UW - 2026

frank.computer

Data, Accessibility, and Tools

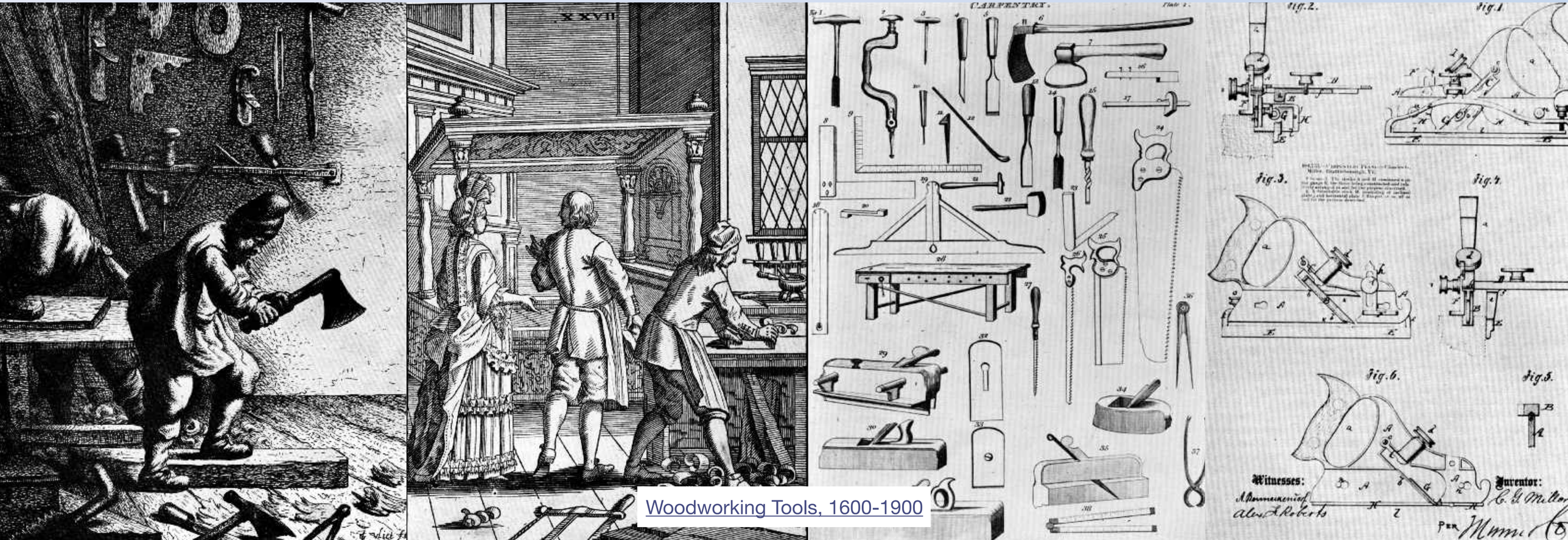
Frank Elavsky

Human-Computer Interaction Institute

hcii.cmu.edu, axle-lab.com, dig.cmu.edu

Credit: Jeff Kubina, Wikimedia

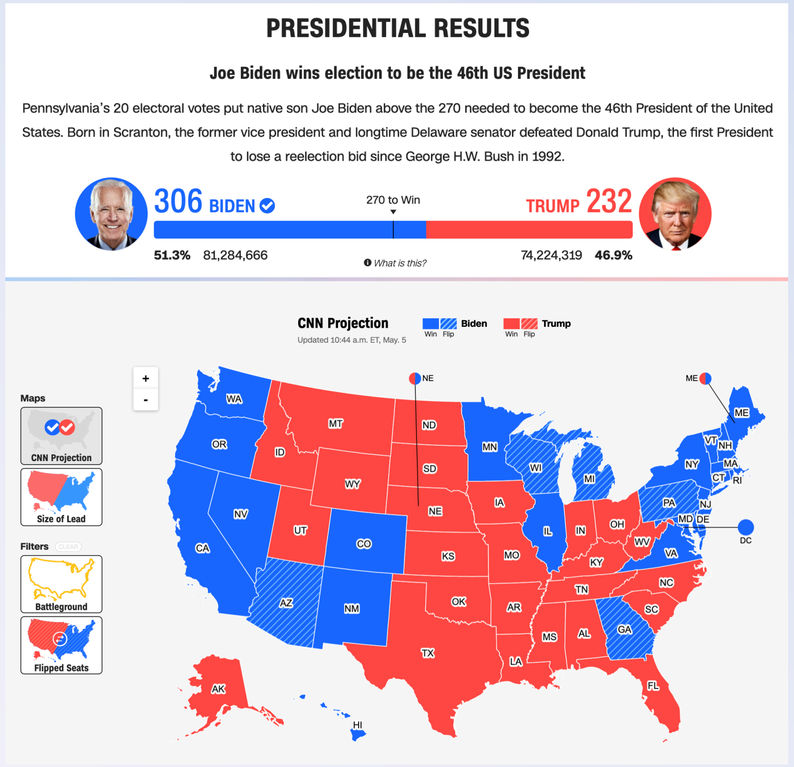
Human-tool interaction and the role of the tool-maker



Woodworking Tools, 1600-1900

People with disabilities deserve to:

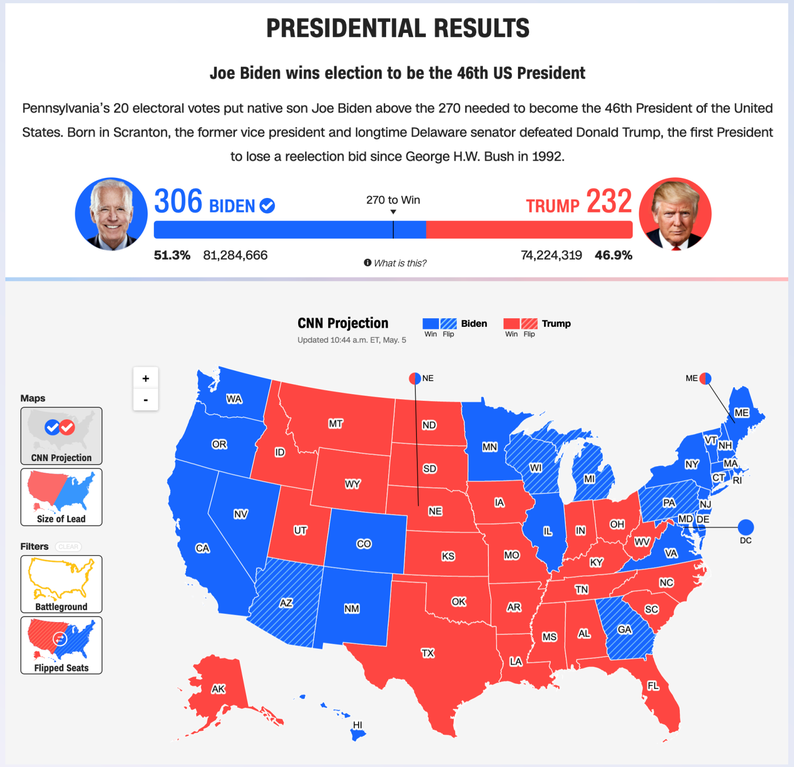
Participate in politics



Credit: CNN

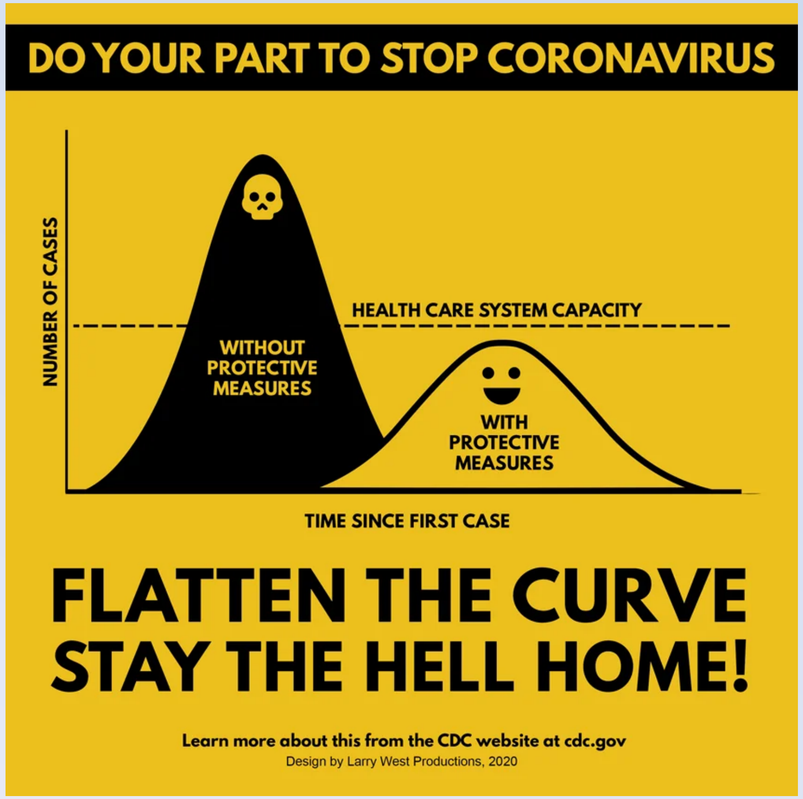
People with disabilities deserve to:

Participate in politics



Credit: CNN

Make informed decisions



Credit: Reddit

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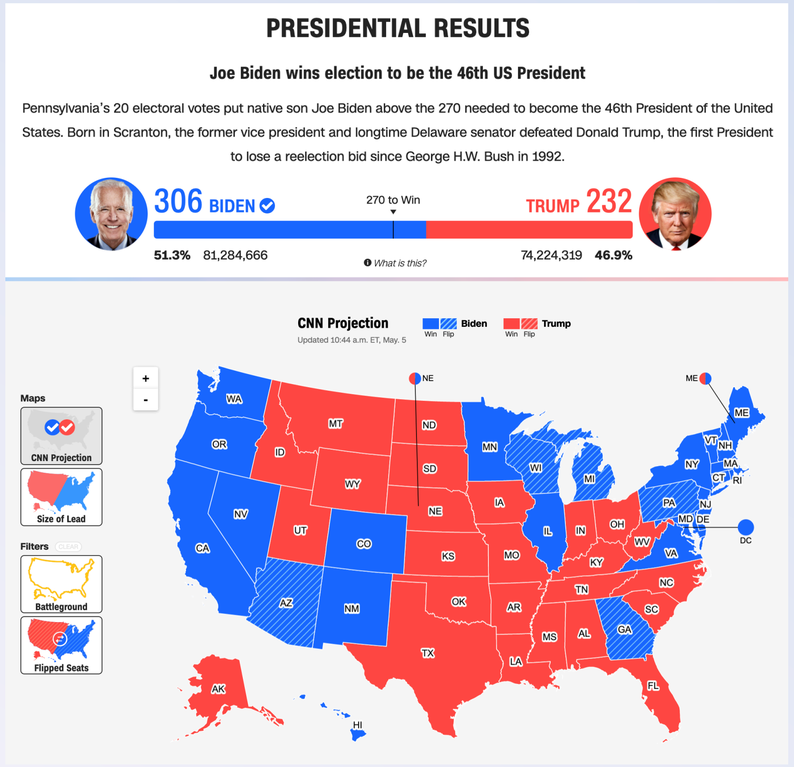
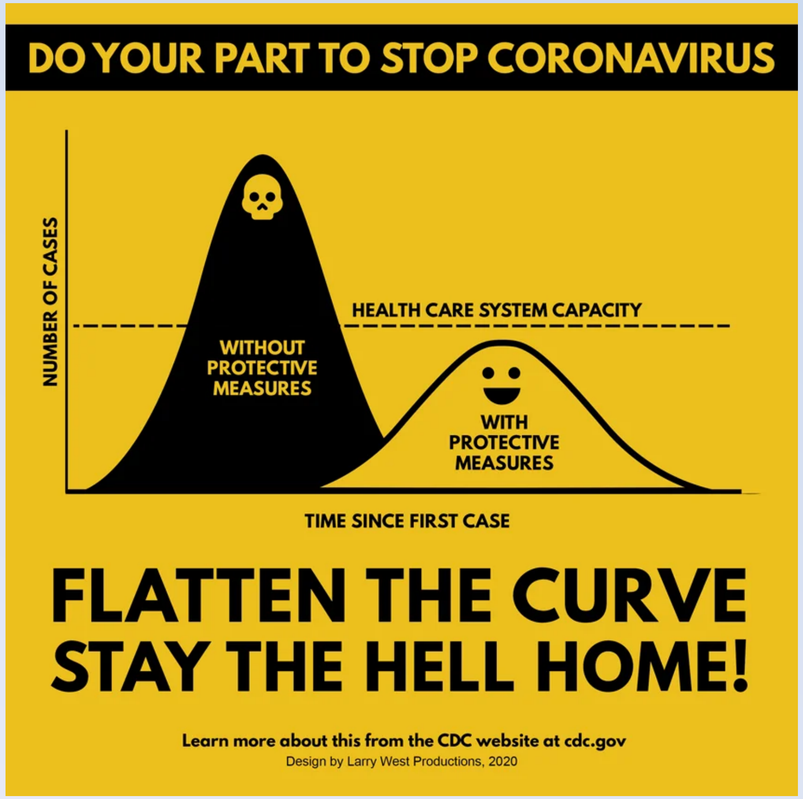


