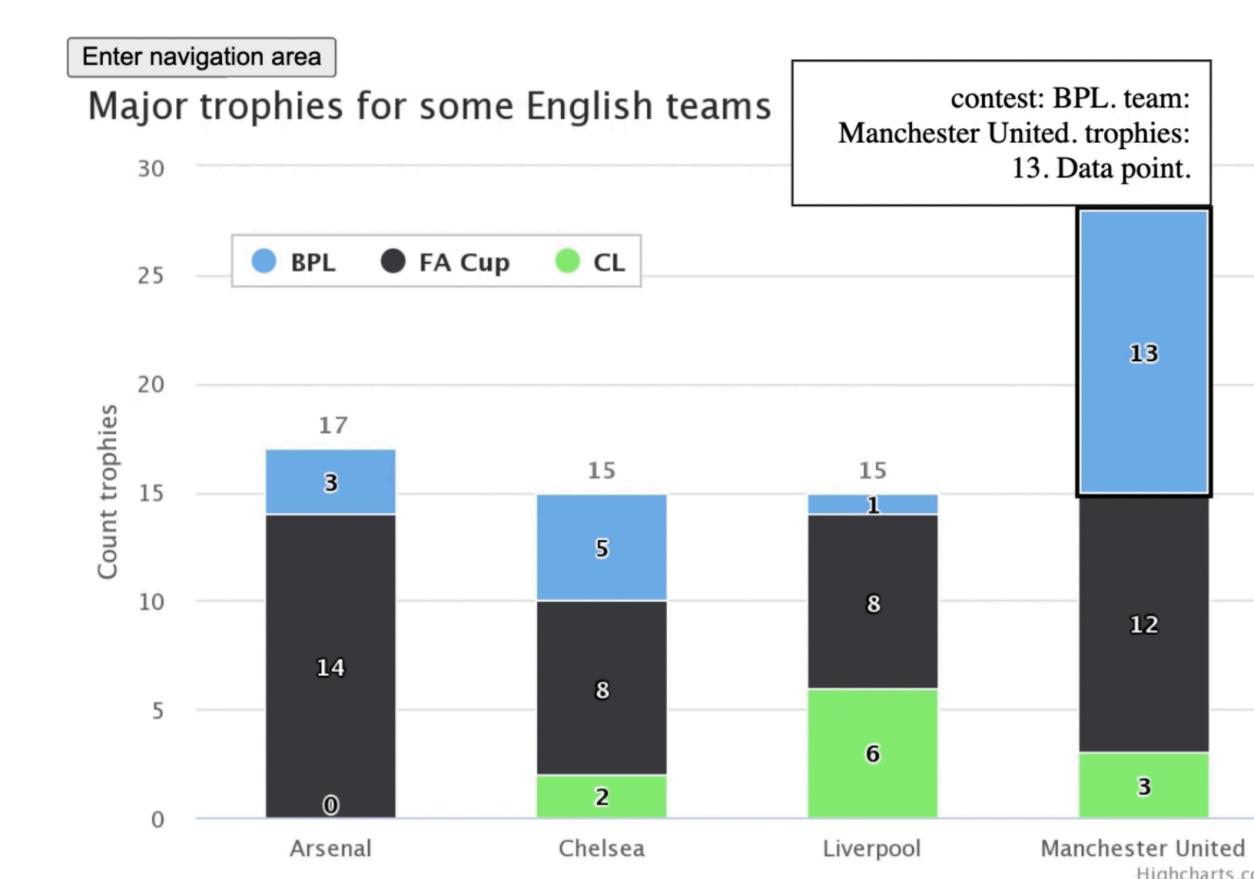
## 2018 (visa charts)



## 2022 (olli)

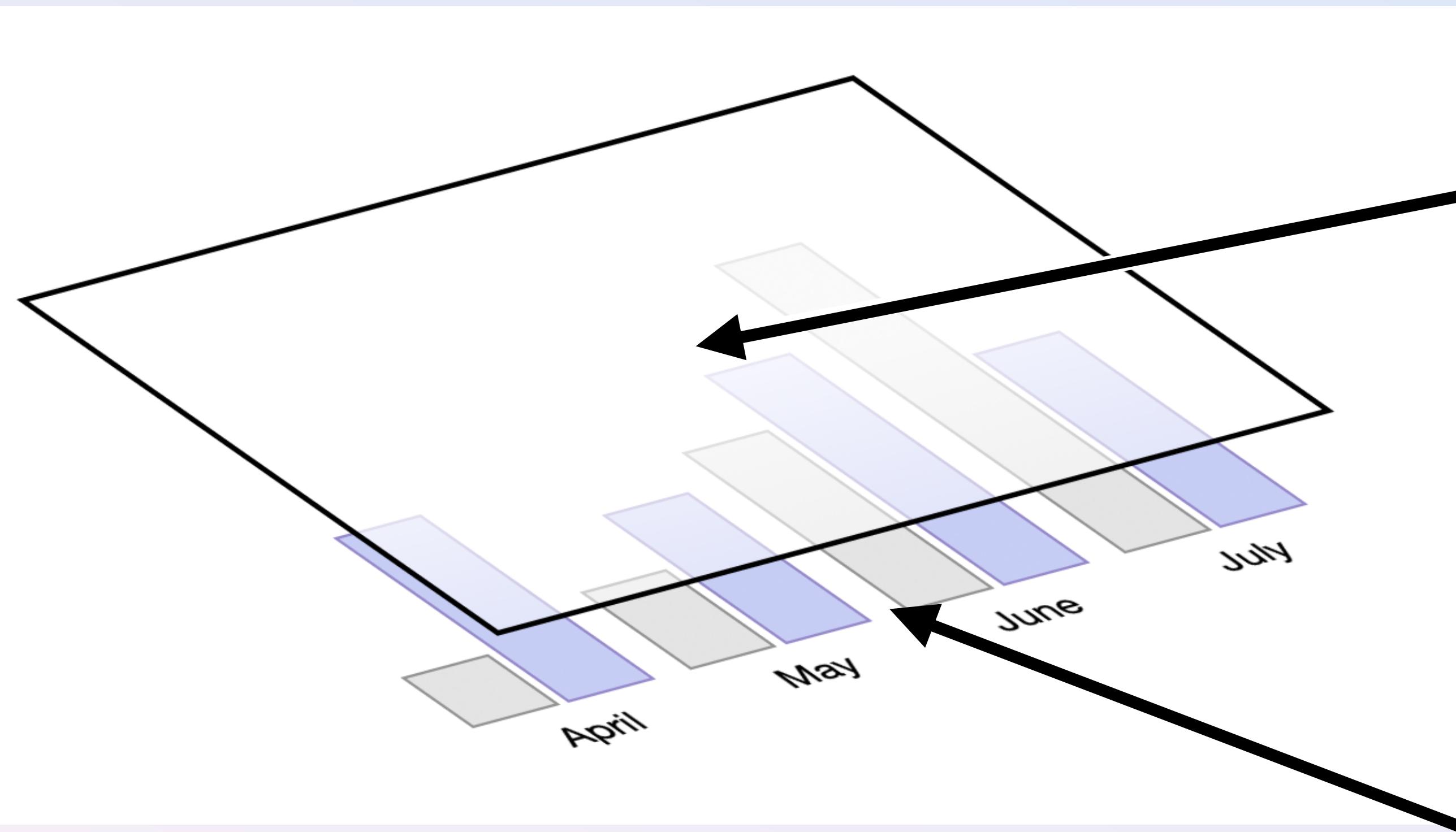


## 2023 (data navigator)

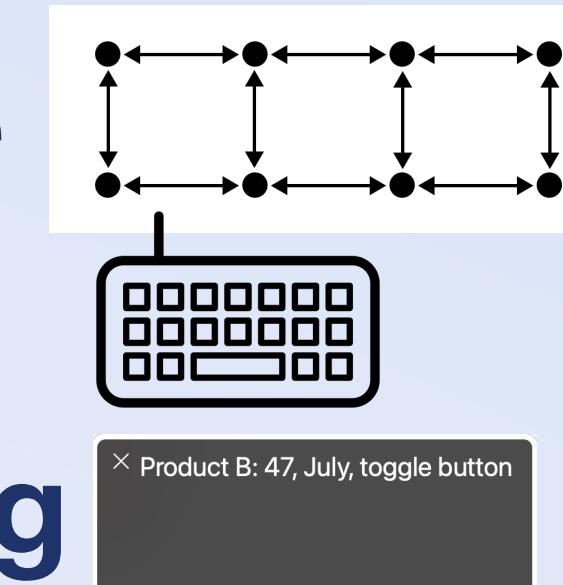


F. Elavsky, L. Nadolskis, and D. Moritz, “*Data Navigator: An Accessibility-Centered Data Navigation Toolkit*,” *IEEE Transactions on Visualization and Computer Graphics*, 2023.