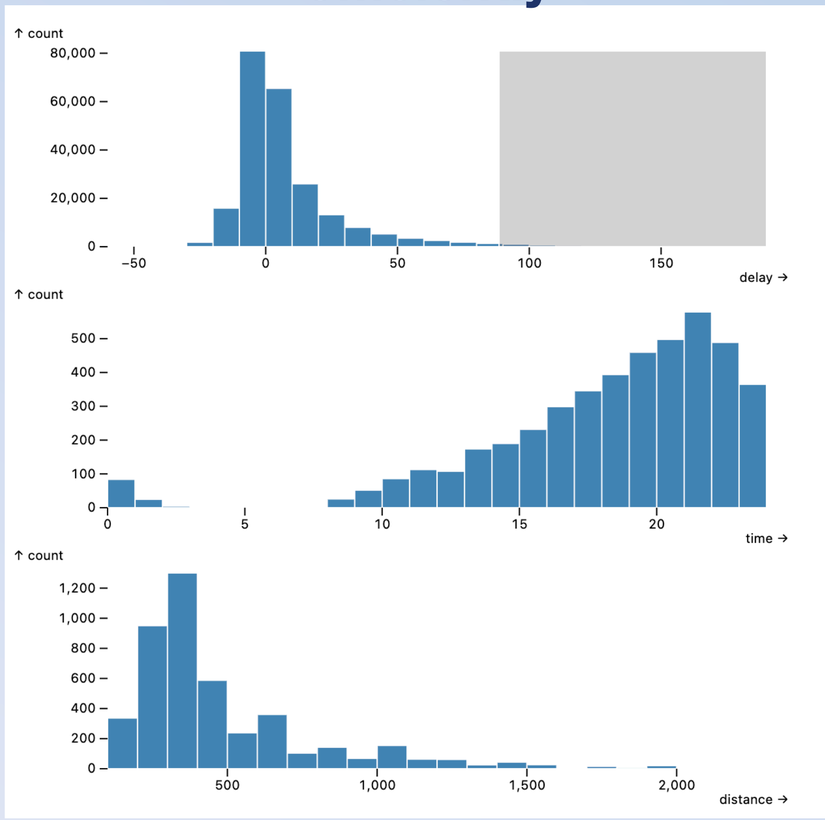
Credit: CNN

Make informed decisions



Credit: Reddit

Analyze data quickly and efficiently



Credit: Our research

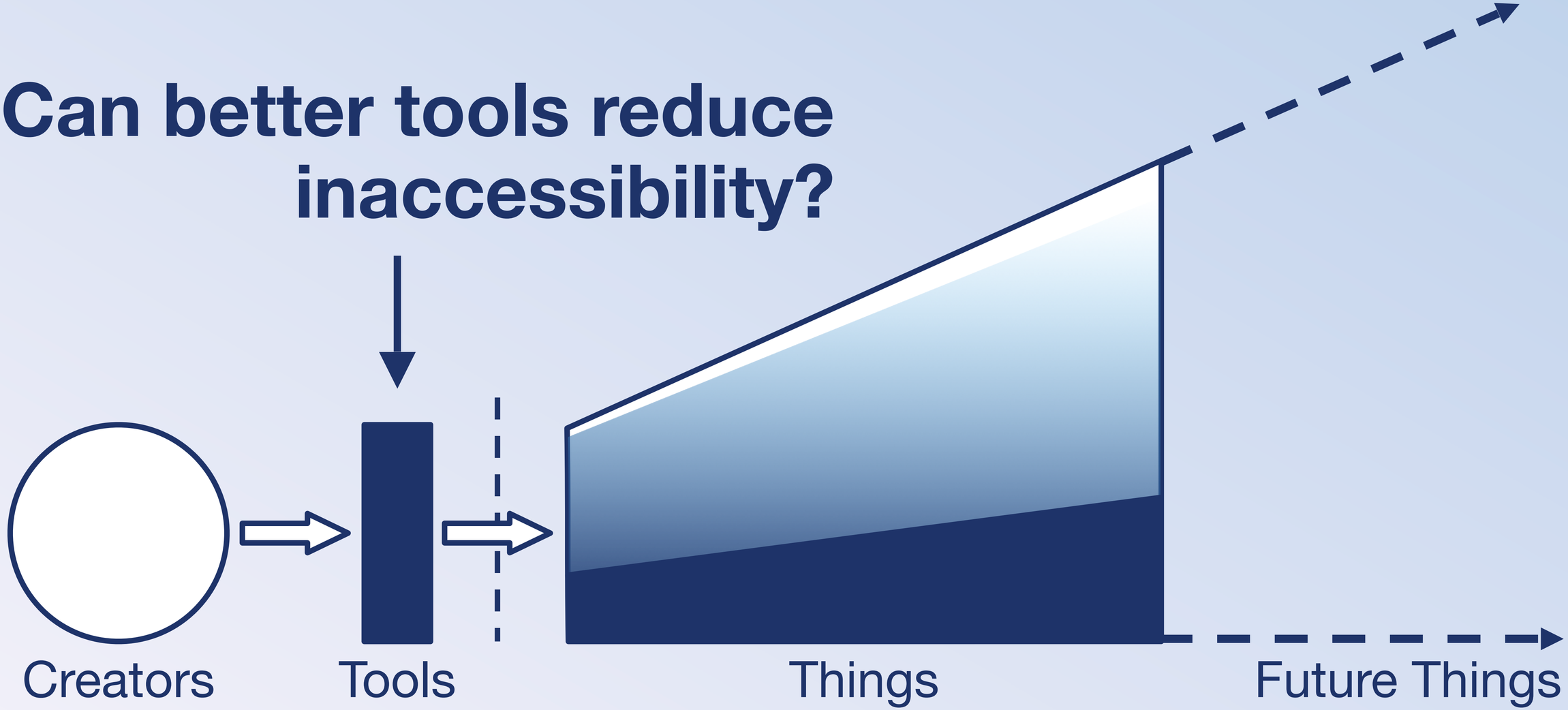
Tools serve the intentions of their creators

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

ge that

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

Can better tools reduce inaccessibility?



Data, Accessibility, and Tools

Tools for ***explanation***

Tools for ***exploration***

Tools for ***scale***

Industry work

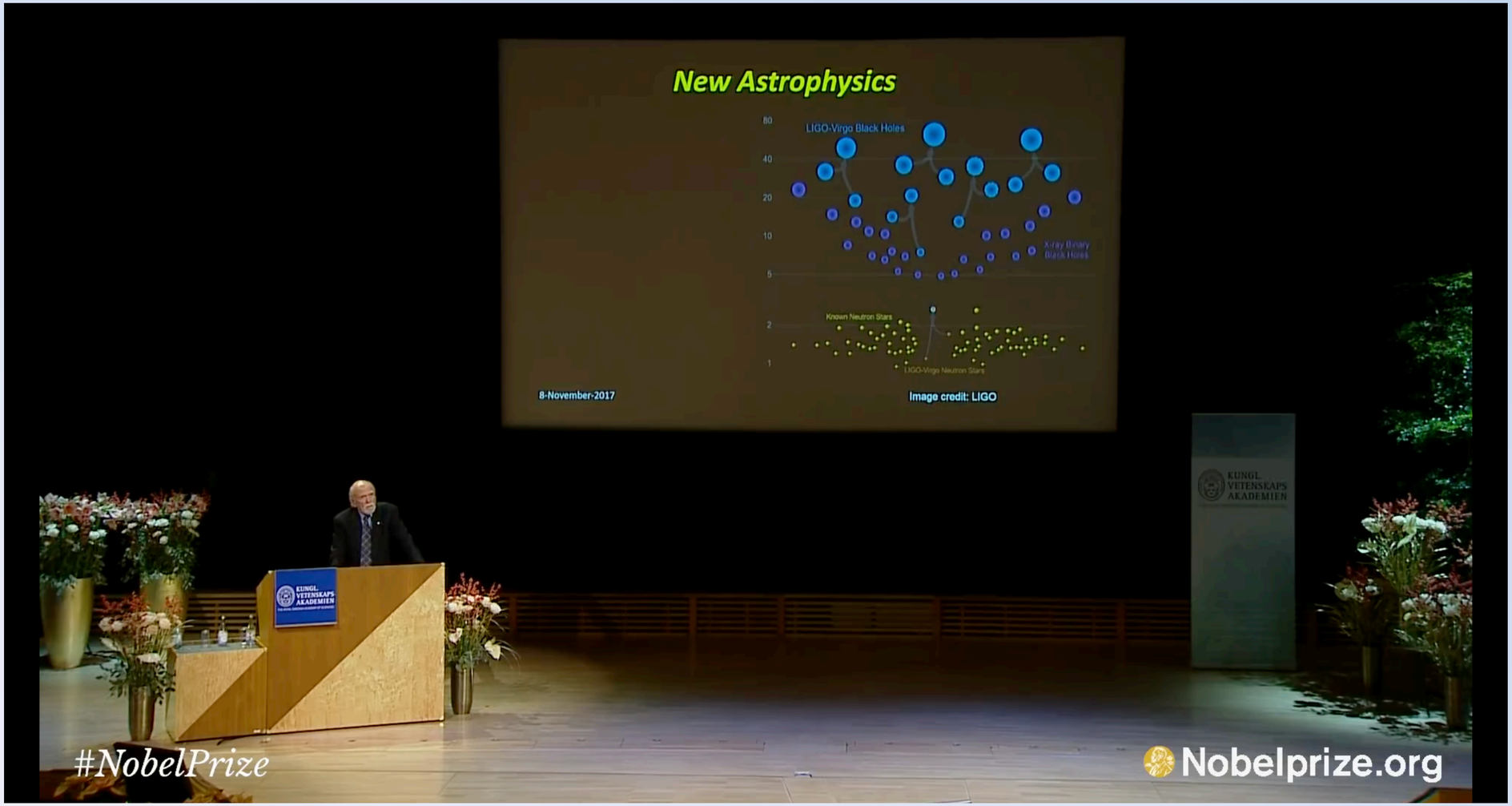
Tools for ***thinking***

Tools for ***complexity***

Tools for ***possibility***

PhD research

Tools for *explanation*: Empower people to communicate, teach, and captivate

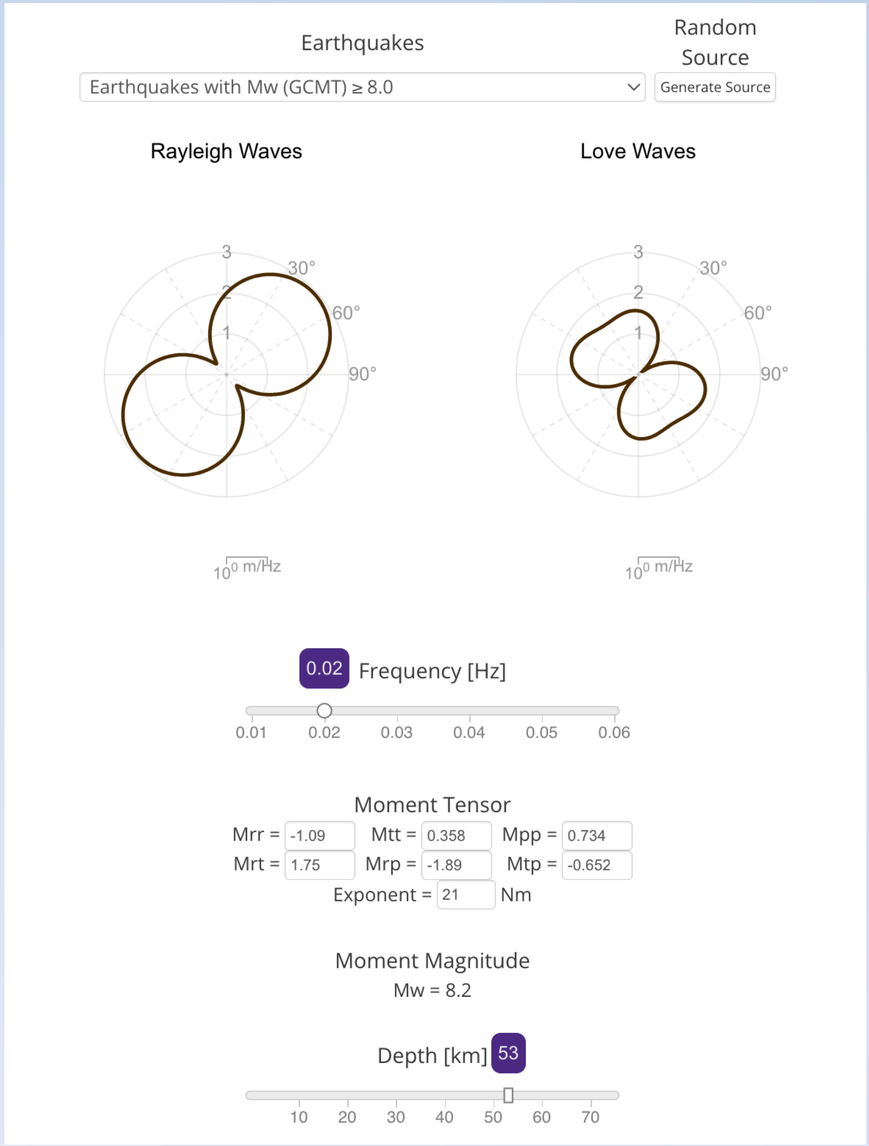


Source

Barish, B. C. (2018). Nobel Lecture: LIGO and gravitational waves II. Reviews of Modern Physics, 90(4). doi:10.1103/revmodphys.90.040502

Tools for *exploration*: Provide people with methods for discovery

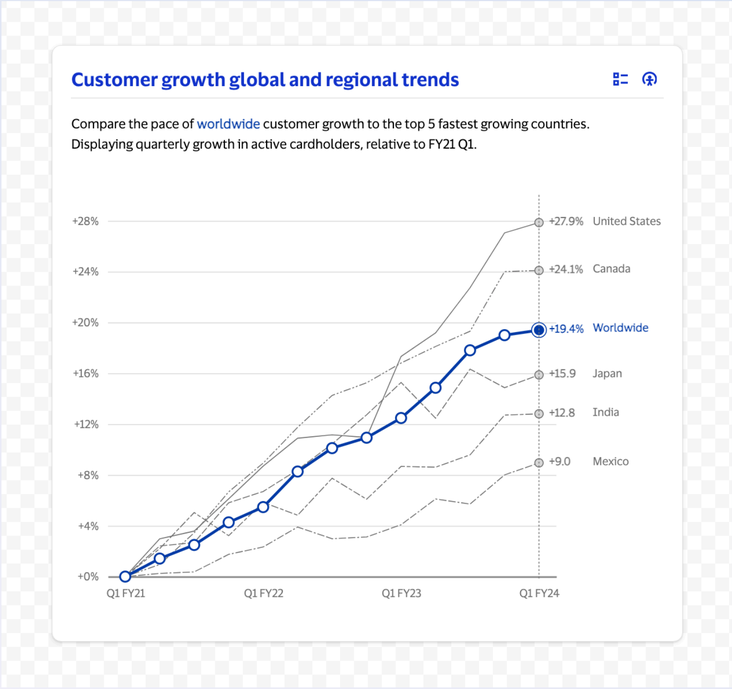
Arbitrary (and data-driven) surface wave model visualization for seismologists

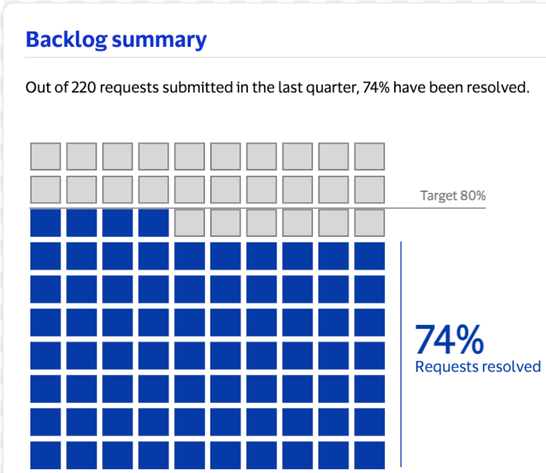


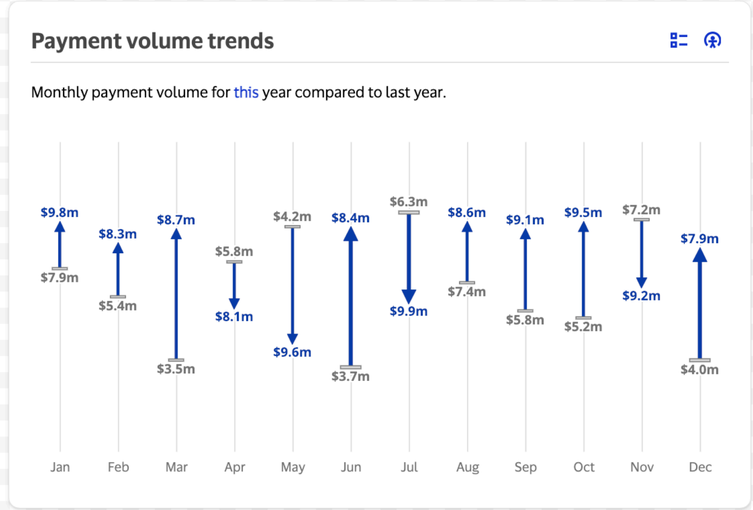
Rösler, B., and S. van der Lee (2020). Using Seismic Source Parameters to Model Frequency-Dependent Surface-Wave Radiation Patterns. Seismol. Res. Lett. 91, 992–1002, doi:10.1785/0220190128.