# How does data navigator work?

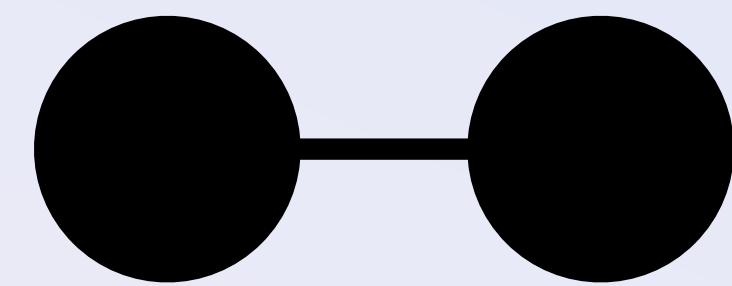


Structure  
Input  
Rendering



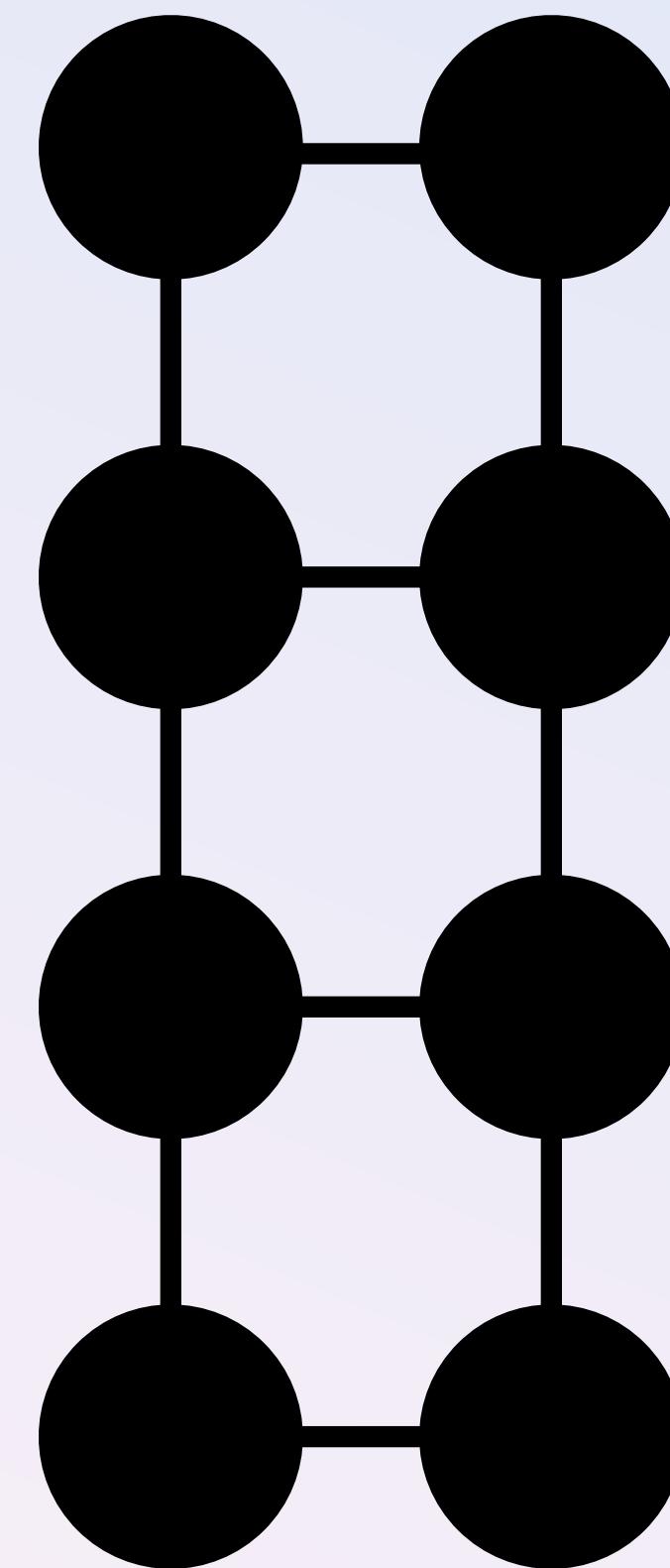
To visualization toolkits

# Structure is a *graph*: nodes and edges

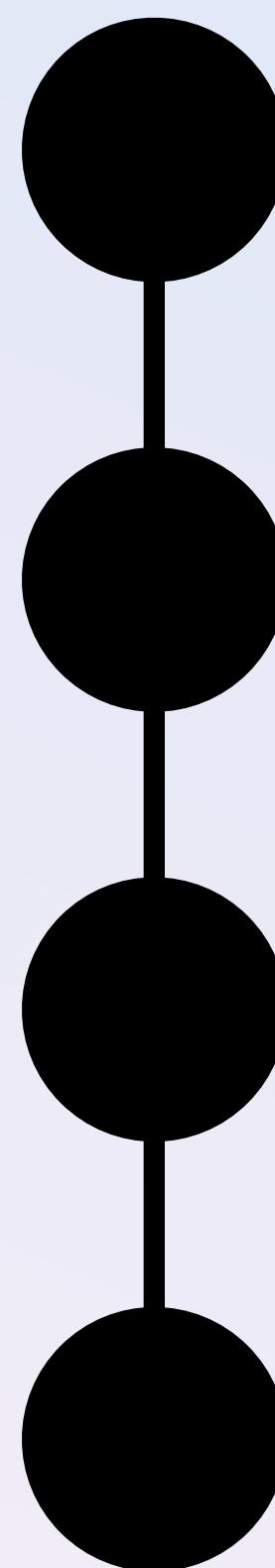


# Graphs can create nearly all *other* structures

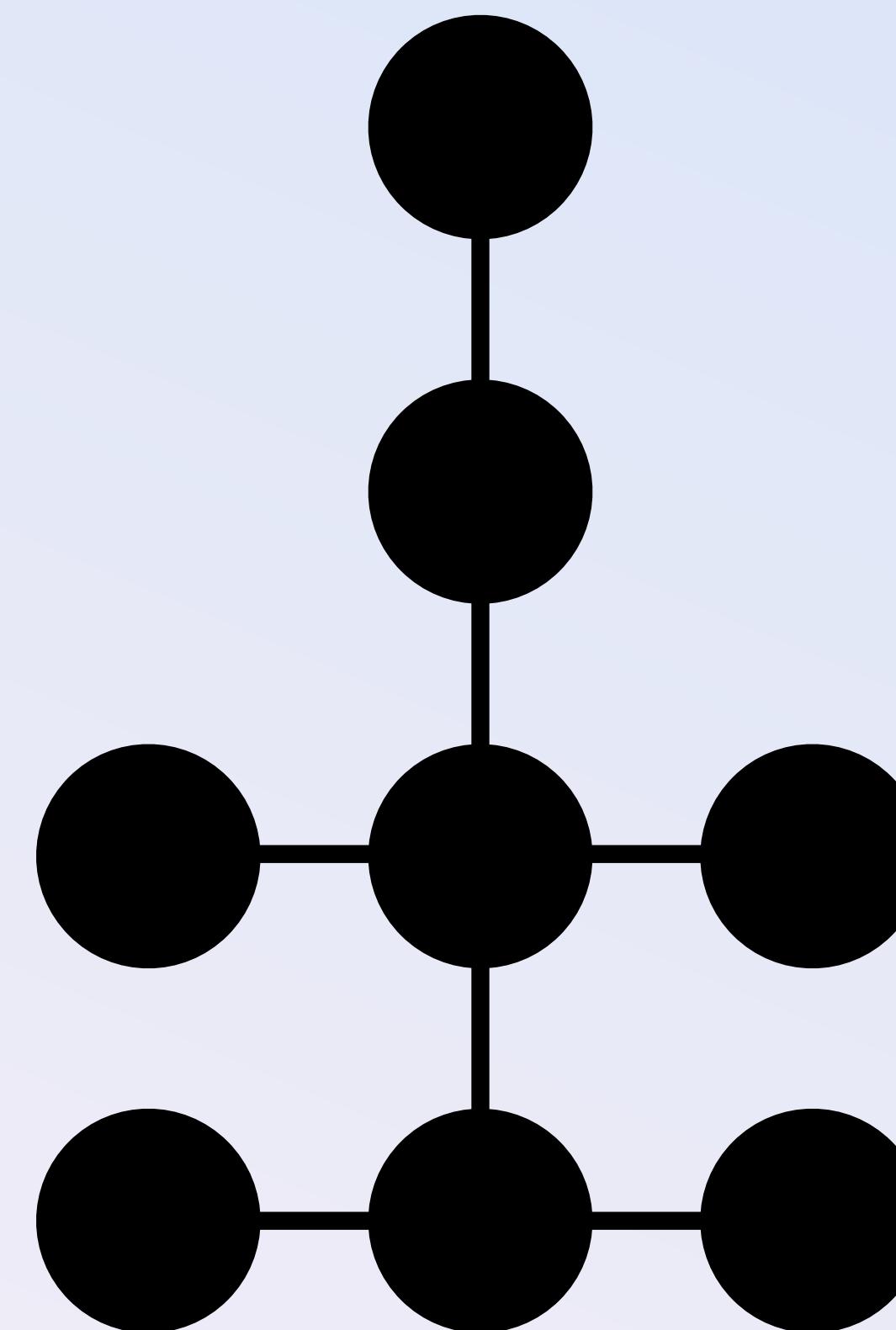
Tables



Lists

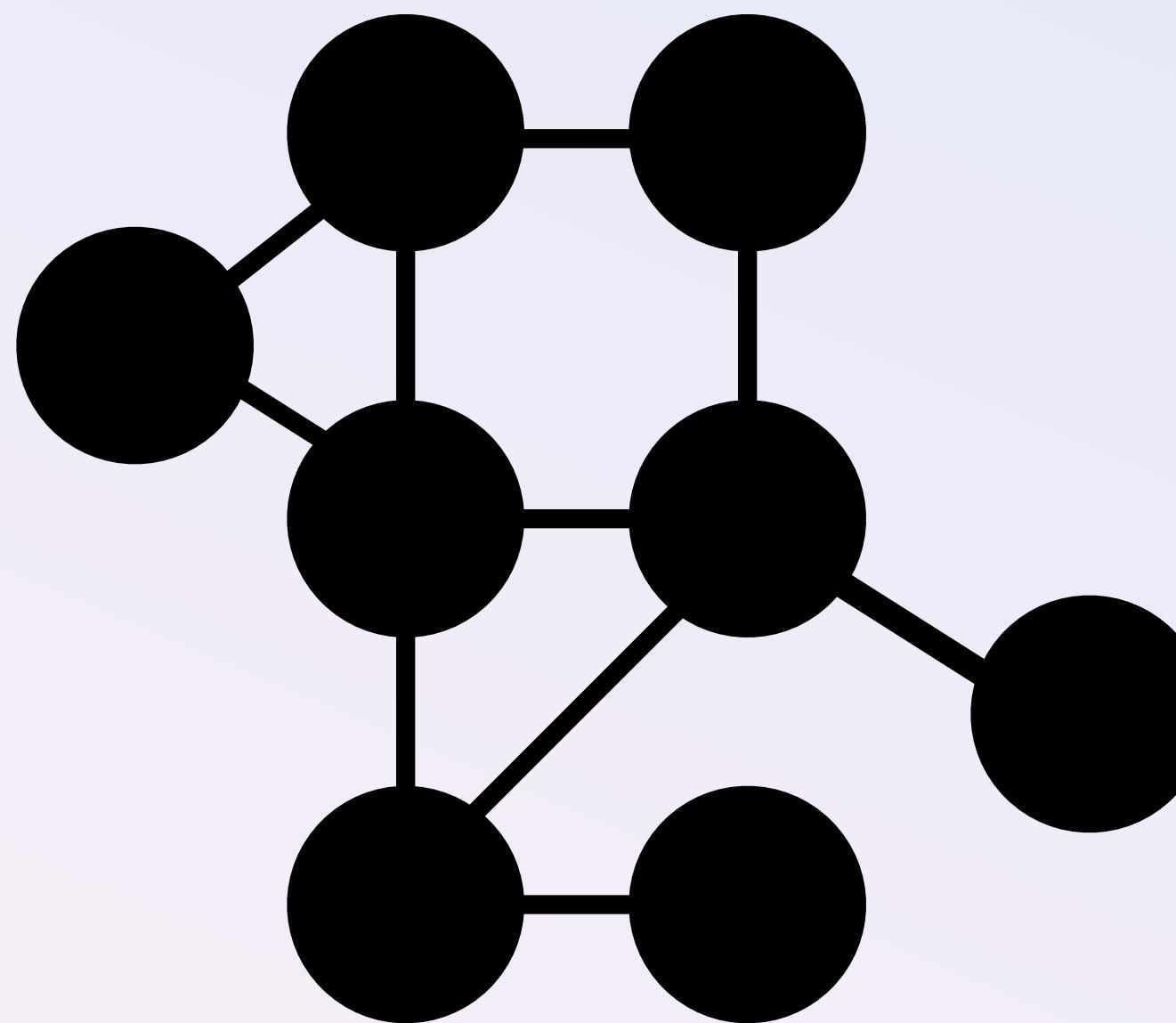


Hierarchies

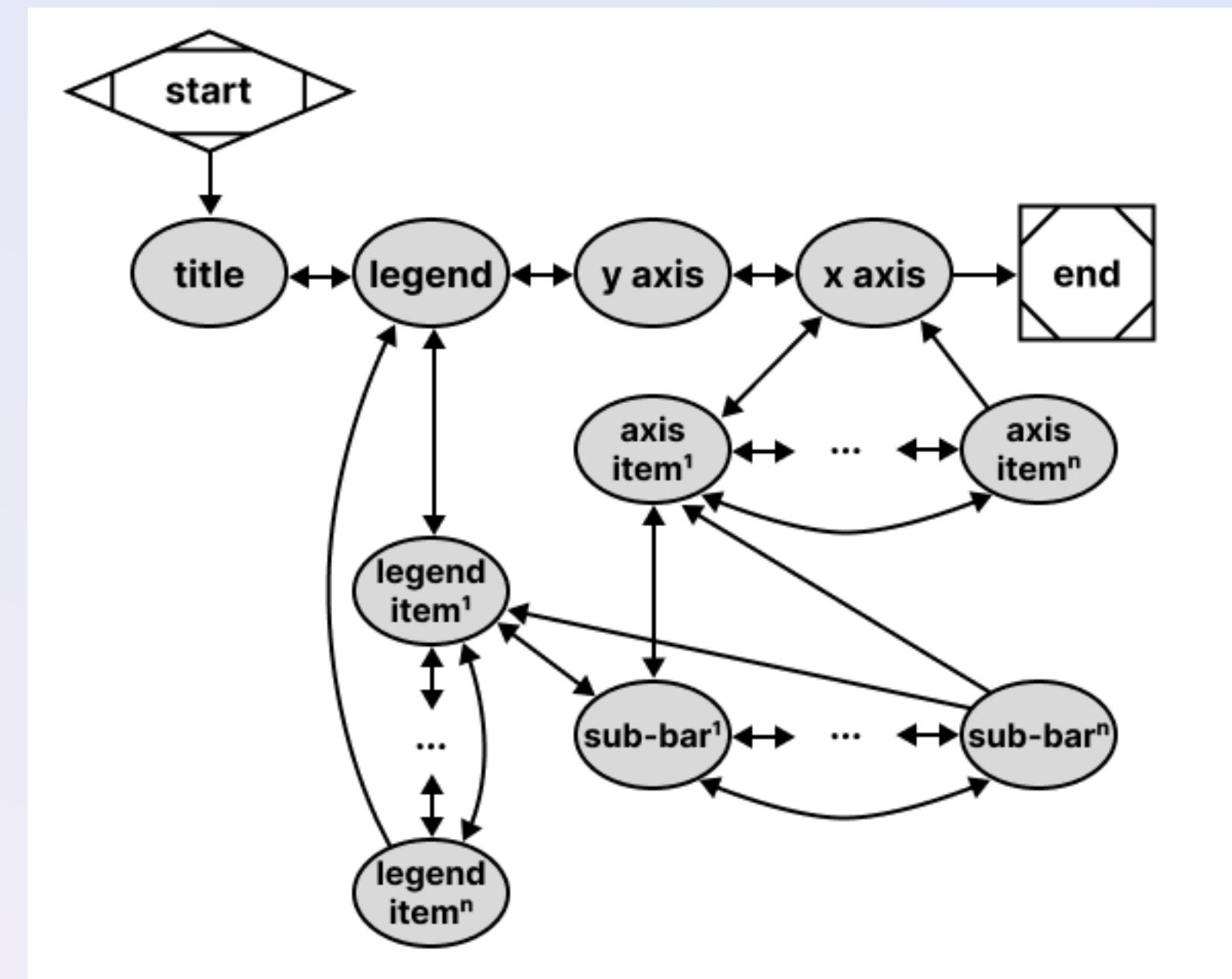


# Nodes can become virtually anything

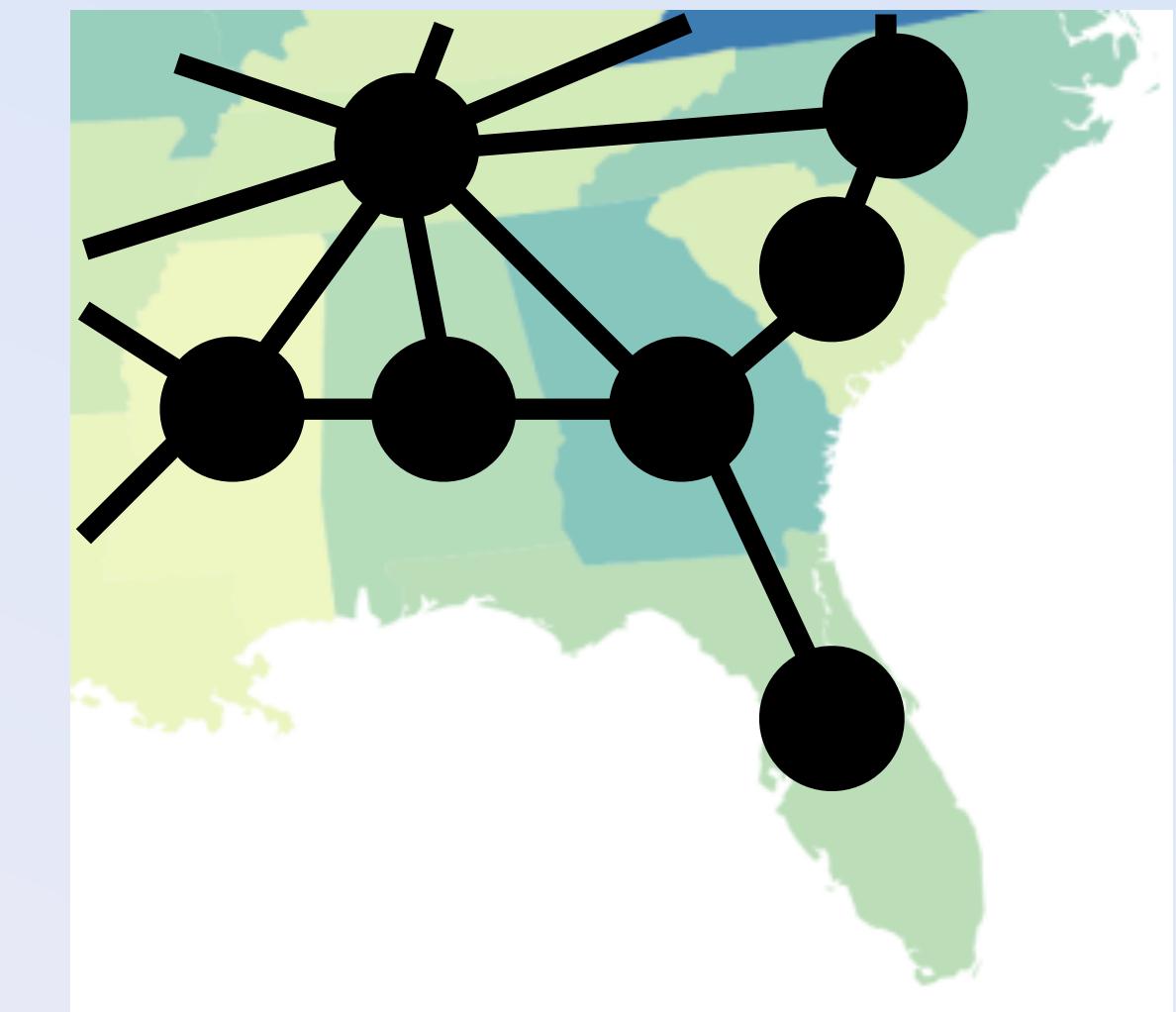
Network graphs



Diagrams

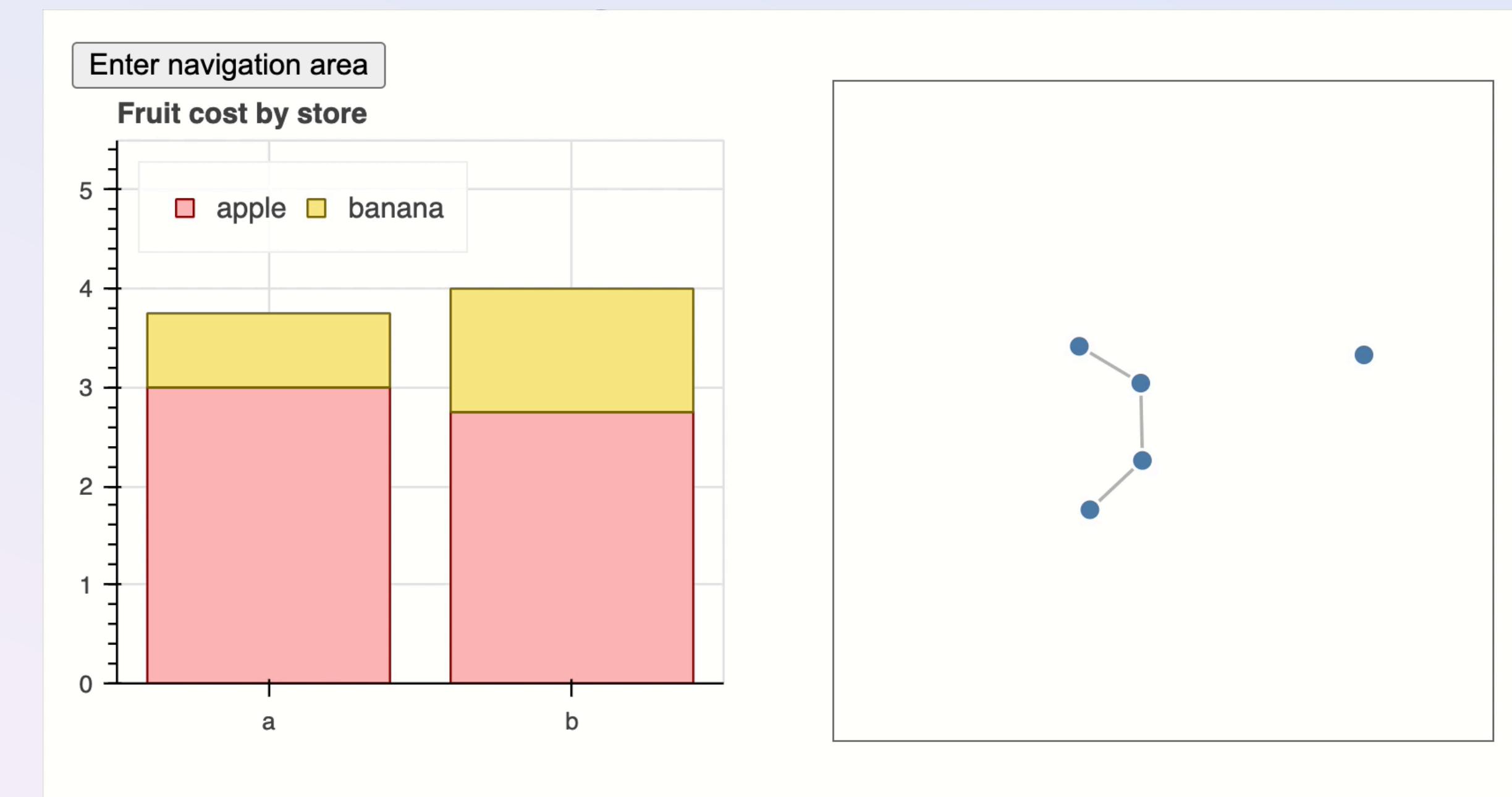


Maps



# Data Navigator: Empowering practitioners

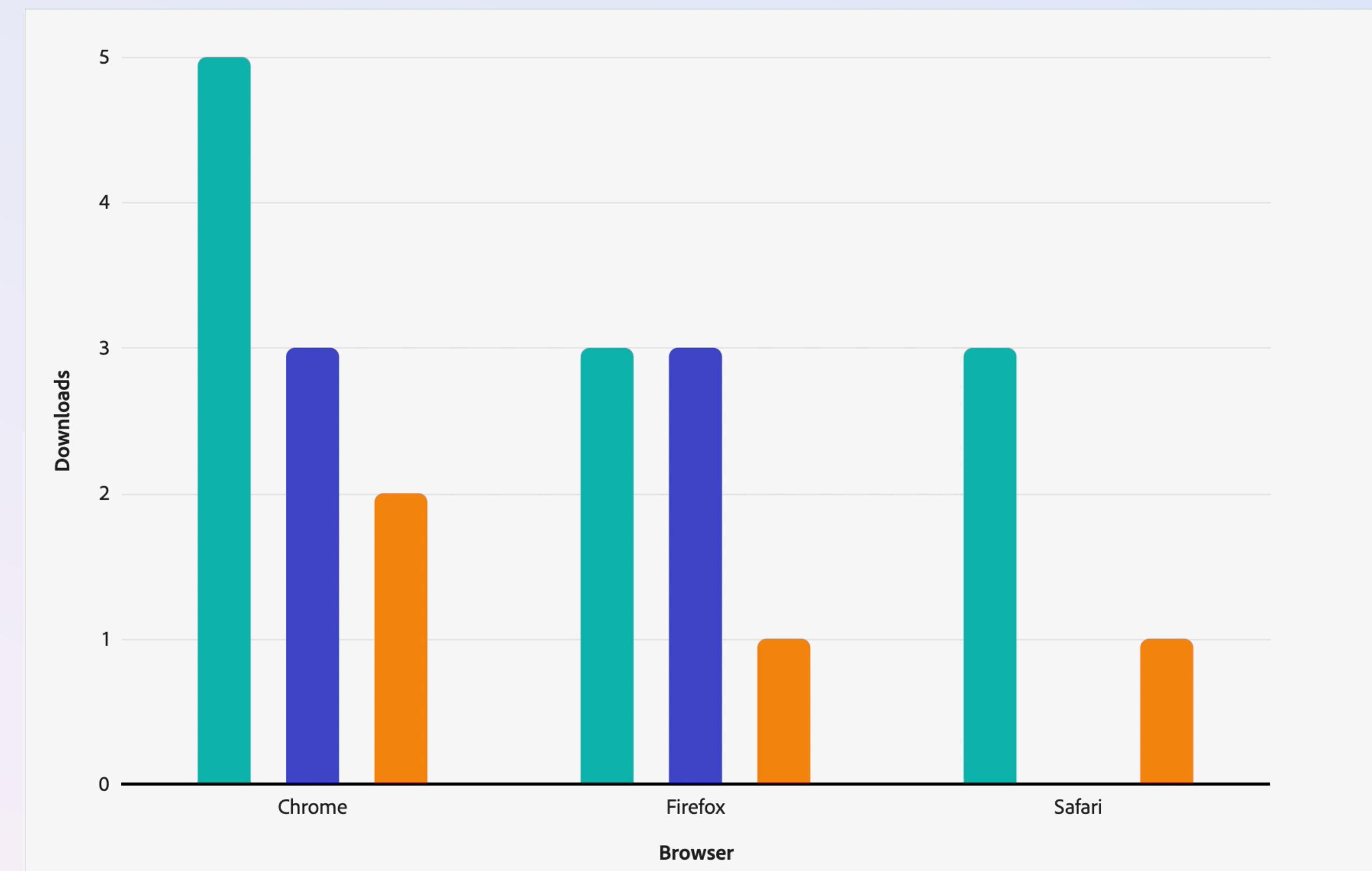
*Bokeh, a python visualization library,  
Work enabled thanks to a CZI EOSS Cycle 6 Grant*