Tools for *scale*:
Drive people to build better and faster

Visa Chart Components and “out of the box” accessibility





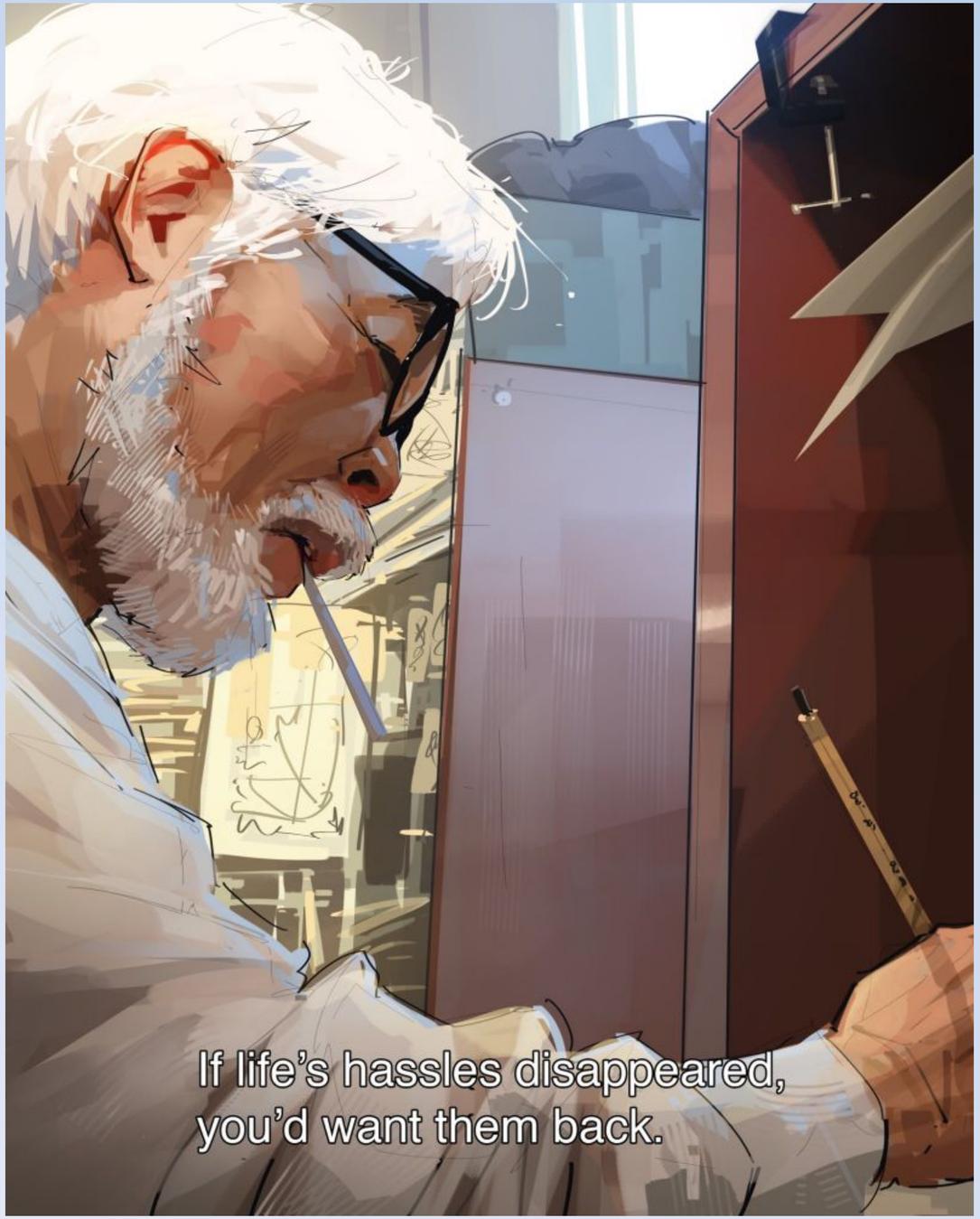


Visa Chart Components, Visa Design System

Automatic accessibility validation

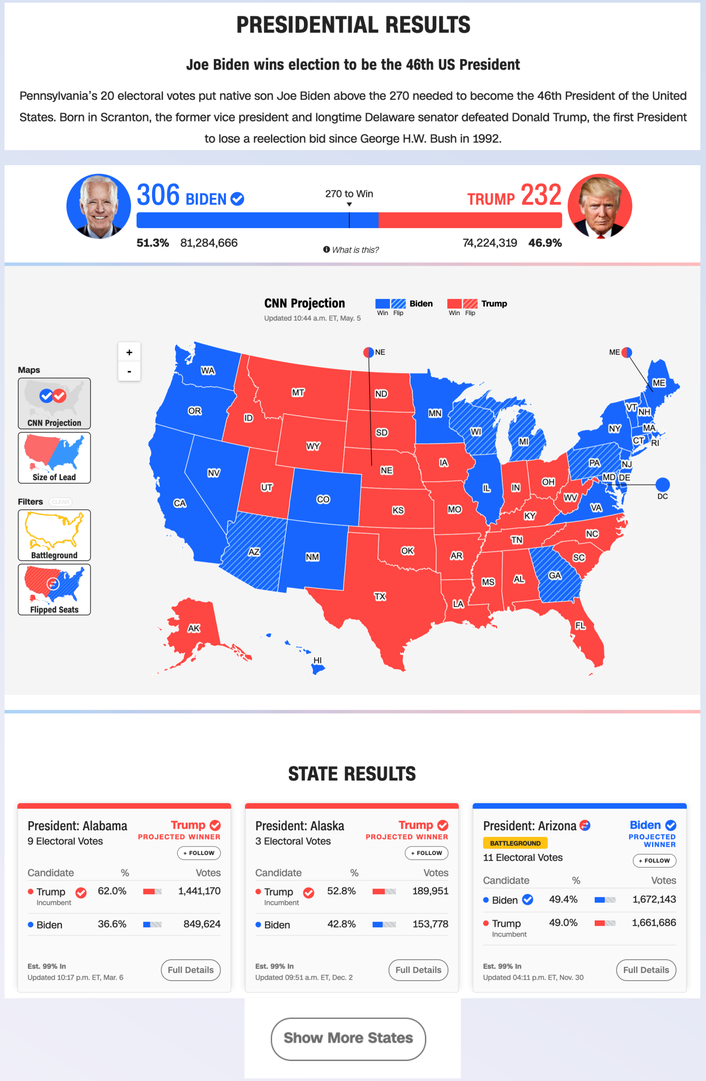
```
▸ bar-chart-1 has strong accessibility recommendations                    bar-chart.entry.js:49478
▾ bar-chart-2 has accessibility warnings and other messages               bar-chart.entry.js:49497
  ⚠ ▸                                                                     bar-chart.entry.js:49499
    longDescription: Either accessibility.longDescription or accessibility.contextExplanation is
    required
  ⚠ ▸                                                                     bar-chart.entry.js:49499
    executiveSummary: Either accessibility.purpose or accessibility.executiveSummary is required
  ⚠ ▸                                                                     bar-chart.entry.js:49499
    elementsAreInterface: elementsAreInterface must be a `boolean` type, but the final value was:
    `null`.
    If "null" is intended as an empty value be sure to mark the schema as `.nullable()`
                                                                          bar-chart.entry.js:49481
    longDescription: Either accessibility.longDescription or accessibility.contextExplanation
    should have minimum 40 characters and a combined length between 40 and 500 characters
                                                                          bar-chart.entry.js:49481
    executiveSummary: Either accessibility.purpose or accessibility.executiveSummary should have
    minimum 40 characters and a combined length between 40 and 250 characters
                                                                          bar-chart.entry.js:49481
    statisticalNotes: accessibility.statisticalNotes should have length between 40 and 250
    characters
                                                                          bar-chart.entry.js:49481
    structureNotes: accessibility.structureNotes should have length between 40 and 250 characters
```

“If life’s hassles disappeared, you’d want them back”
- Hiyao Miyazaki



Art credit: Sam Yang

Tools for *thinking*: Help people to evaluate critically



How do you find and evaluate access barriers in interactive visualizations?

Chartability is a workbook of tests, tools, and principles

How do you use Chartability?

There are a lot of different ways to perform an audit, and so there are also many different ways to use Chartability. Sometimes an audit is as casual as checking your work while you do it. And other times it is a big affair that involves teams of specialists and lawyers.

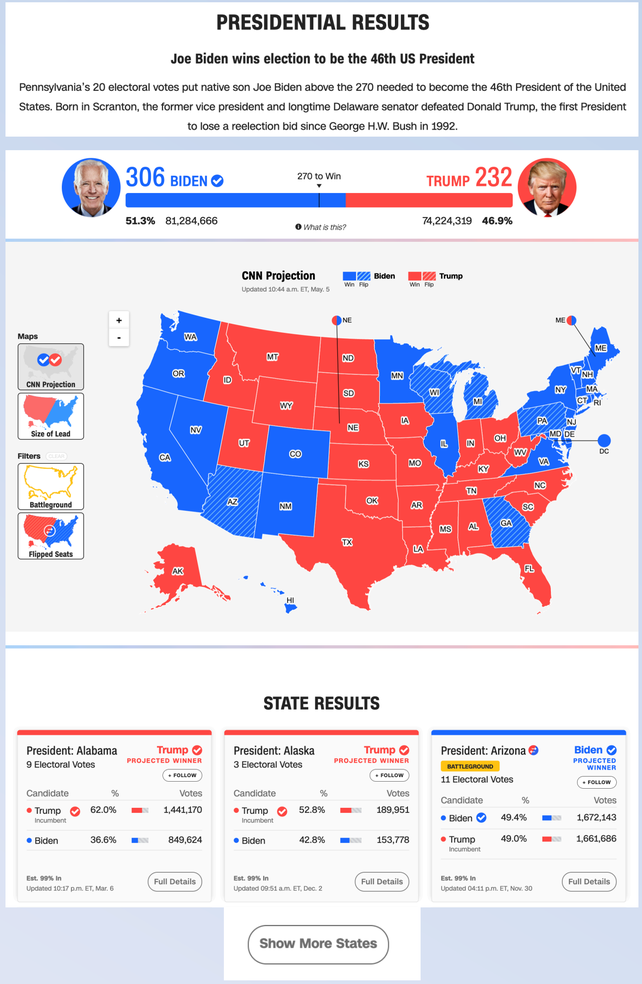
Realistically, while a highly trained auditor may be able to casually evaluate an artifact in as little as 30 minutes or even hold heuristics in mind as they are doing their own creative work, those new to auditing may take anywhere between 2 and 8 hours to complete a full pass of Chartability. Professional audits, which can take weeks or months, often include multiple auditors and provide rigorous documentation and detailed recommendations for remediation, typically in the form of a report. Chartability is meant to serve both quick pass and deep dive styles of audits, so users are expected to leverage it as they see fit.

Below we give an example of what might be a fast pass audit, using Chartability, in 5 steps. This isn't super thorough, but a good way to quickly check a handful of access barriers quickly.

1. Visual Testing

Figure 1: A low contrast chart (left) compared to a higher contrast version (right). A dropper tool is extracting the fill color of the bar and then a contrast ratio has been calculated. Note that the fill color is the same on both bars, but darker borders have been added to ensure the visualization passes contrast tests.

Checking for contrast is the most common critical failure across all of our audits (88% of audits failed this heuristic). In order to evaluate contrast, often a combination of automatic (code-driven) and manual tooling is performed. When manually auditing, practitioners typically use a dropper and a contrast calculator (Figure 1). Contrast is measured by finding adjacent colors that are intended to convey meaning or boundaries, and finding a ratio between them. Standards require a different minimum contrast for text (4.5:1) than geometries like marks in a chart (3:1). Most auditors find this to be one of the easiest tasks to perform, but techniques can be tricky to handle. Testing for contrast accomplishes 3 different heuristics in Chartability: ensuring text/geometries have contrast, interactive states for elements have enough contrast change, and the keyboard focus indicator is easy to distinguish.



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

Chartability is used in:

15+ Policy orgs and governments worldwide

150+ Tech, news, and non-profit companies/orgs

24+ Undergraduate and graduate courses

World Health Organization

European Commission

USWDS

Microsoft

GitHub

Azure

jupyter

HIGHCHARTS

Adobe

The New York Times

REUTERS

BBC

Carnegie Mellon University

Massachusetts Institute of Technology

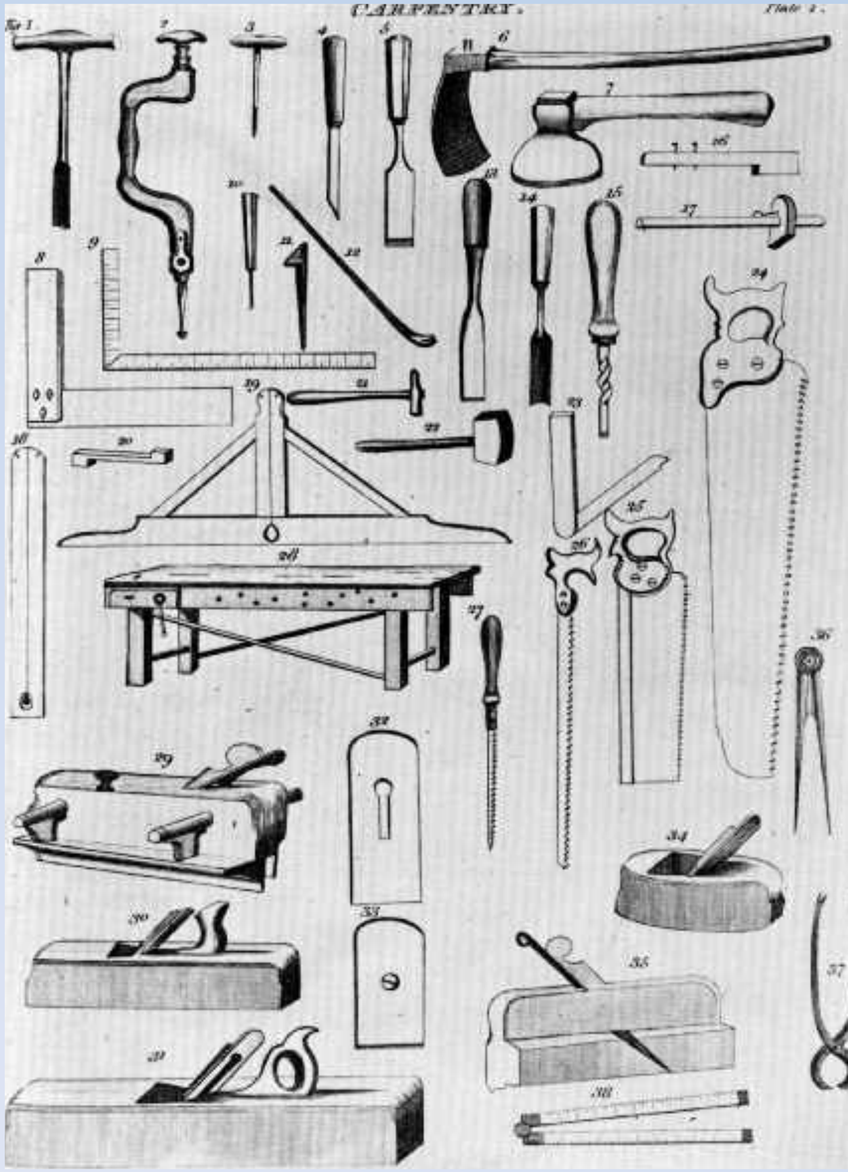
UNIVERSITY of WASHINGTON

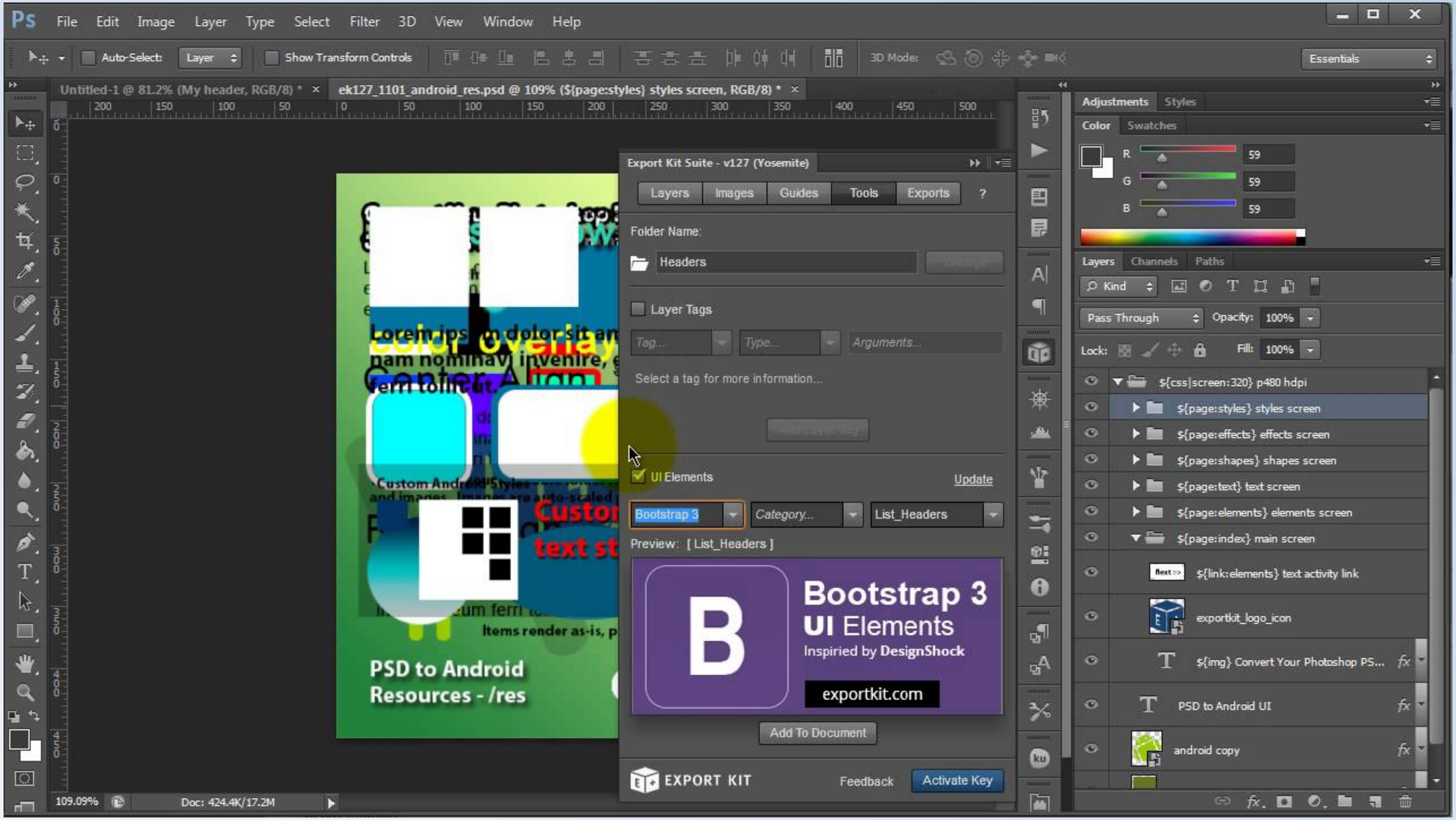
Northwestern University

COLUMBIA UNIVERSITY IN THE CITY OF NEW YORK

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

Tools for *complexity*: Give people building blocks for assembly




Export Kit Suite - v127 (Yosemite)
Layers
Images
Guides
Tools
Exports
Folder Name:
Headers
Layer Tags
Select a tag for more information...
UI Elements
Update
Bootstrap 3
Category...
List_Headers
Preview: [List_Headers]
Bootstrap 3
UI Elements
Inspiried by DesignShock
exportkit.com
Add To Document
EXPORT KIT
Feedback
Activate Key
PSD to Android
Resources - /res
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Styles
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Swatches
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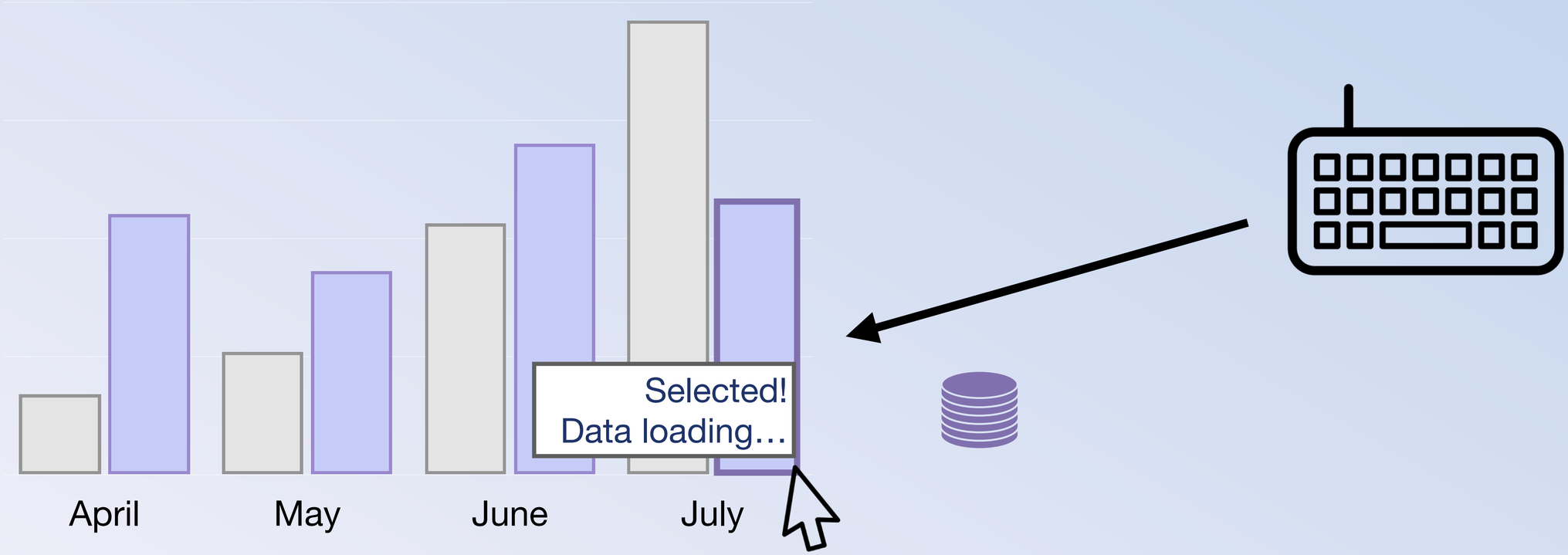
${page:index} main screen
${link:elements} text activity link
exportkit_logo_icon
${img} Convert Your Photoshop PS...
PSD to Android UI
android copy

A keyboard should be able to do everything a mouse can



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

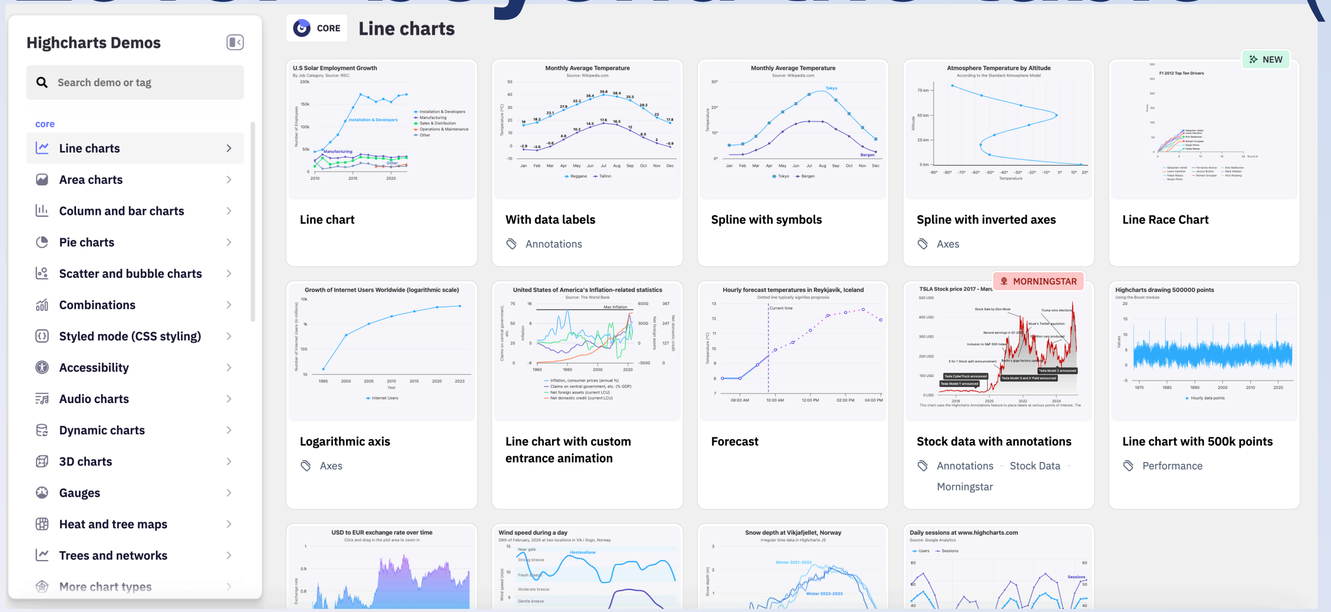
Discrete and direct navigation face more barriers

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.

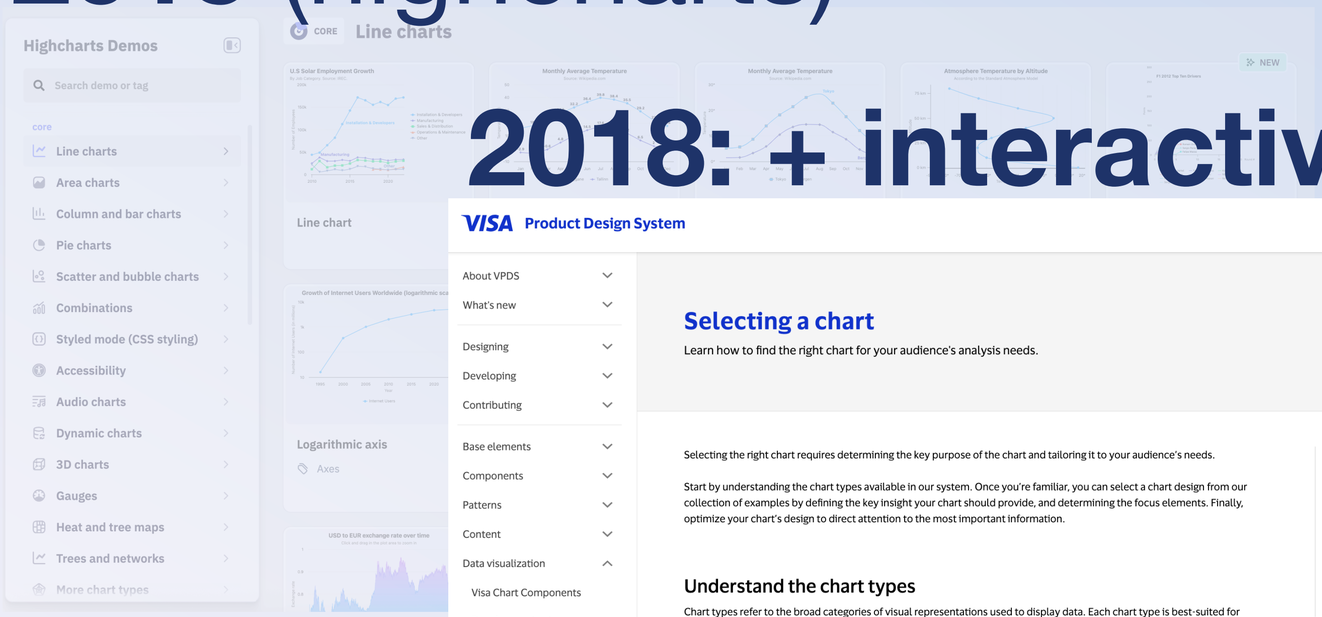
Rich navigation (a short history)

2015: “beyond the table” (highcharts)



Rich navigation (a short history)