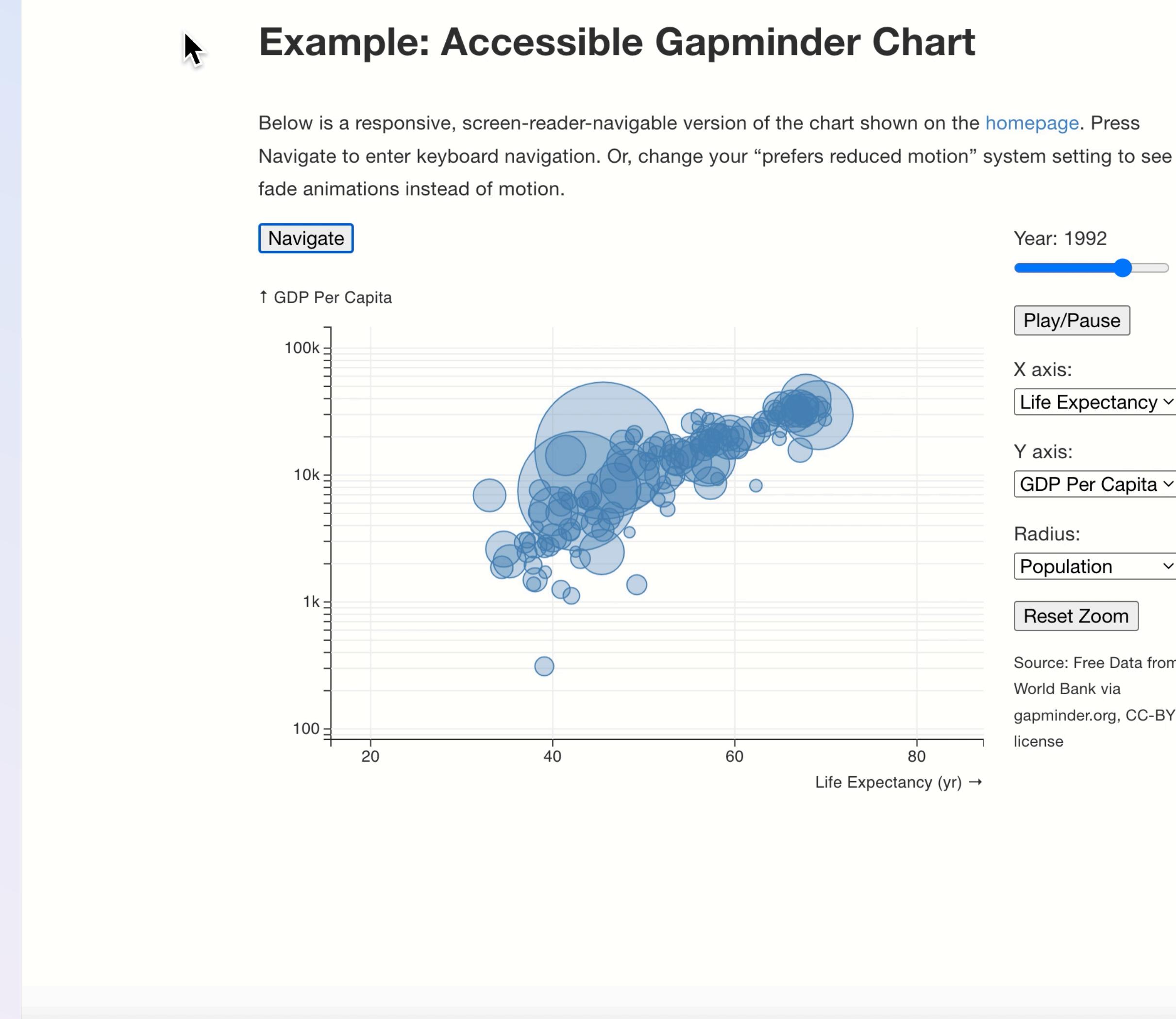
# Data Navigator: Empowering practitioners

*React Spectrum Charts*, Adobe's visualization design system

Work enabled thanks to 2x funding from Adobe



# Navigation + Animation



V. Sivaraman, F. Elavsky, D. Moritz, and A. Perer. “Counterpoint: Orchestrating large- scale custom animated visualizations.” *IEEE Visualization and Visual Analytics*, 2024.

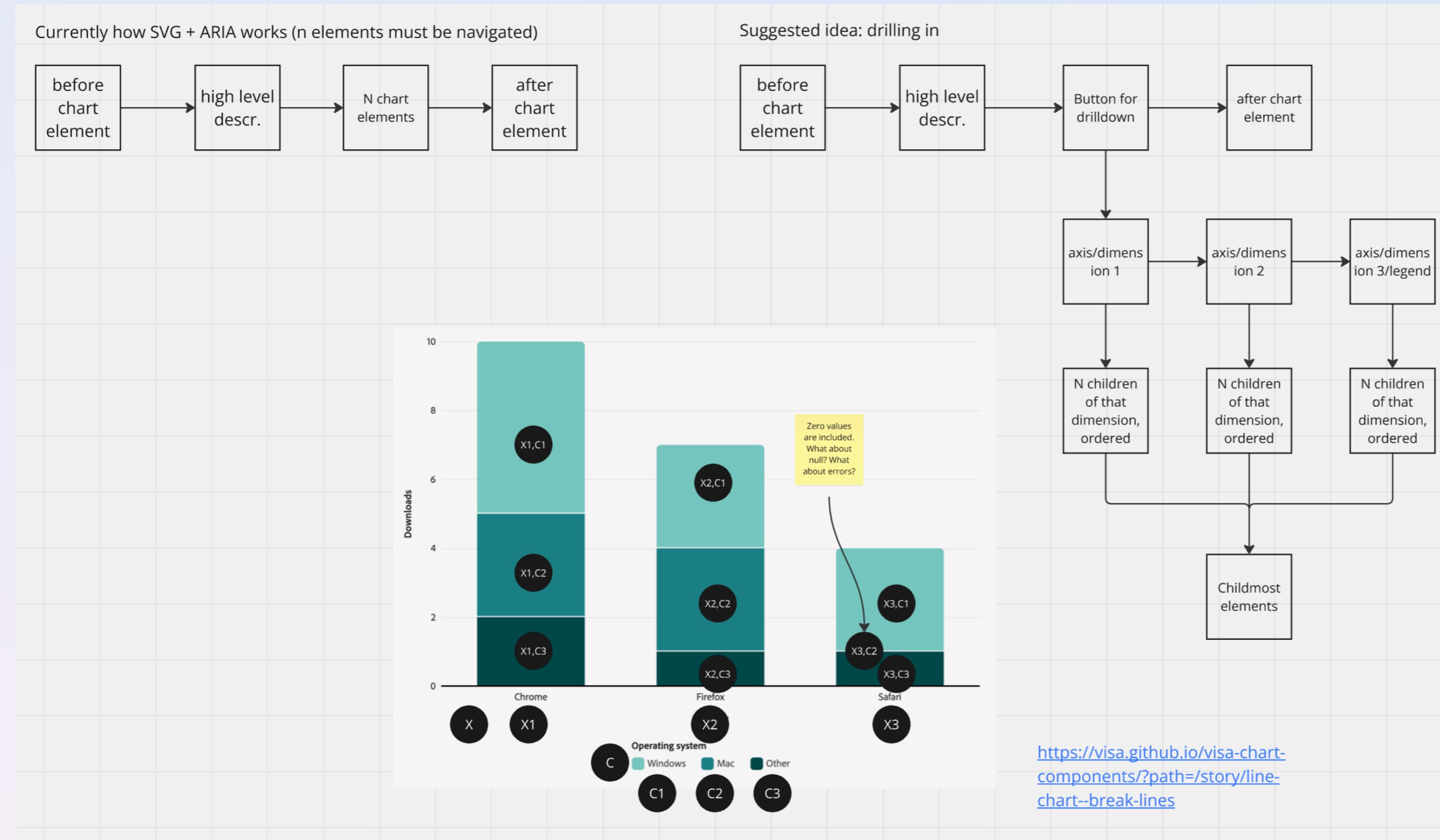
# **Section 3: Current work**

**Skeleton**: a graphical user interface that visualizes non-visual data experiences

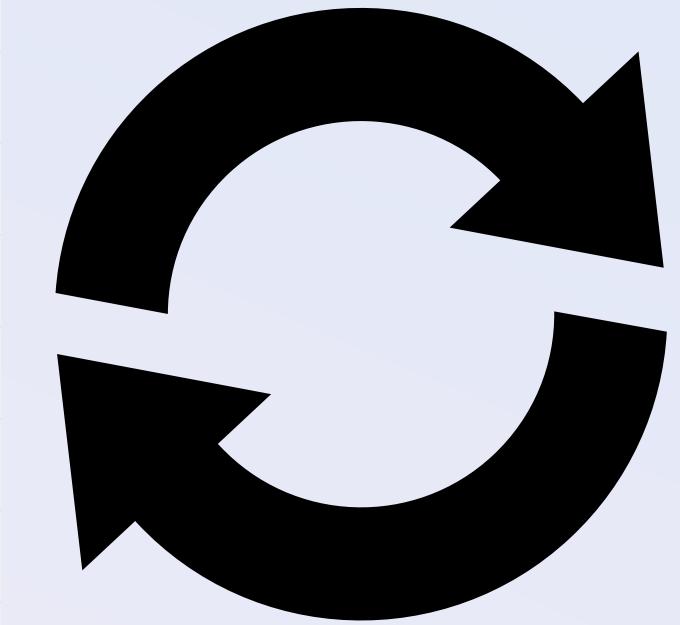
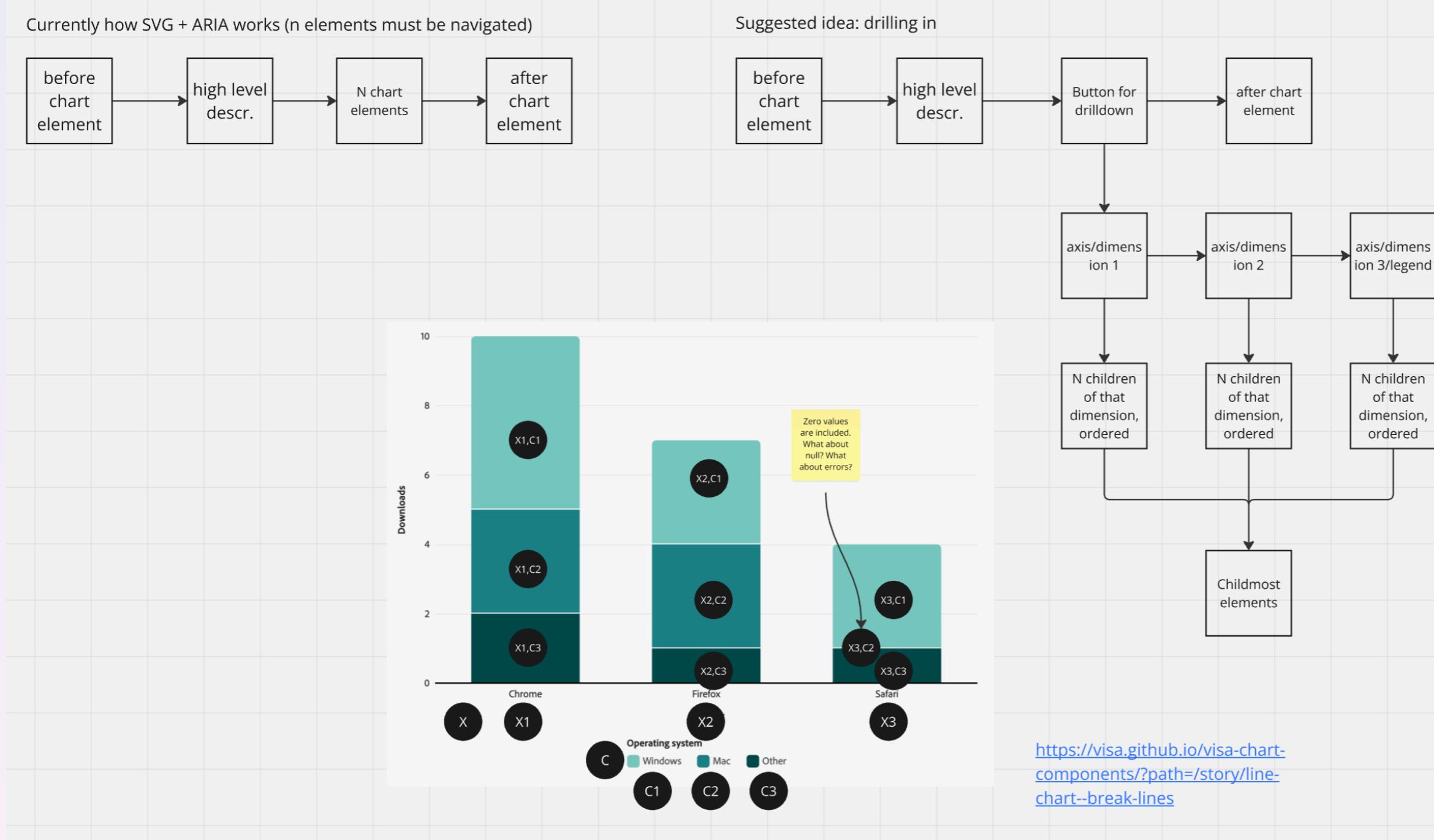
**Skeleton**

**Conjecture: non-visual experiences are an accessibility barrier for *sighted* people**

# Designing navigation schema is hard

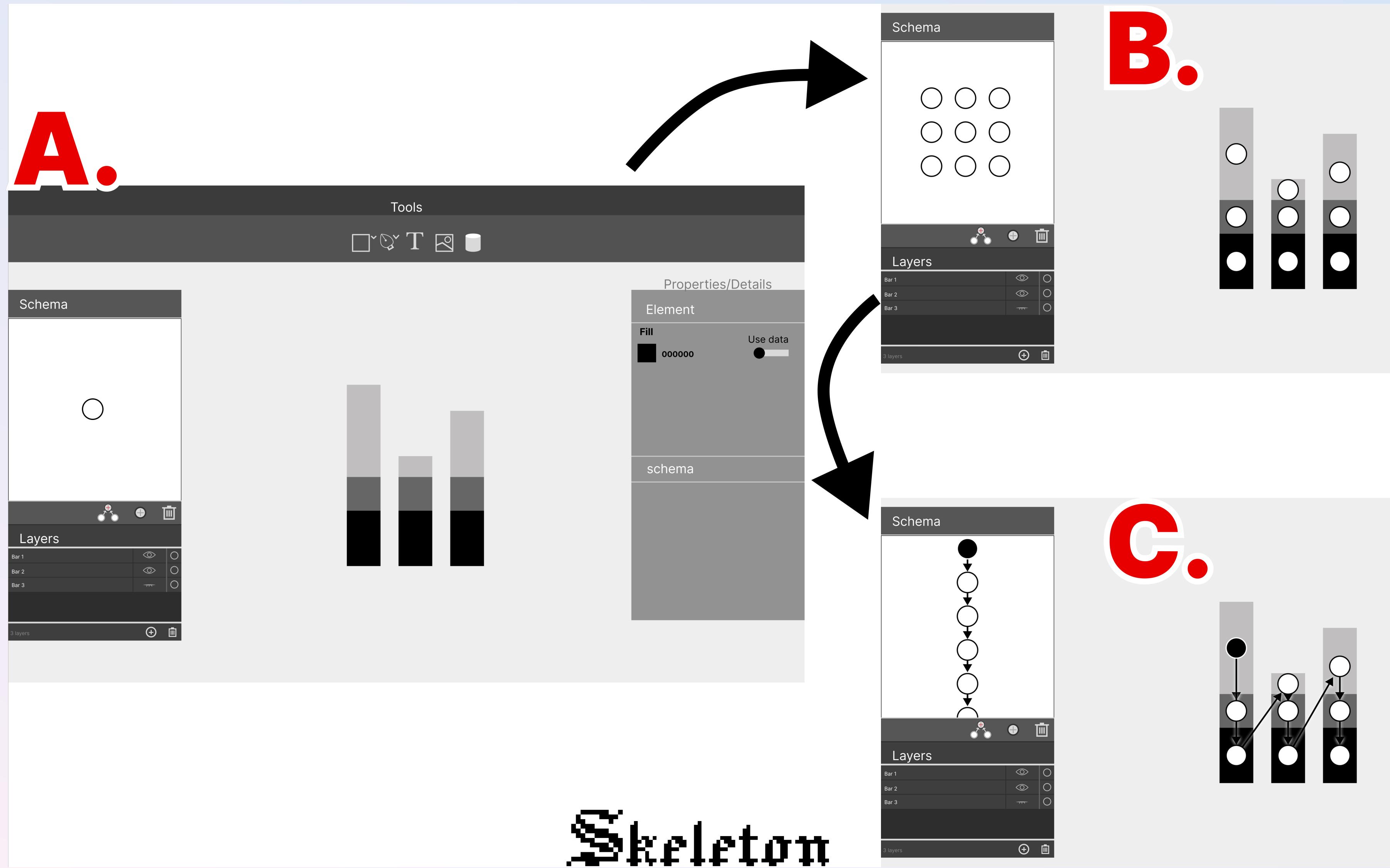


# Design and dev iteration becomes error-prone and slow



```
274 let simpleStructure = dataNavigator.structure({
275   data: simpleDataTest,
276   idKey: 'id',
277   dimensions: {
278     values: [
279       {
280         dimensionKey: 'cat',
281         type: 'categorical',
282         behavior: {
283           extents: 'circular'
284         }
285       },
286       {
287         dimensionKey: 'num',
288         type: 'numerical',
289         behavior: {
290           extents: 'terminal'
291         }
292       }
293     ],
294   },
295   genericEdges: [
296     {
297       edgeId: 'any-exit',
298       edge: {
299         source: (_d, c) => c,
300         target: () => {
301           exit['simple']();
302           return '';
303         },
304         navigationRules: ['exit']
305       }
306     }
307   ]
308 })
```

# We plan to make an interface for authoring and debugging



# Web development accessibility tooling

**Gesture**  
► Show section

Enter navigation area

### Major trophies for some English teams

Count trophies

Legend: BPL (blue), FA Cup (dark grey), CL (green)

contest: BPL. team:

Auditing dig.cmu.edu...

💡 1MB takes a minimum of 5 seconds to download on a typical 3G connection  
[Source: WebPageTest and DevTools 3G definition].

Cancel

Highcharts.com

**Why make Data Navigator?**

Modern data visualization accessibility faces 3 challenges in design and development that we wanted to help practitioners and researchers tackle:

Lighthouse > ▲ 1 🔍 45 ⚙️ ⚙️ X

+ (new report) ⚙️ ⚙️

Generate a Lighthouse report Analyze page load

Mode [Learn more](#)

Navigation (Default)

Timespan

Snapshot

Device

Mobile

Desktop

Categories

Performance

Accessibility

Best practices

SEO

Skeleton

# Web development accessibility tooling

**Gesture**  
► Show section  
  
Enter navigation area

Major trophies for some English teams

Team	BPL	FA Cup	CL	Total
Arsenal	3	14	0	17
Chelsea	5	8	2	15
Liverpool	1	8	6	15
Manchester United	13	12	3	28

Count trophies

Highcharts.com

**Why make Data Navigator?**

Modern data visualization accessibility faces 3 challenges in design and development that we wanted to help practitioners and researchers tackle:

1. Navigable structure is hard to build for data visualizations. Structure is important for understanding and usability but is often ignored.

Elements Console Sources Lighthouse > ▲ 1 ! 40 ⚙ ⋮ ×

+ 11:50:31 AM - dig.cmu.edu □

http://dig.cmu.edu/data-navigator/ ⋮

Category	Score
Performance	75
Accessibility	100
Best Practices	59
SEO	100

There were issues affecting this run of Lighthouse:

- Clearing the browser cache timed out. Try auditing this page again and file a bug if the issue persists.

skip to main content  
**Data Navigator demo**  
This page is a live, interactive application that demos some of the coolest capabilities of our system, Data Navigator.  
What is Data

Skeleton

# What if you could see AT navigation?

## Currently navigation is still manually verified!

**Gesture**  
► Show section

Enter navigation area

### Major trophies for some English teams

Team	BPL	FA Cup	CL	Total
Arsenal	3	14	0	17
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Count trophies

Highcharts.com

### Why make Data Navigator?

Modern data visualization accessibility faces 3 challenges in design and development that we wanted to help practitioners and researchers tackle:

1. Navigable structure is hard to build for data visualizations. Structure is important for understanding and usability but is often ignored.
2. Only mouse input is treated well (with sporadic support for touch or screen reader input). Many other input modalities are unaddressed!

Elements Console Sources Lighthouse > ▲ 1 ! 40 ⚙ ⋮ ×

+ 11:50:31 AM - dig.cmu.edu

http://dig.cmu.edu/data-navigator/

75 100 59 100

100

### Accessibility

These checks highlight opportunities to [improve the accessibility of your web app](#). Automatic detection can only detect a subset of issues and does not guarantee the accessibility of your web app, so [manual testing](#) is also encouraged.

ADDITIONAL ITEMS TO MANUALLY CHECK (10) Hide

- Interactive controls are keyboard focusable
- Interactive elements indicate their purpose and state
- The page has a logical tab order
- Visual order on the page follows DOM order

Skeleton

# What if you could see AT navigation?

## Currently navigation is still manually verified!

**Gesture**  
► Show section  
Enter navigation area

Major trophies for some English teams

The chart shows the following trophy counts:

Team	BPL	FA Cup	CL	Total
Arsenal	14	3	0	17
Chelsea	10	5	2	15
Liverpool	8	1	6	15
Manchester United	12	13	3	28

Highcharts.com

**Why make Data Navigator?**

Modern data visualization accessibility faces 3 challenges in design and development that we wanted to help practitioners and researchers tackle:

1. Navigable structure is hard to build for data visualizations. Structure is important for understanding and usability but is often ignored.
2. Only mouse input is treated well (with sporadic support for touch or screen reader input). Many other input modalities are unaddressed!

Elements Console Sources Lighthouse > ▲ 1 ! 40 ⚙ ⋮ ×

11:50:31 AM - dig.cmu.edu

http://dig.cmu.edu/data-navigator/

75 100 59 100

**Accessibility**

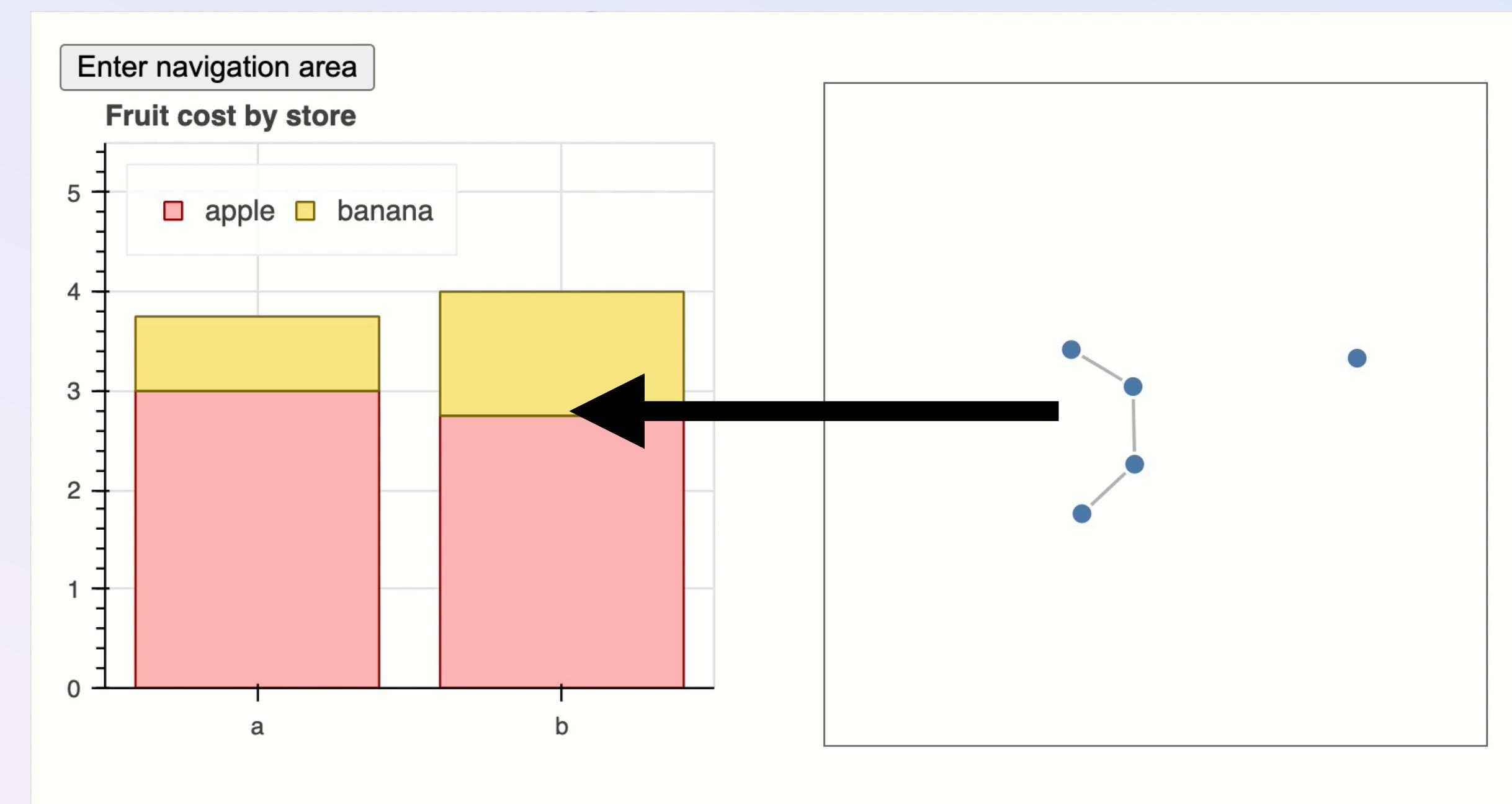
These checks highlight opportunities to [improve the accessibility of your web app](#). Automatic detection can only detect a subset of issues and does not guarantee the accessibility of your web app, so [manual testing](#) is also encouraged.