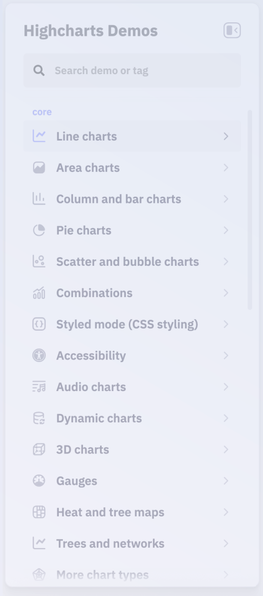
2015 (highcharts)

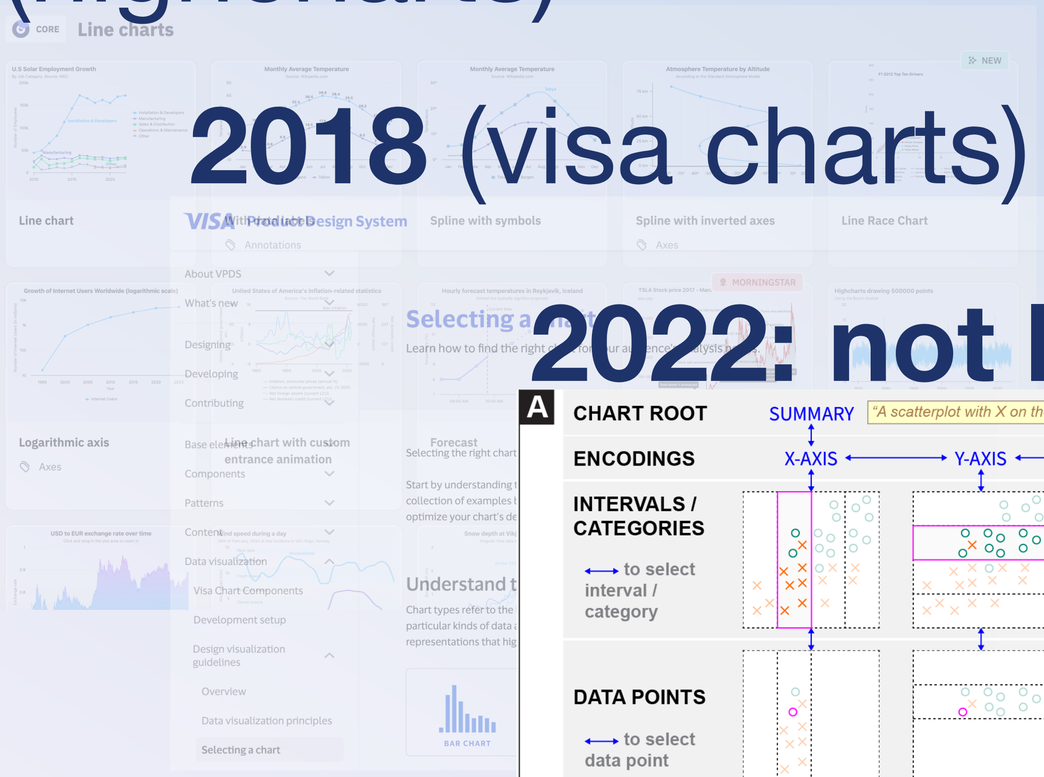


2018: + interactivity (visa charts)

Rich navigation (a short history)

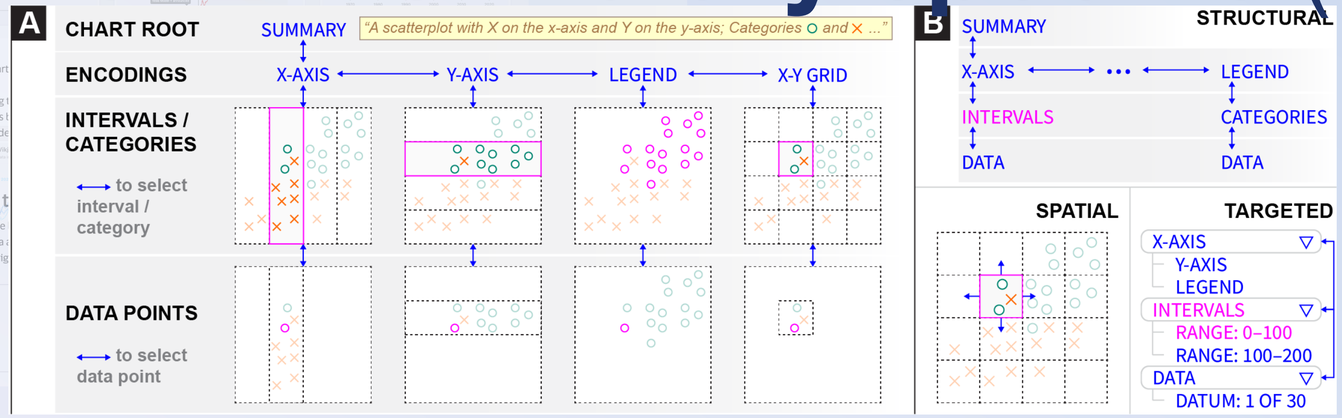
2015 (highcharts)





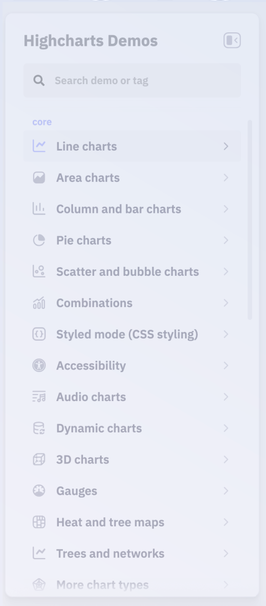
2018 (visa charts)

2022: not library specific (olli)



Rich navigation (a short history)

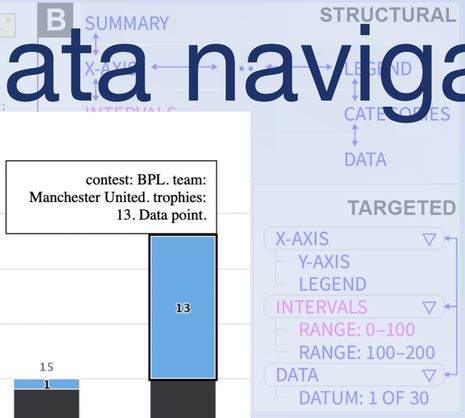
2015 (highcharts)

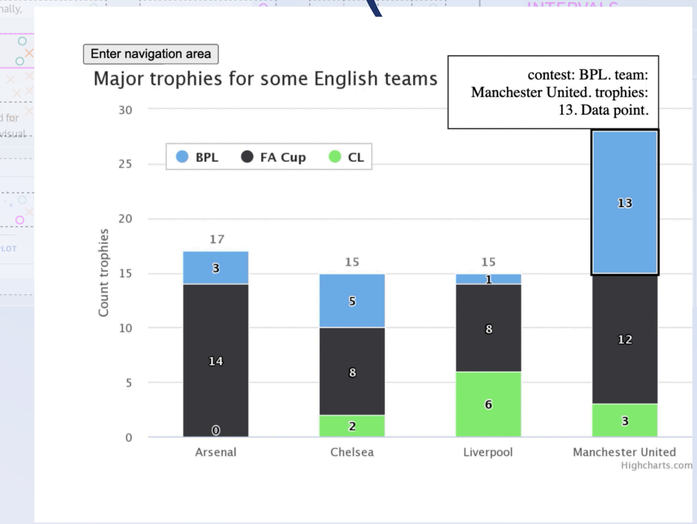


2018 (visa charts)

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.

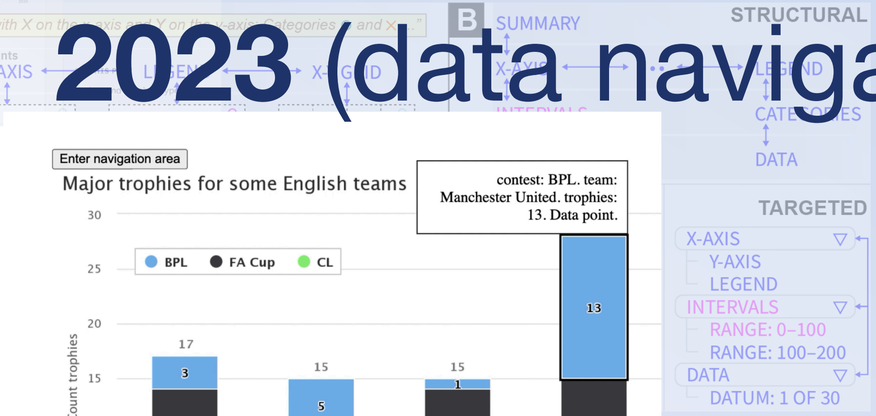
Rich navigation (a short history)

2015 (highcharts)

2018 (visa charts)

2022 (olli)

2023 (data navigator)



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Rich navigation (a short history)

2015 (highcharts)

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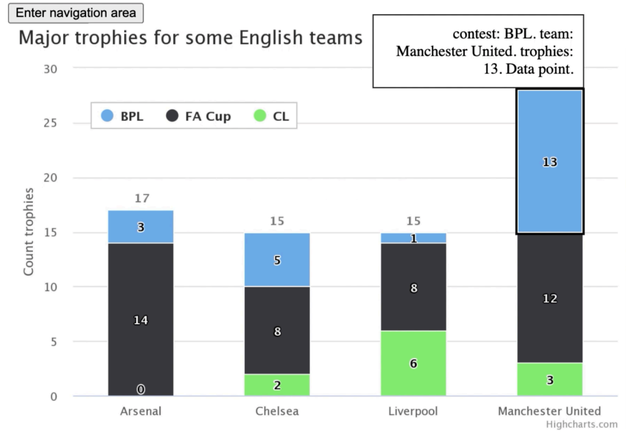
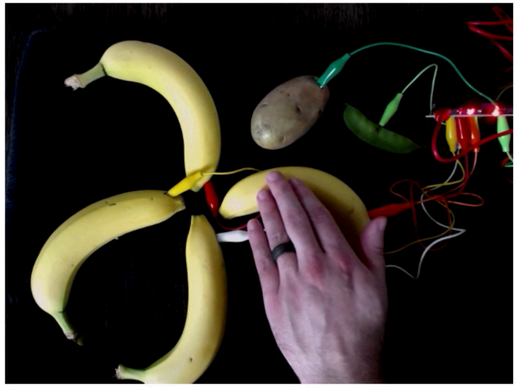
2022 (olli)

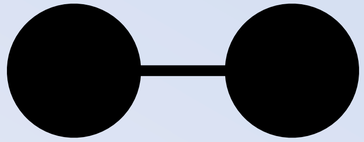
2023 (data navigator)





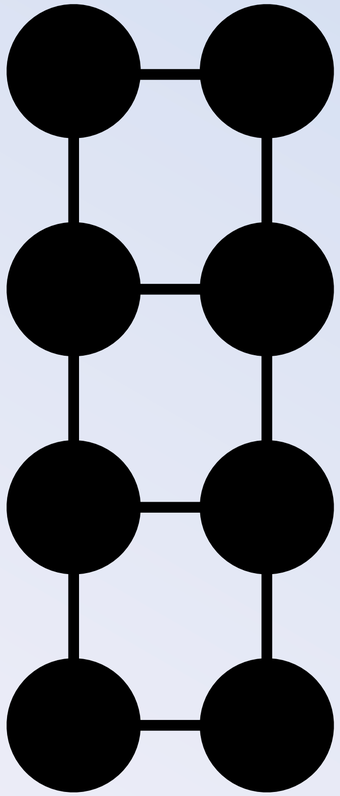
F. Elavsky, L. Nadolskis, and D. Moritz, "*Data Navigator*: An Accessibility-Centered Data Navigation Toolkit," *IEEE Transactions on Visualization and Computer Graphics*, 2023.