ADDITIONAL ITEMS TO MANUALLY CHECK (10) Hide

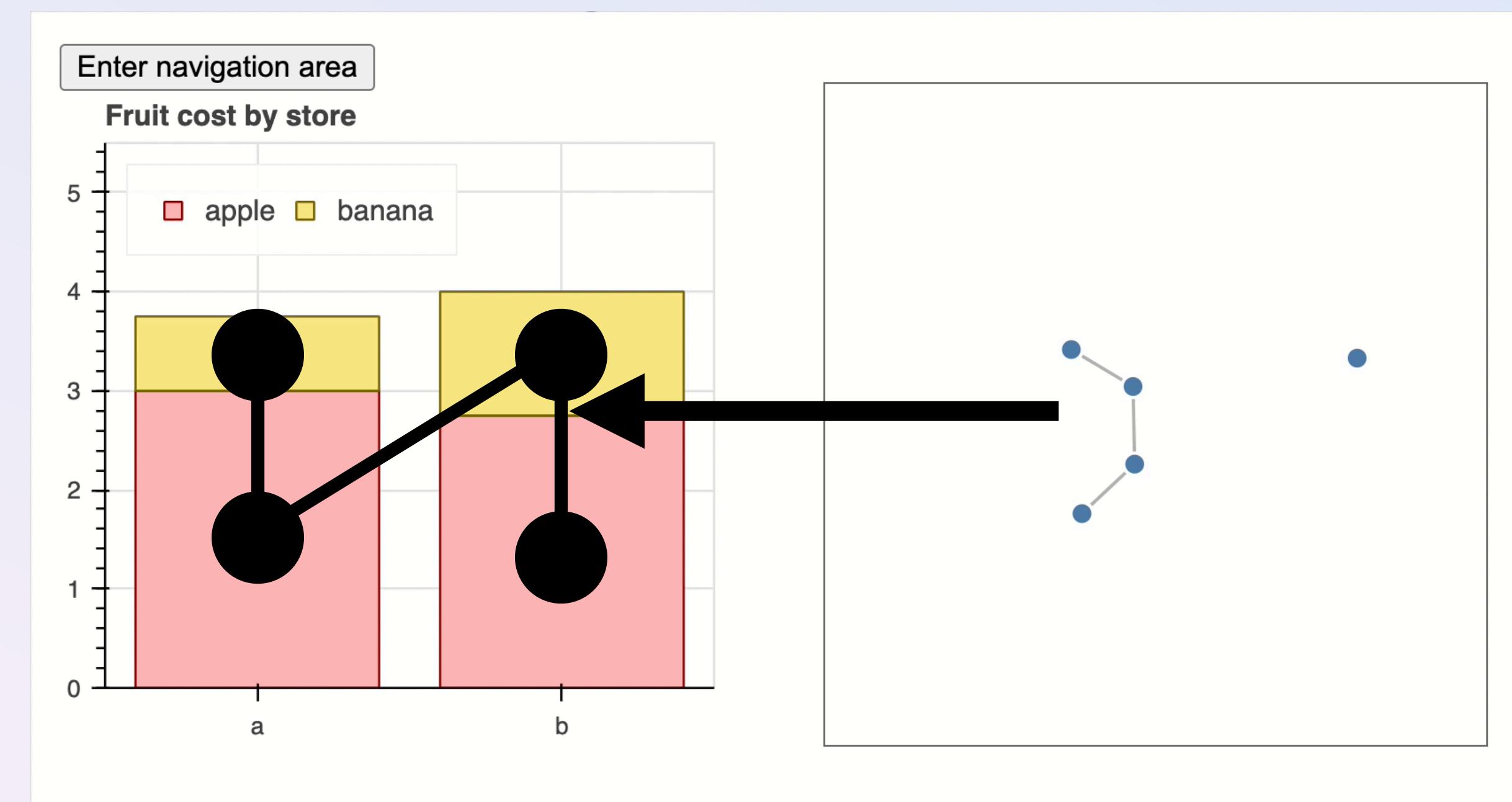
- Interactive controls are keyboard focusable
- Interactive elements indicate their purpose and state
- The page has a logical tab order
- Visual order on the page follows DOM order

Skeleton

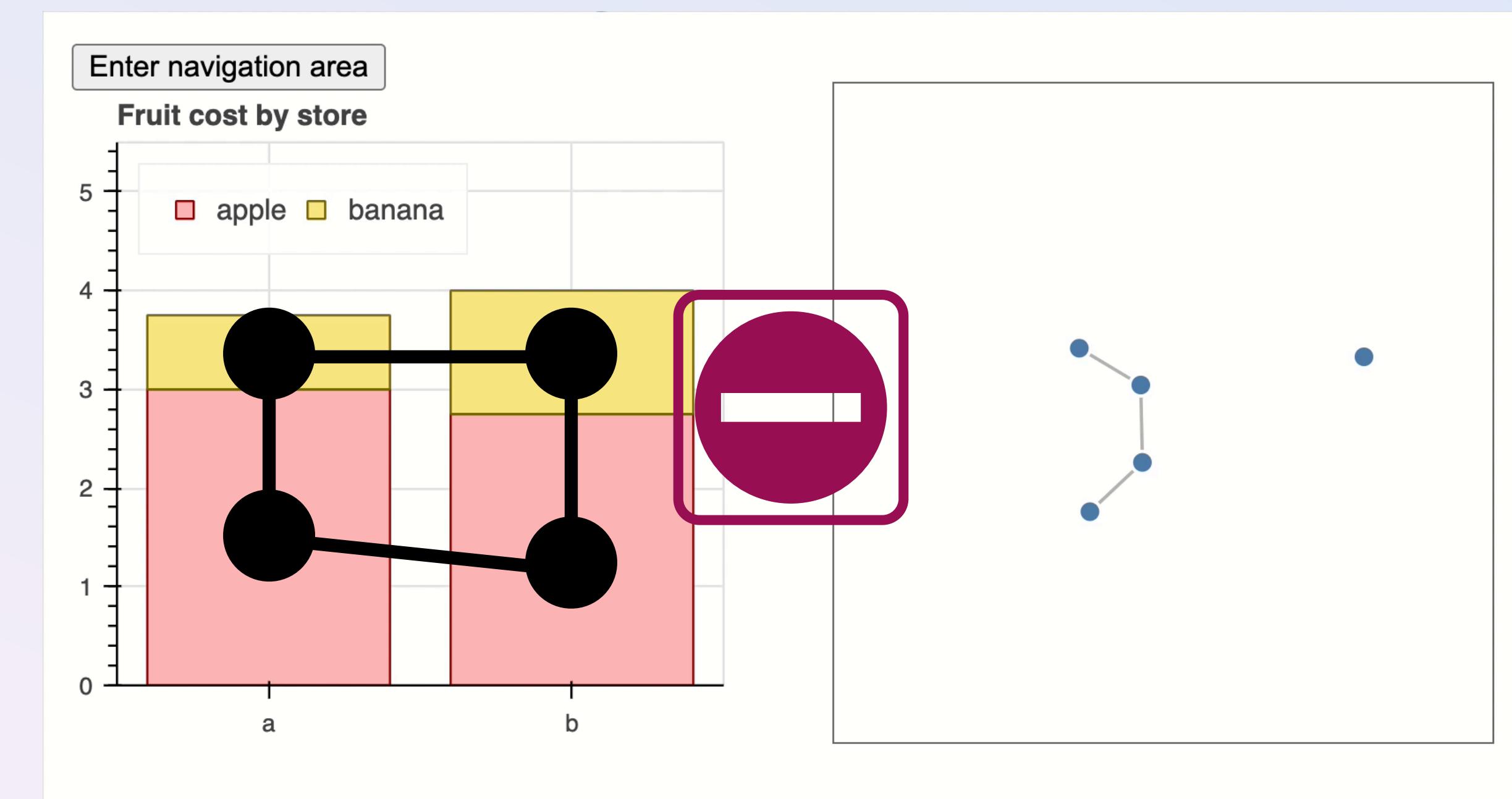
# What if you could see the navigation structure?



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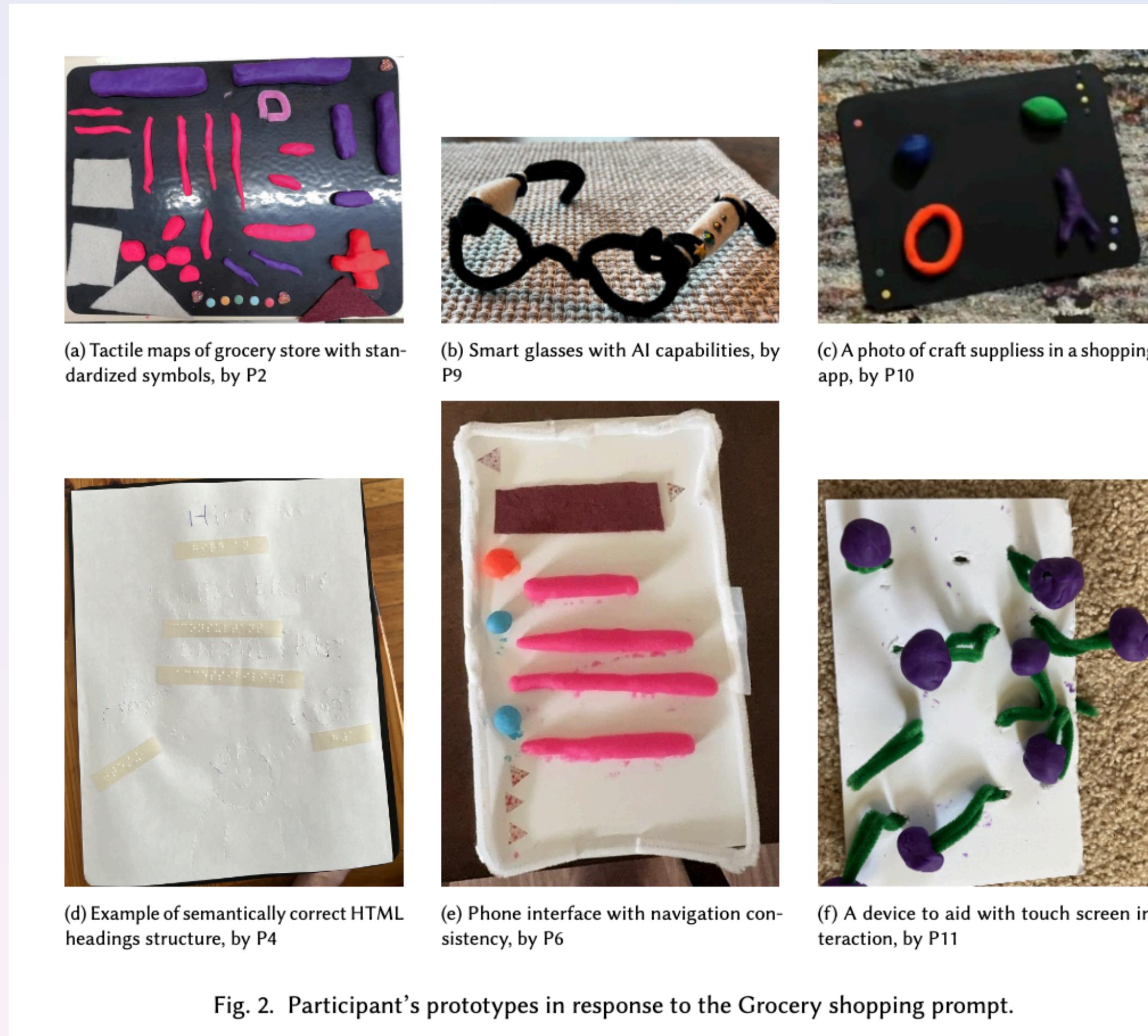


# What if you could see the navigation structure?



# My latest community and critical work

## Blind-led innovation and using community response to build a *how-not-to* guide



## How Not To Make Bad Assistive Tech: A Guide

Created by [Iman Ouzzani](#), Advised by [Frank Elavsky](#).

Some technologies that are created with "good" intentions can end up effectively useless, sometimes even harmful. This can especially be true when technology is made for people with disabilities. So how do you avoid making bad assistive technologies? We created this guide and framework to help you ask questions about your own work and suggest directions for how you can rethink, reframe, and adjust your approach.

### Motivation: Avoiding Disability Dongles

Consider the following examples of bad assistive technology:

#### Sign-Language Glove



**Why is it bad?** The people who make these projects rarely consult with deaf people when they create it, which results in gloves that make an assumption that sign language only occurs in the movement of the hands, rather than with facial expressions and body language as well.