Structure is a *graph*: nodes and edges

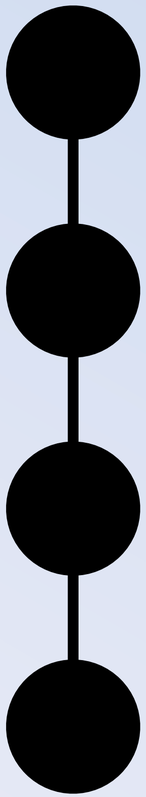


Graphs can create nearly all *other* structures

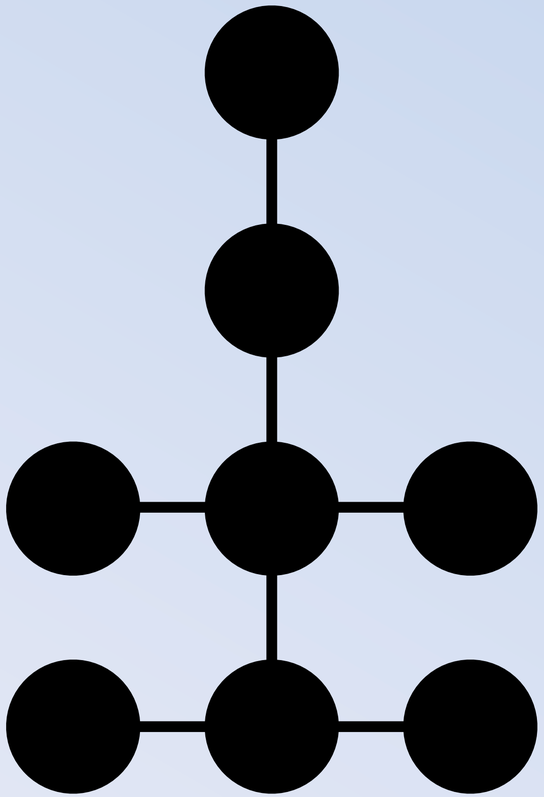
Tables



Lists

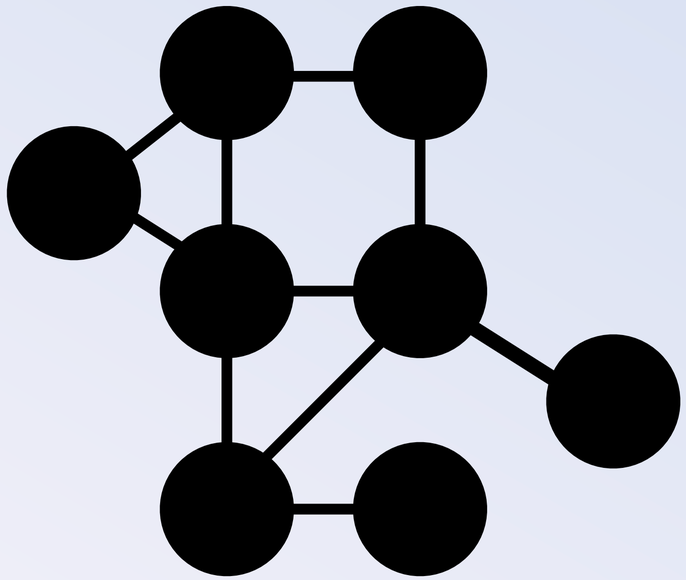


Hierarchies

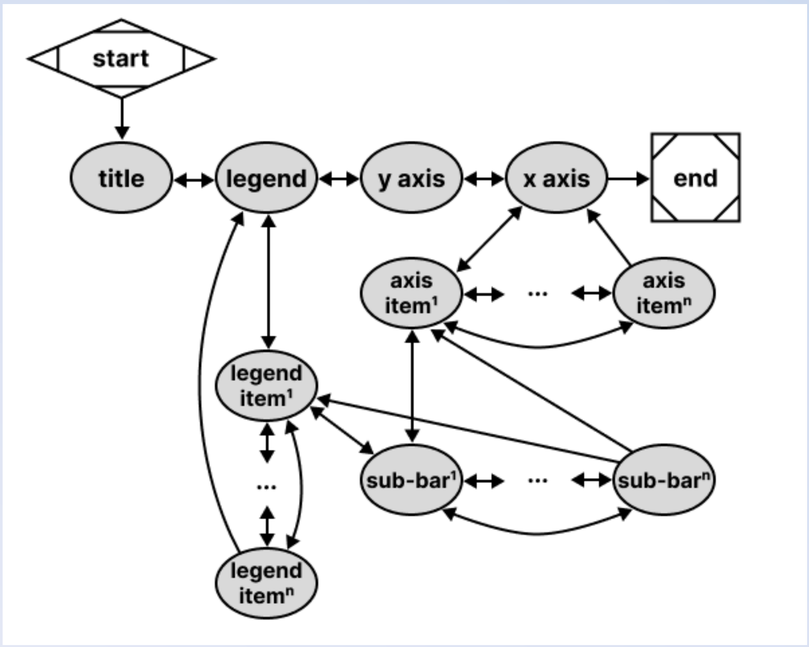


Nodes can become virtually anything

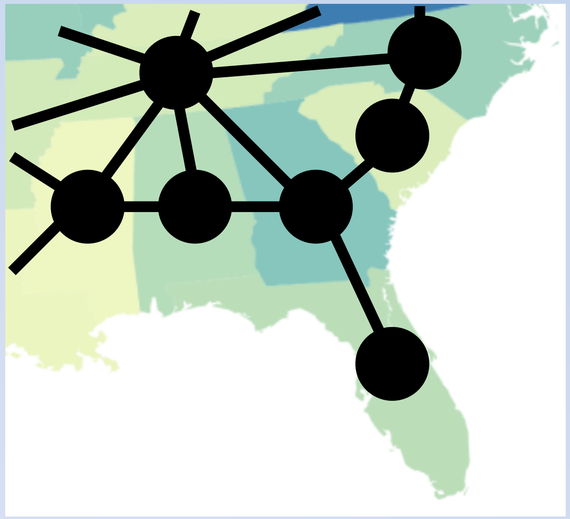
Network graphs



Diagrams



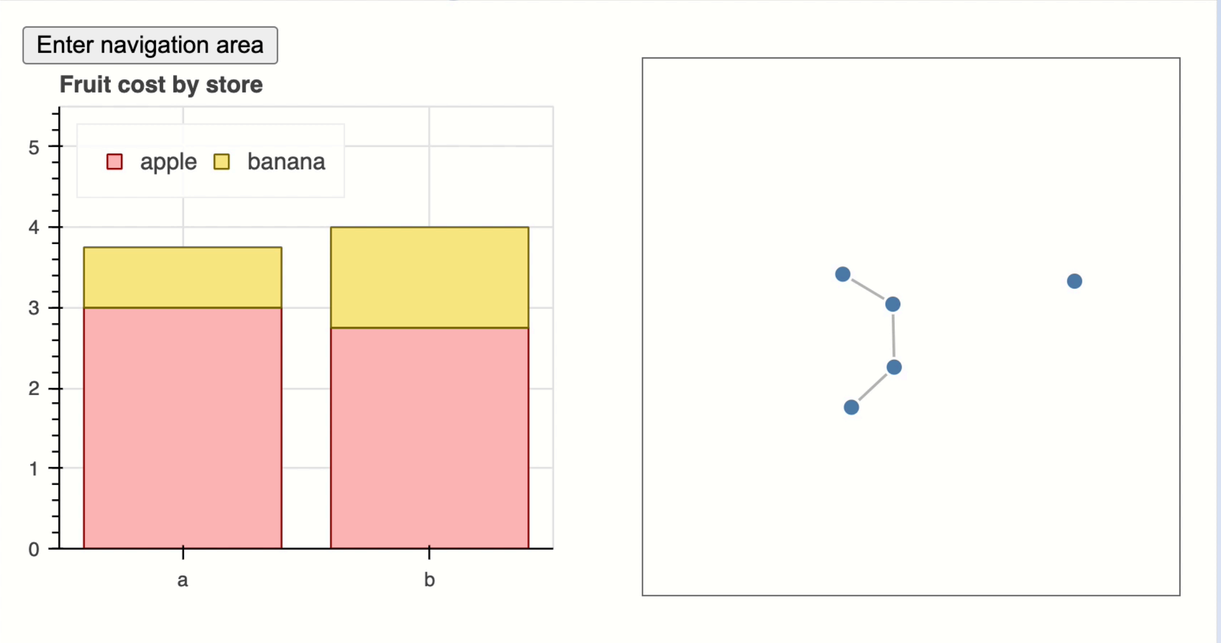
Maps



Data Navigator: Empowering practitioners

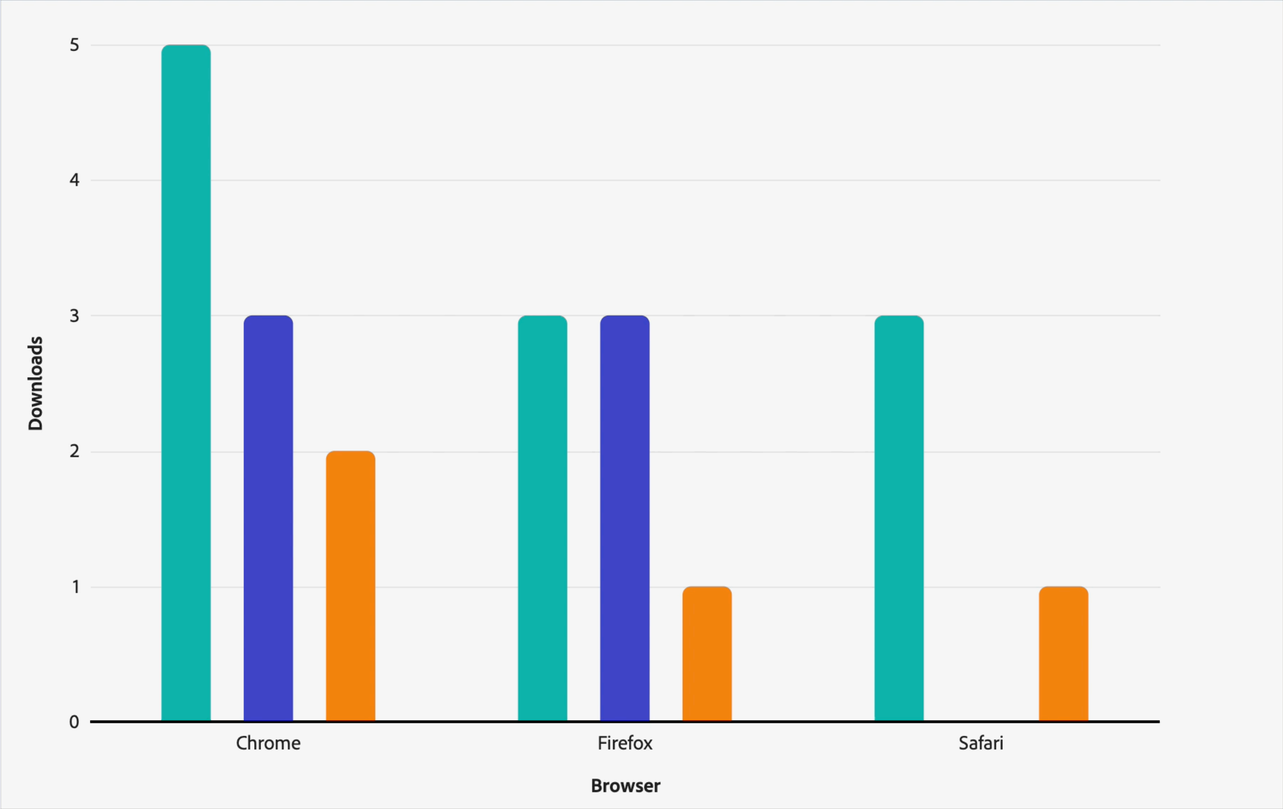
Bokeh, a python visualization library

(Acquired $200k USD CZI EOSS Grant with Quansight+Anaconda)

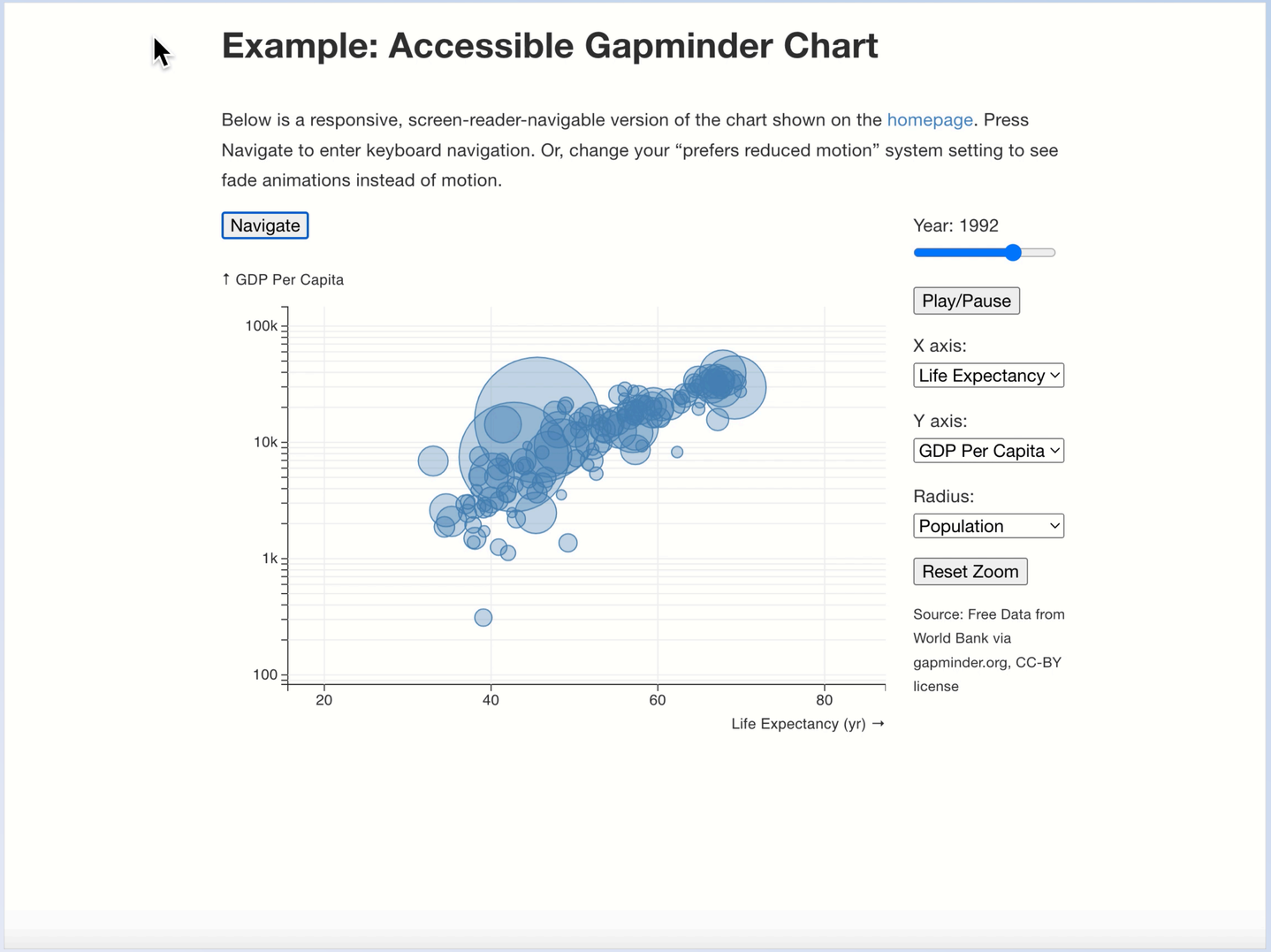


Data Navigator: Empowering practitioners

React Spectrum Charts, Adobe's visualization design system (Acquired $40k prototype funding + $200k research gift)