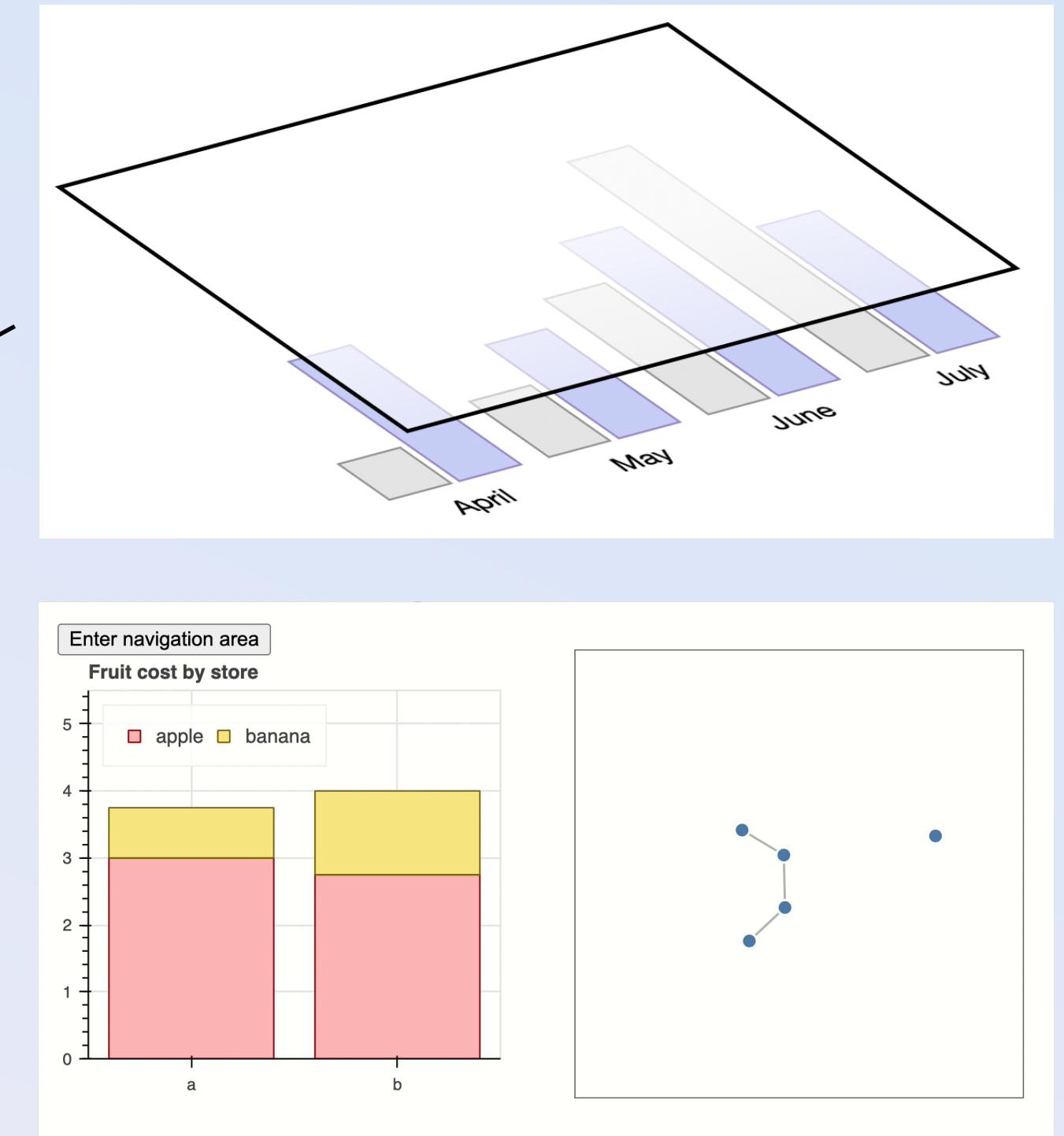
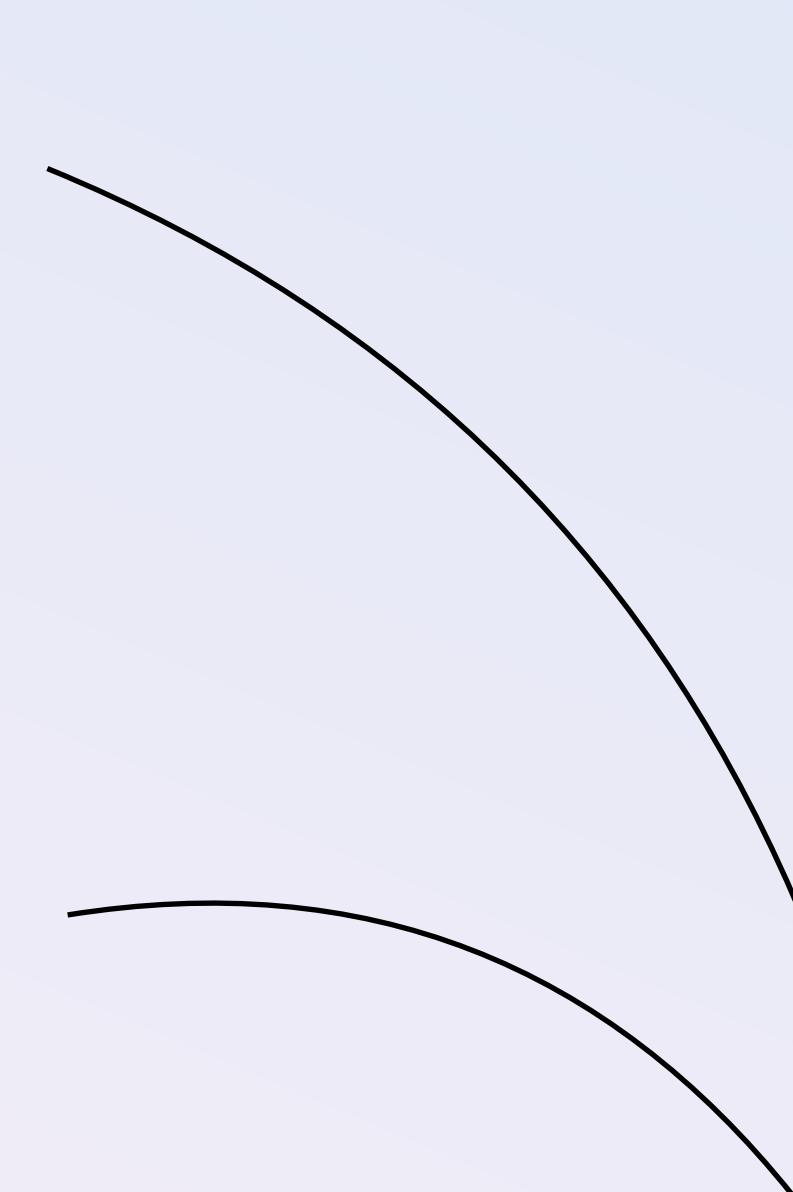
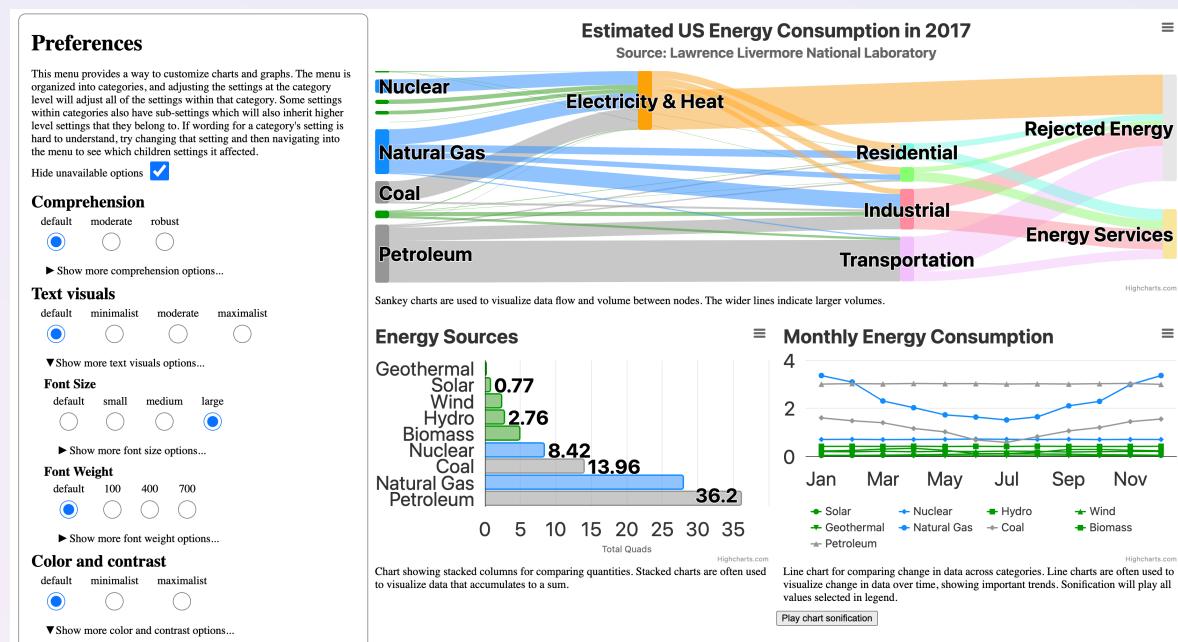
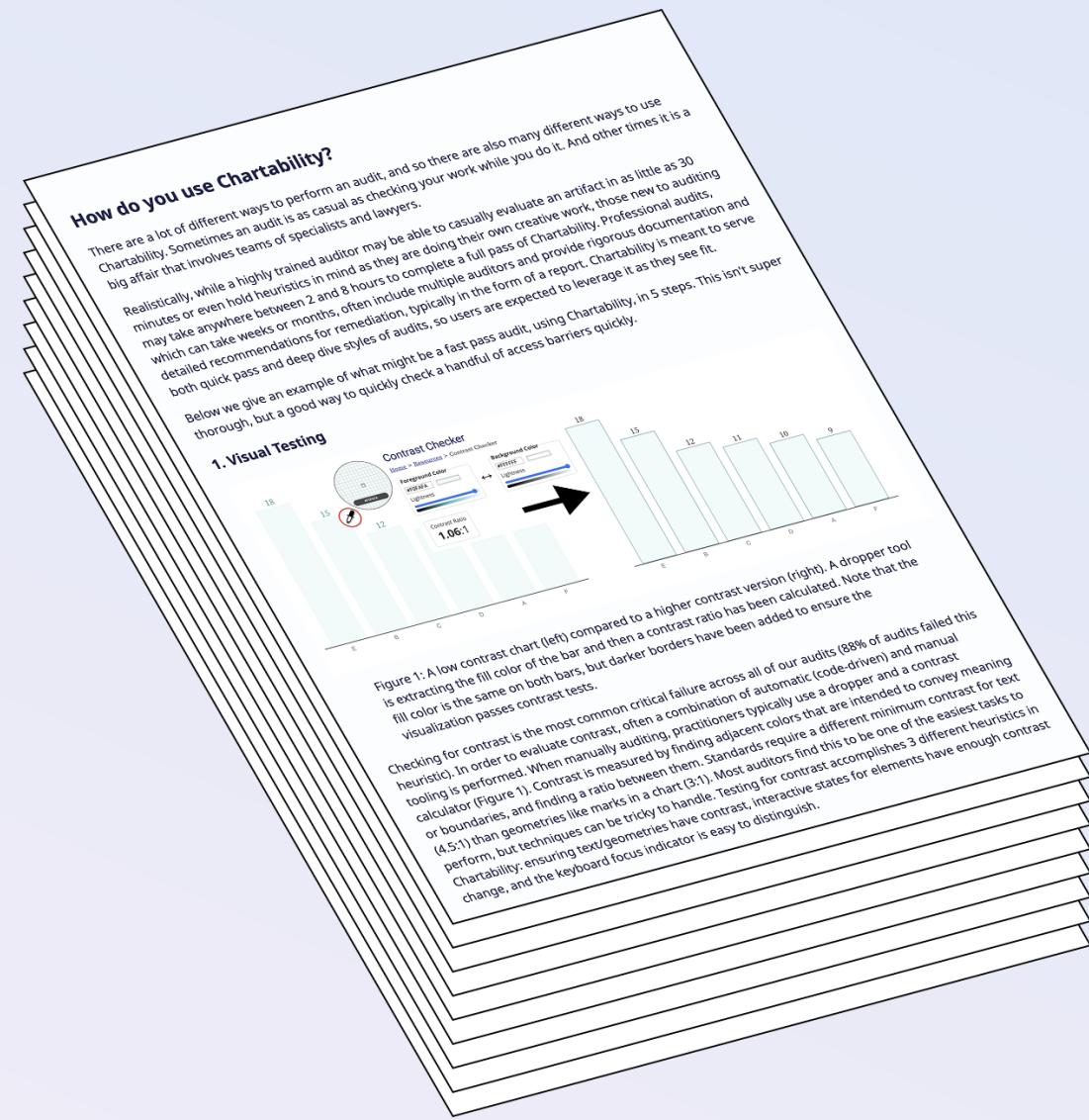
#### Stair-Climbing Wheelchair



# Section 4: Summary

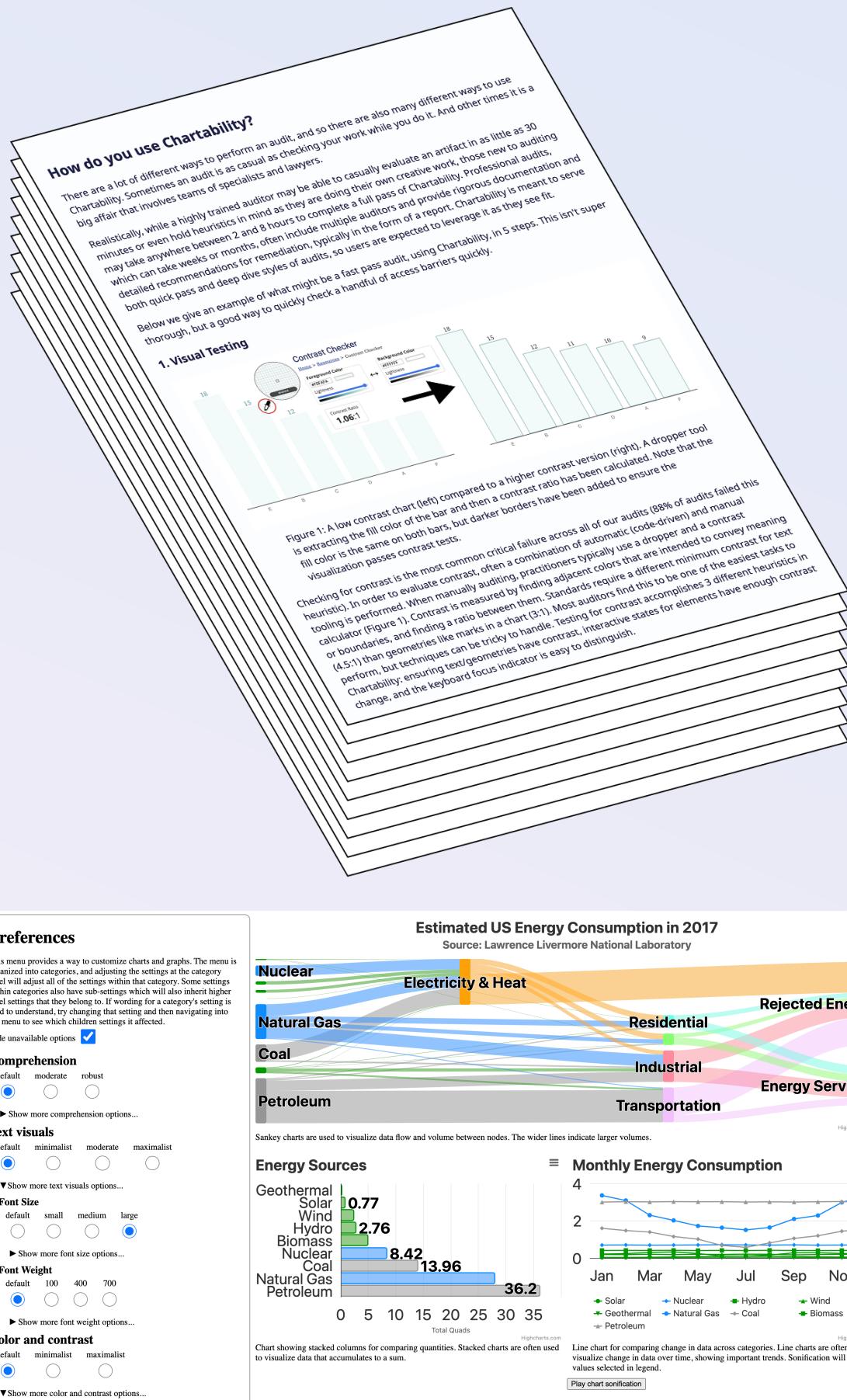
# "Strictly speaking, nothing is a tool unless during actual use."

Samuel Butler

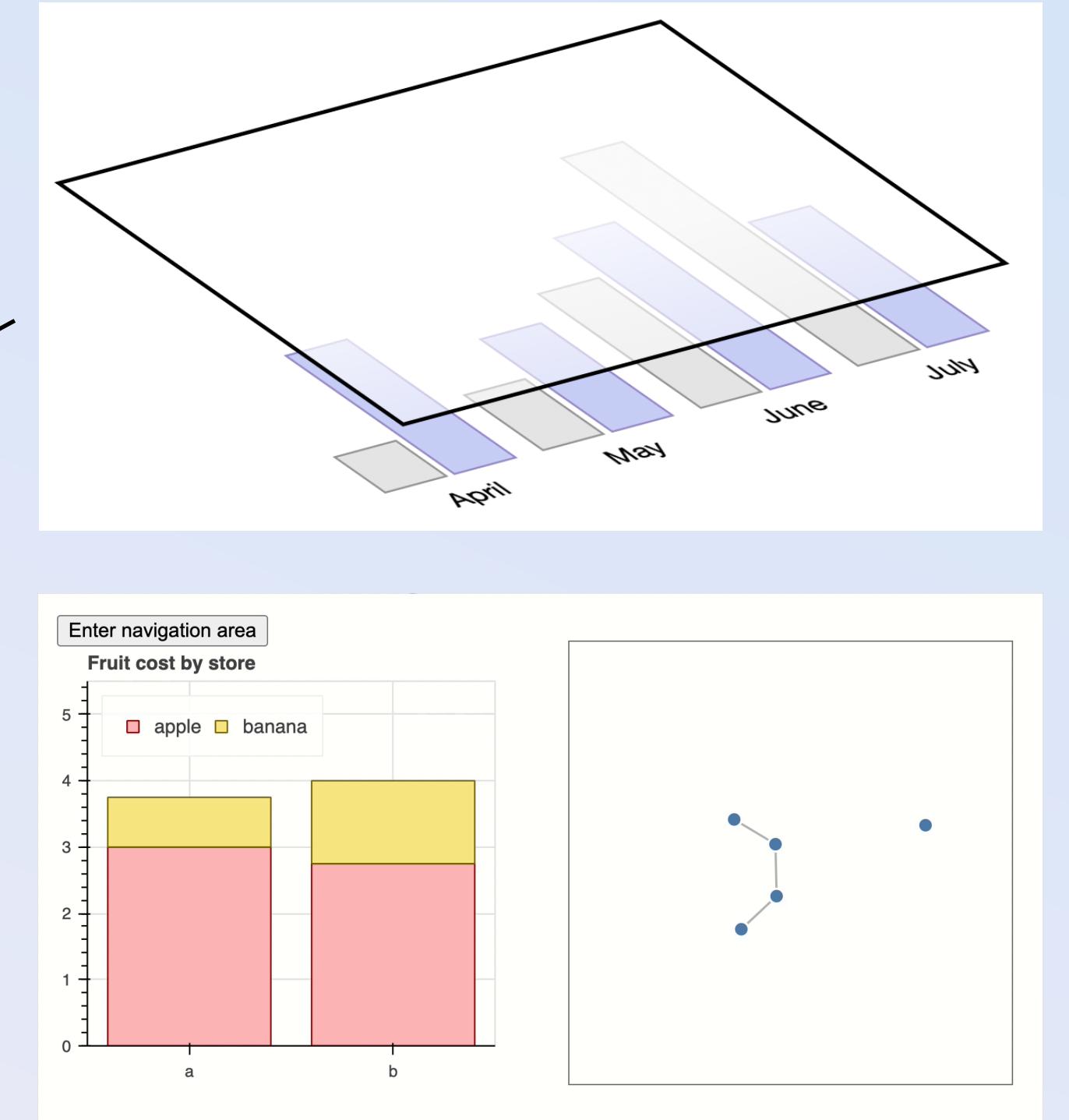


**"Strictly speaking,  
nothing is a tool unless  
during actual use."**

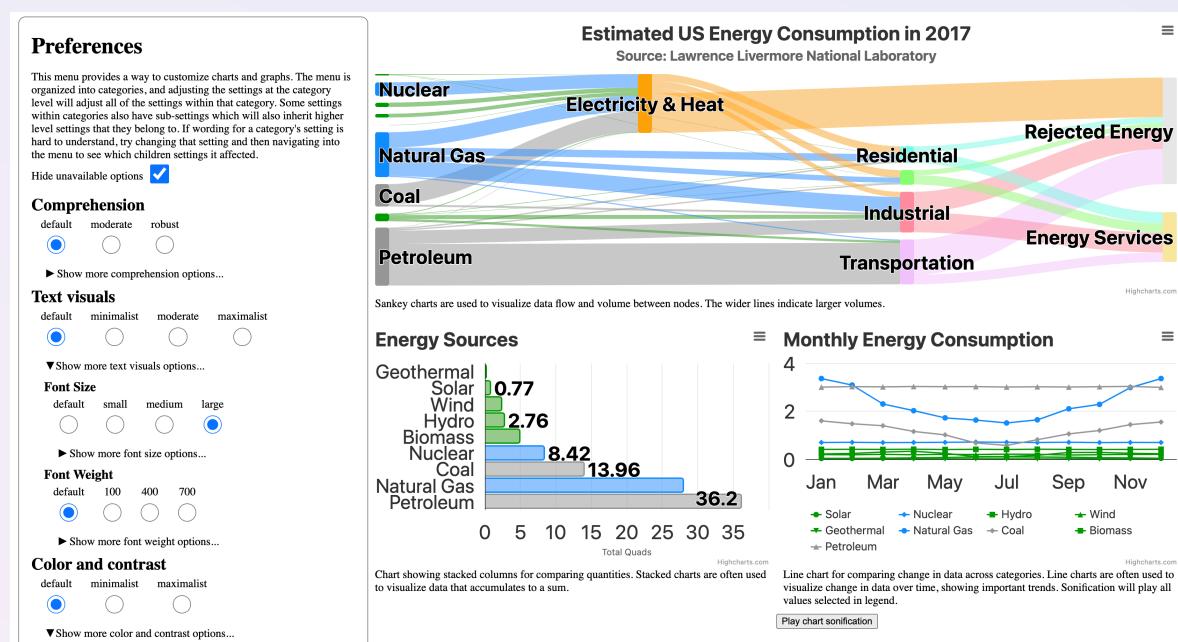
Samuel Butler



Working with people as they work with data is how you **build effective tools**.



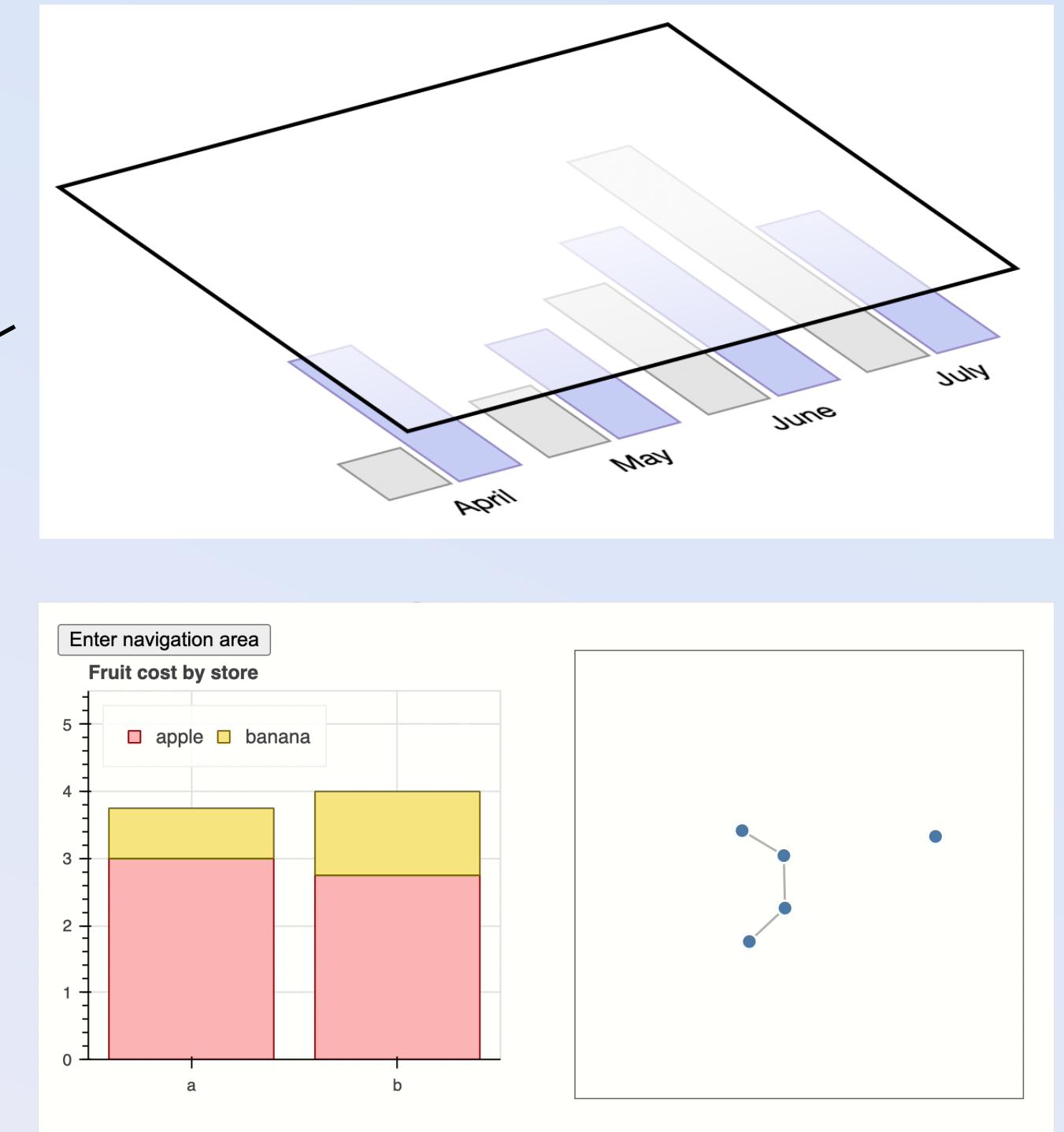
# Section 5: Future Work



**"Strictly speaking,  
nothing is a tool unless  
during actual use."**



**Working with people as they work with [3D graphics, games, data] is how you build effective tools.**



2025

[frank.computer](http://frank.computer)

# Tools for Accessible Data Interaction



Frank Elavsky



Human-  
Computer  
Interaction  
Institute



[hcii.cmu.edu](http://hcii.cmu.edu), [axle-lab.com](http://axle-lab.com), [dig.cmu.edu](http://dig.cmu.edu)