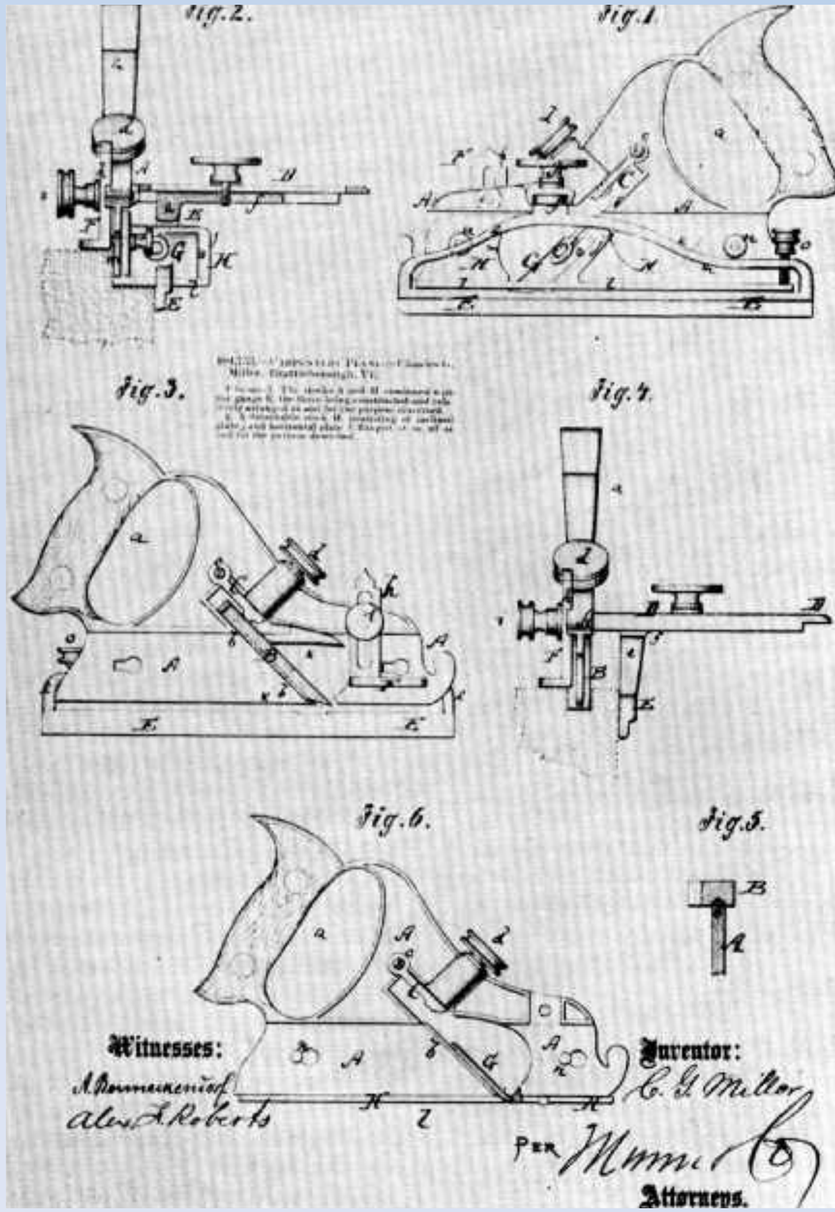


Navigation + Animation

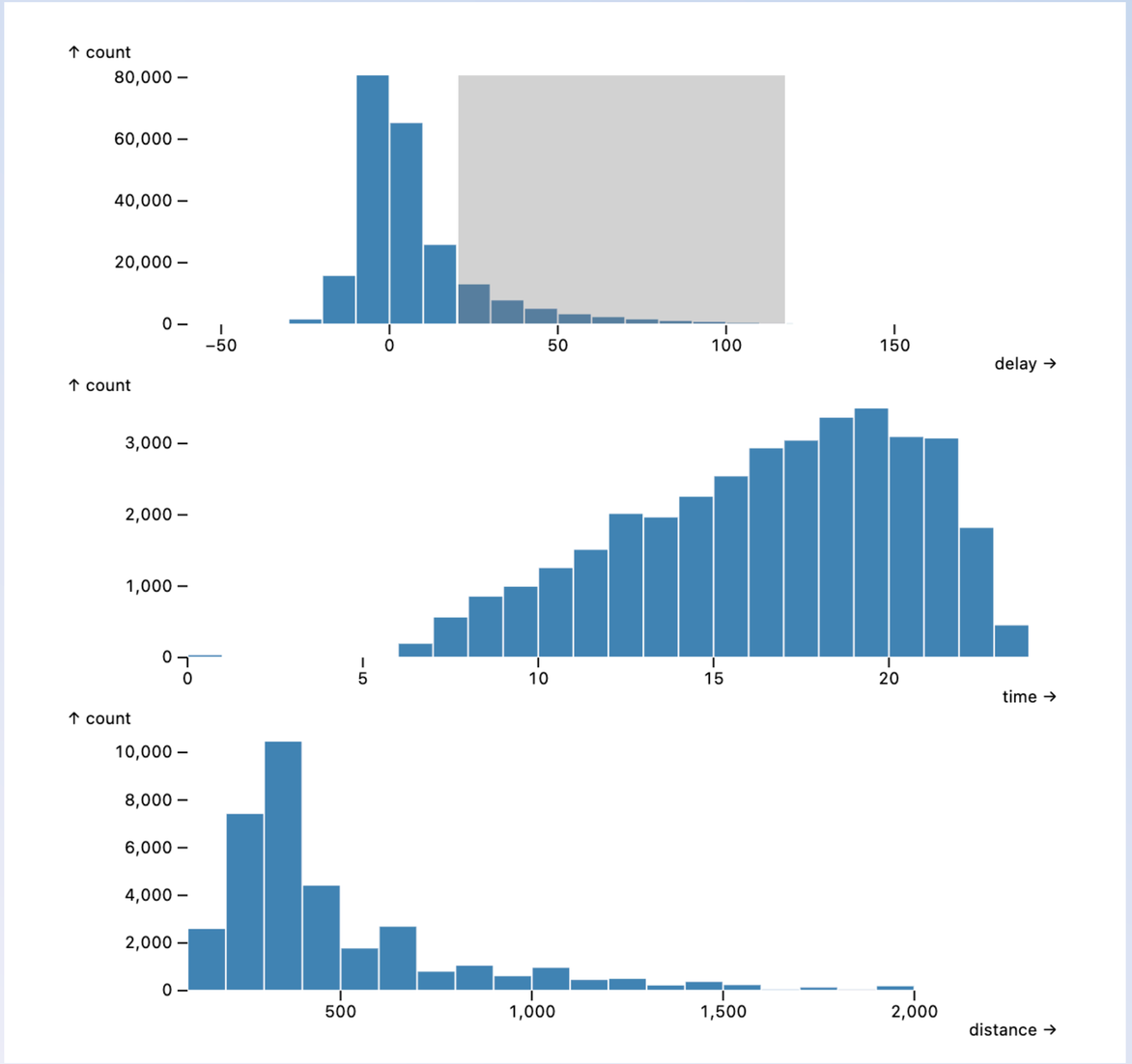


V. Sivaraman, **F. Elavsky**, D. Moritz, and A. Perer. “Counterpoint: Orchestrating large- scale custom animated visualizations.” *IEEE Visualization and Visual Analytics,* 2024.

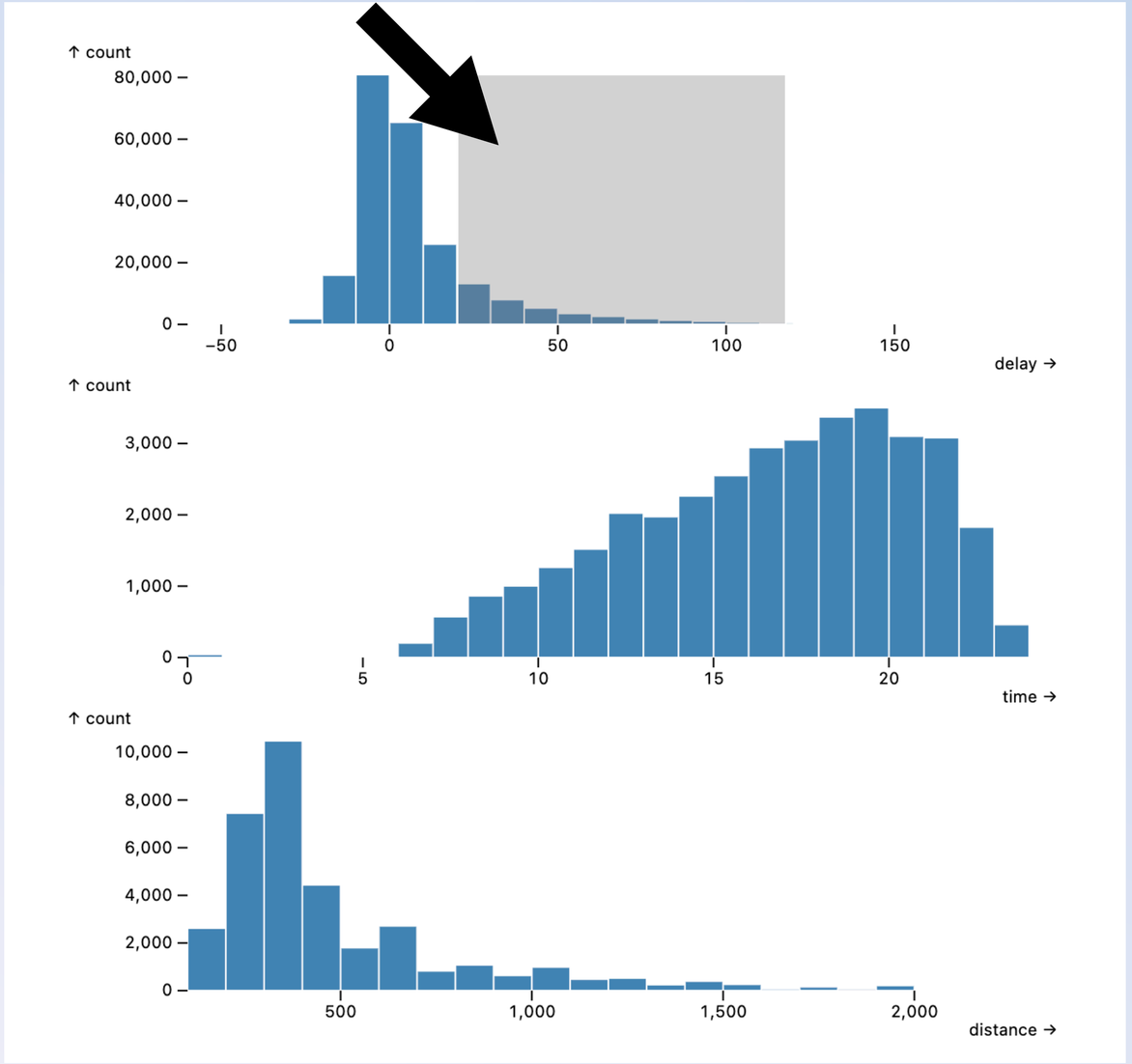
Tools for *possibility*: Enable people with new materials



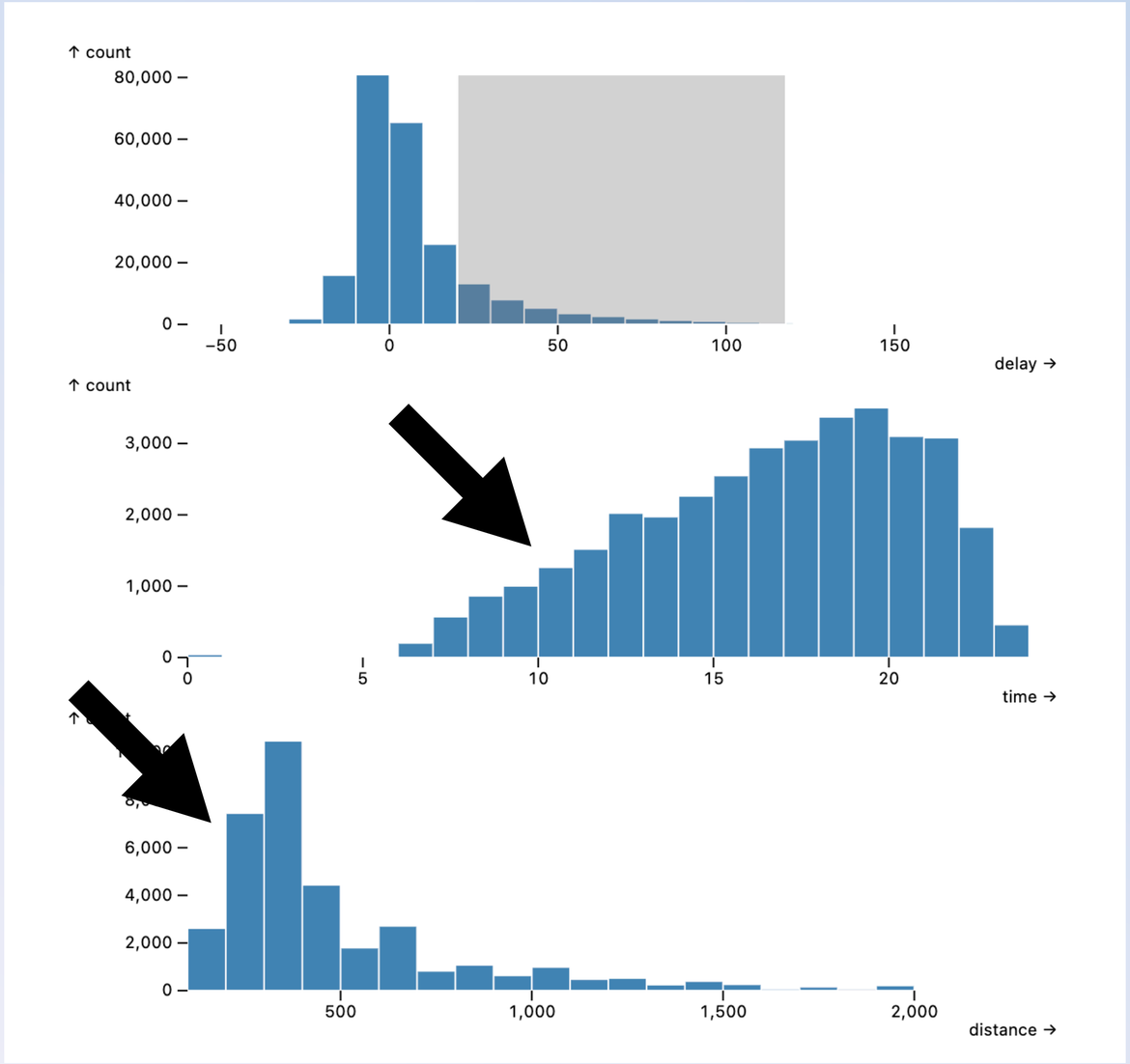
So what about cross-filtering?



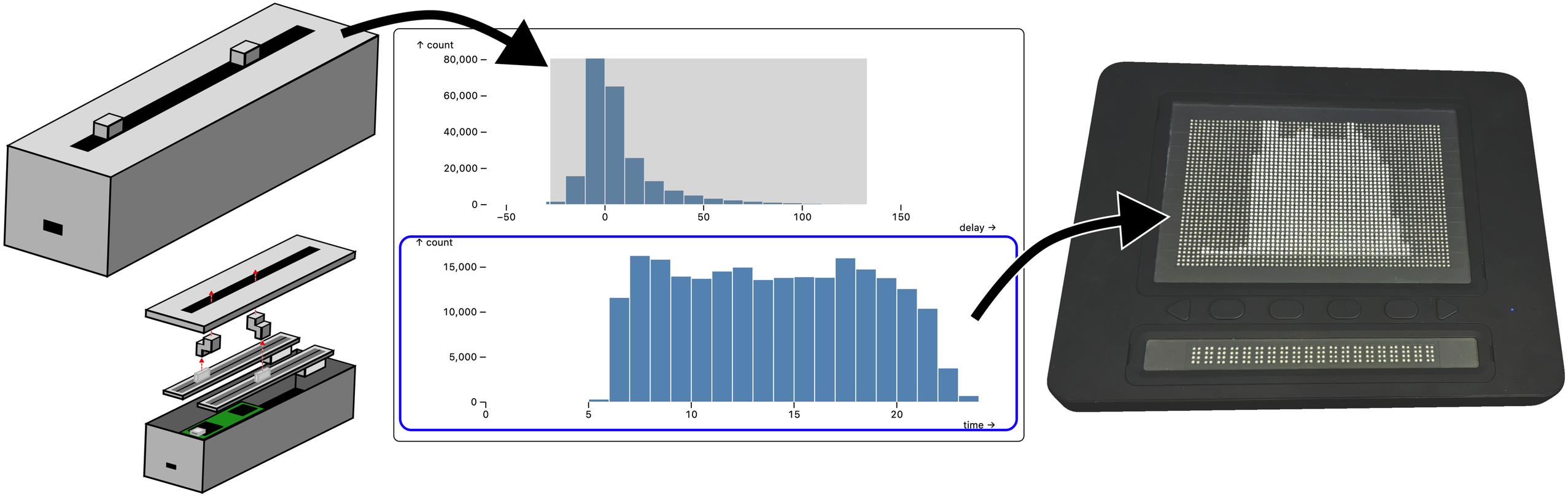
Interaction in one space…



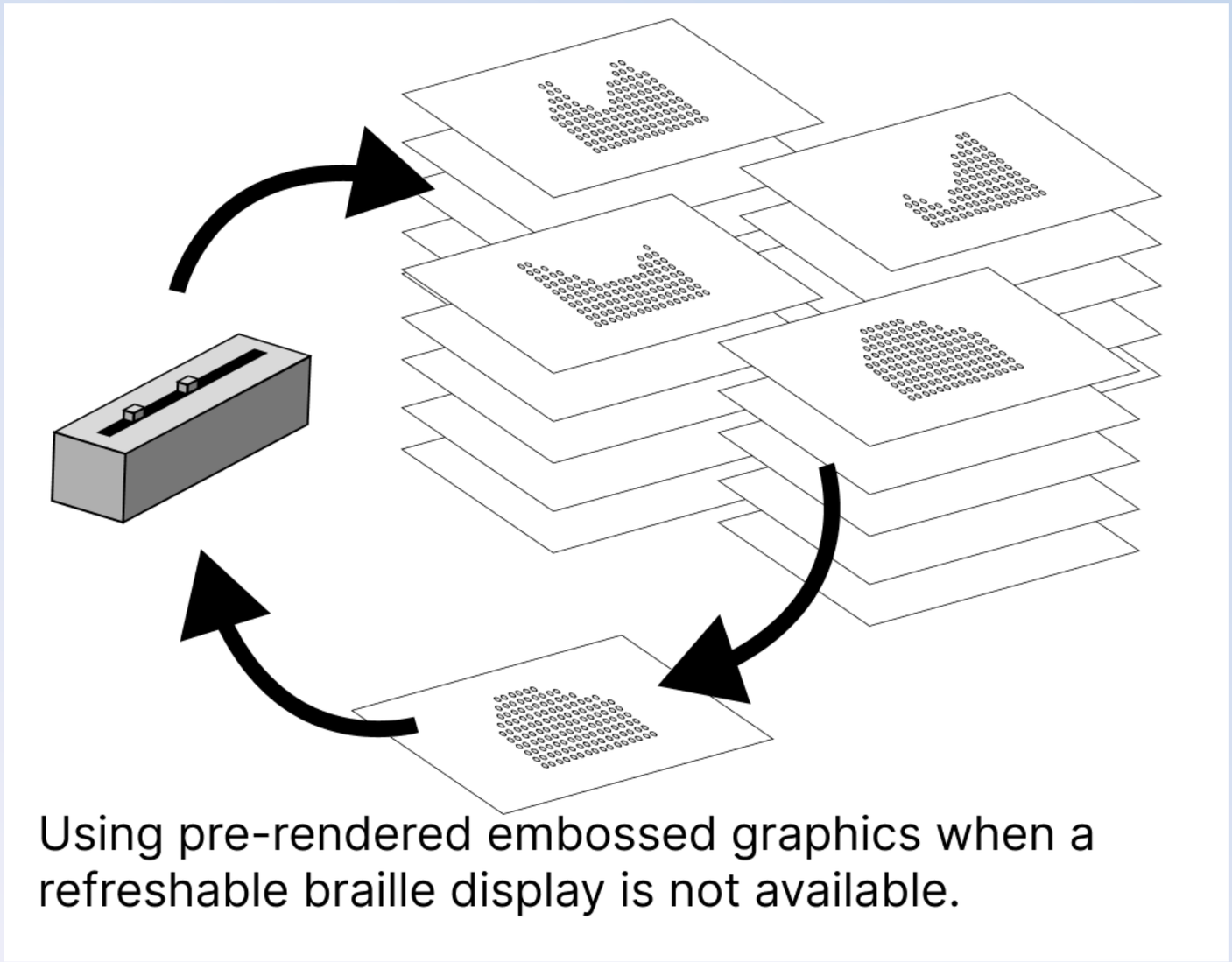
Produces simultaneous, coordinated change in another.



Cross-*feeltering*! A tactile, dual-task paradigm.

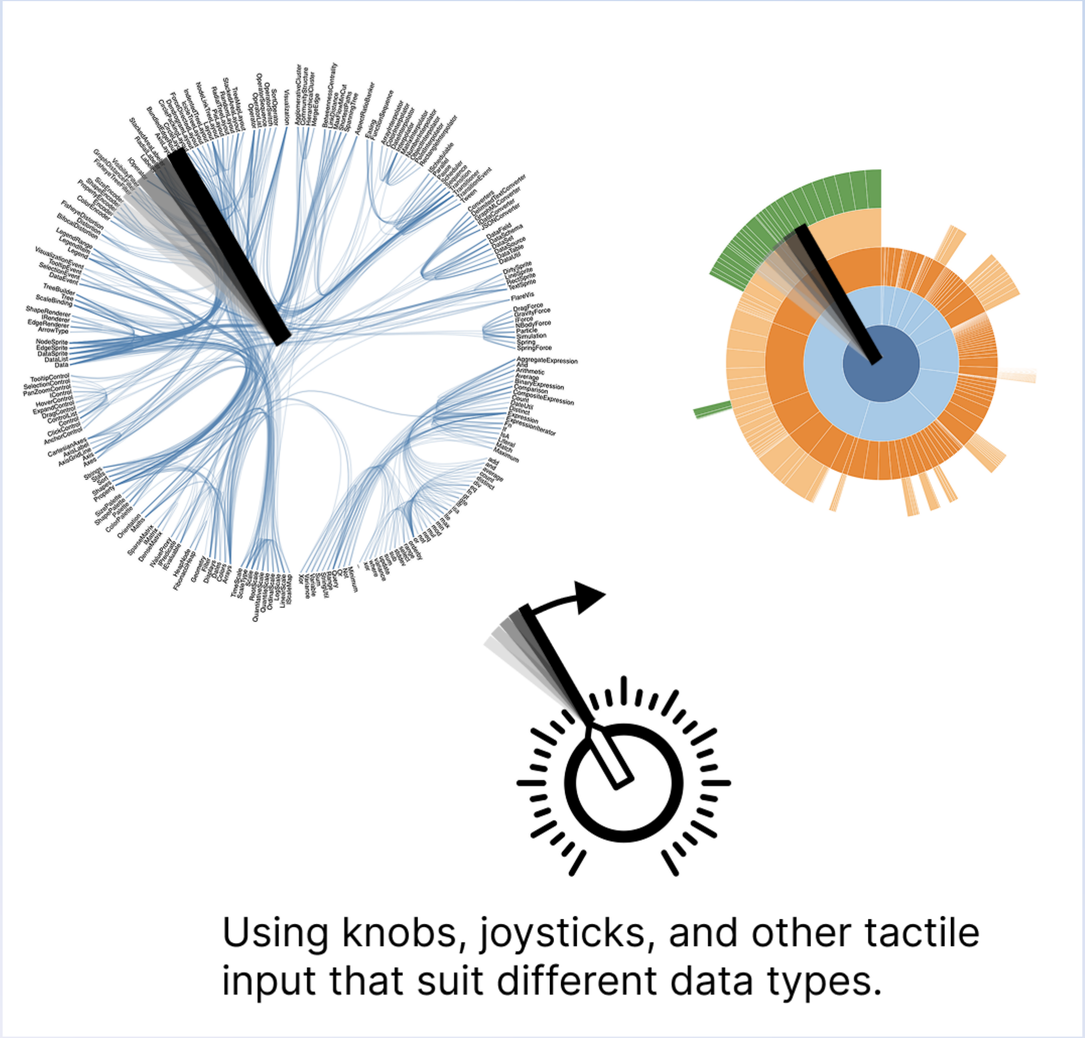


How might we use *cross-feeltering* for new experiences?



Using pre-rendered embossed graphics when a refreshable braille display is not available.

How might we use *cross-feeltering* for new experiences?



Using knobs, joysticks, and other tactile input that suit different data types.

Data, Accessibility, and Tools

Tools for ***explanation***

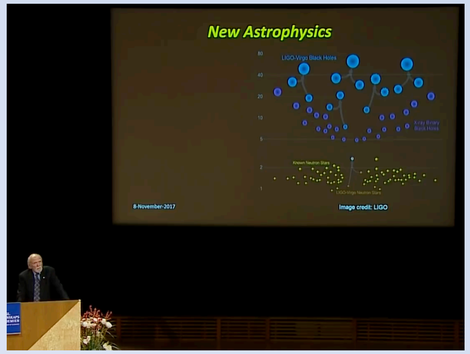
Tools for ***exploration***

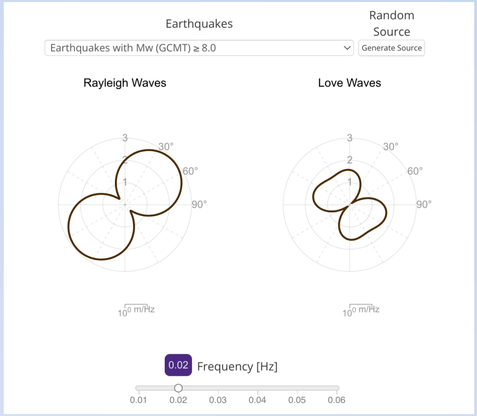
Tools for ***scale***

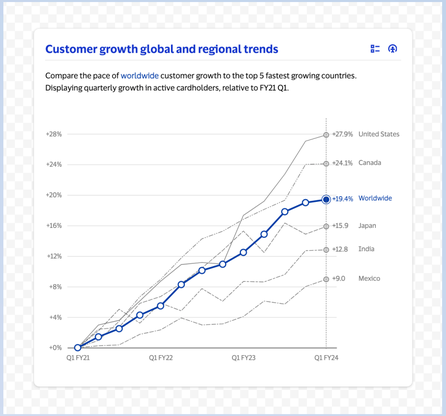
Tools for ***thinking***

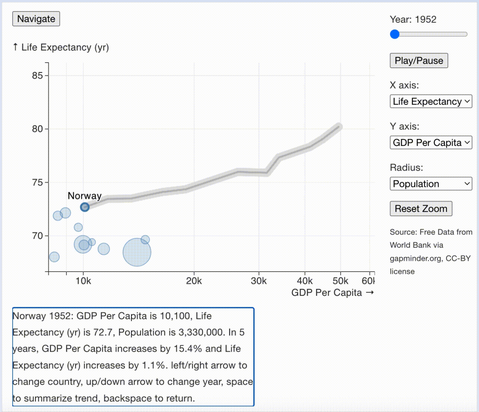
Tools for ***complexity***

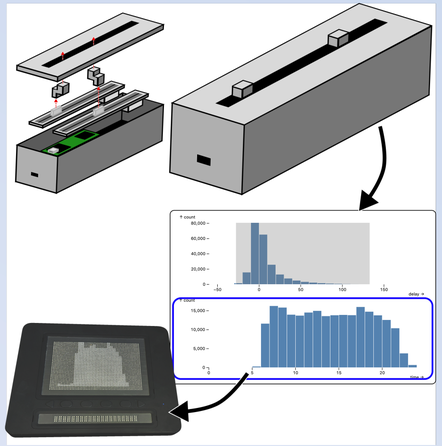
Tools for ***possibility***











UW - 2026

frank.computer

Data, Accessibility, and Tools

Frank Elavsky

Human-Computer Interaction Institute

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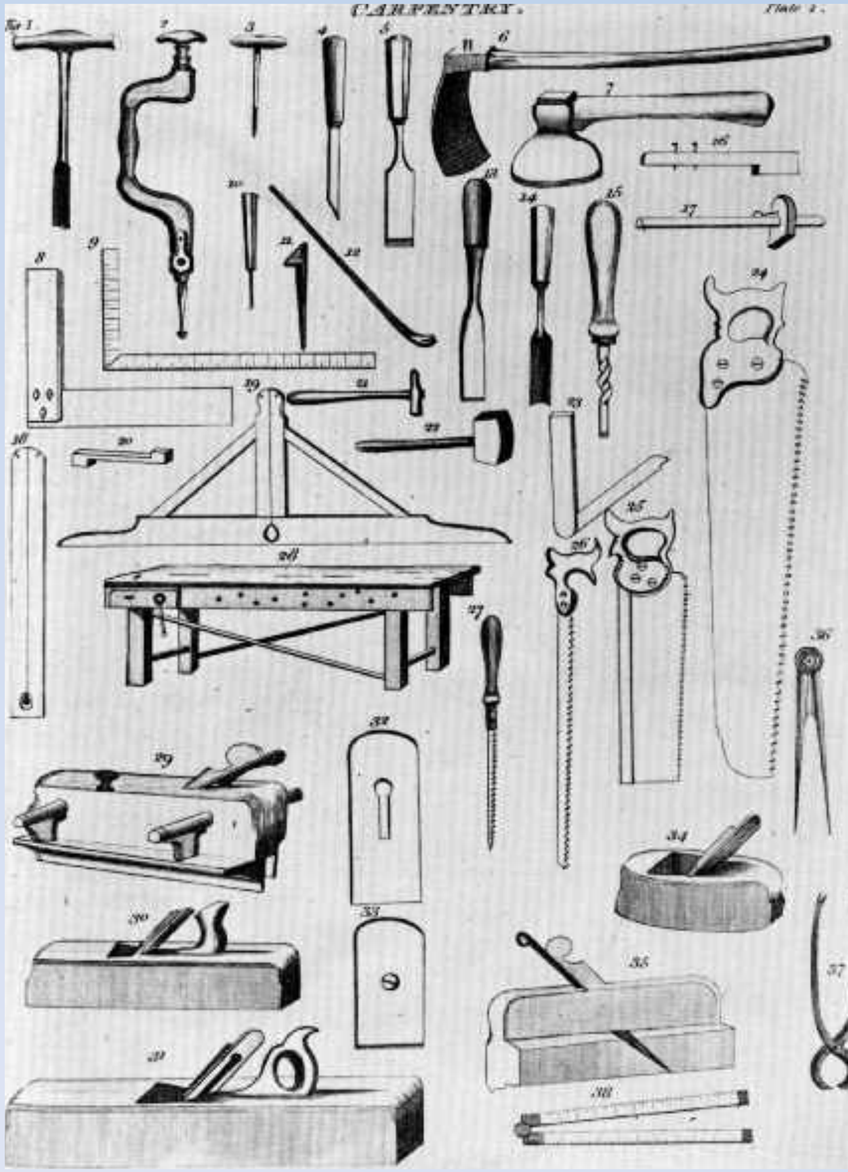
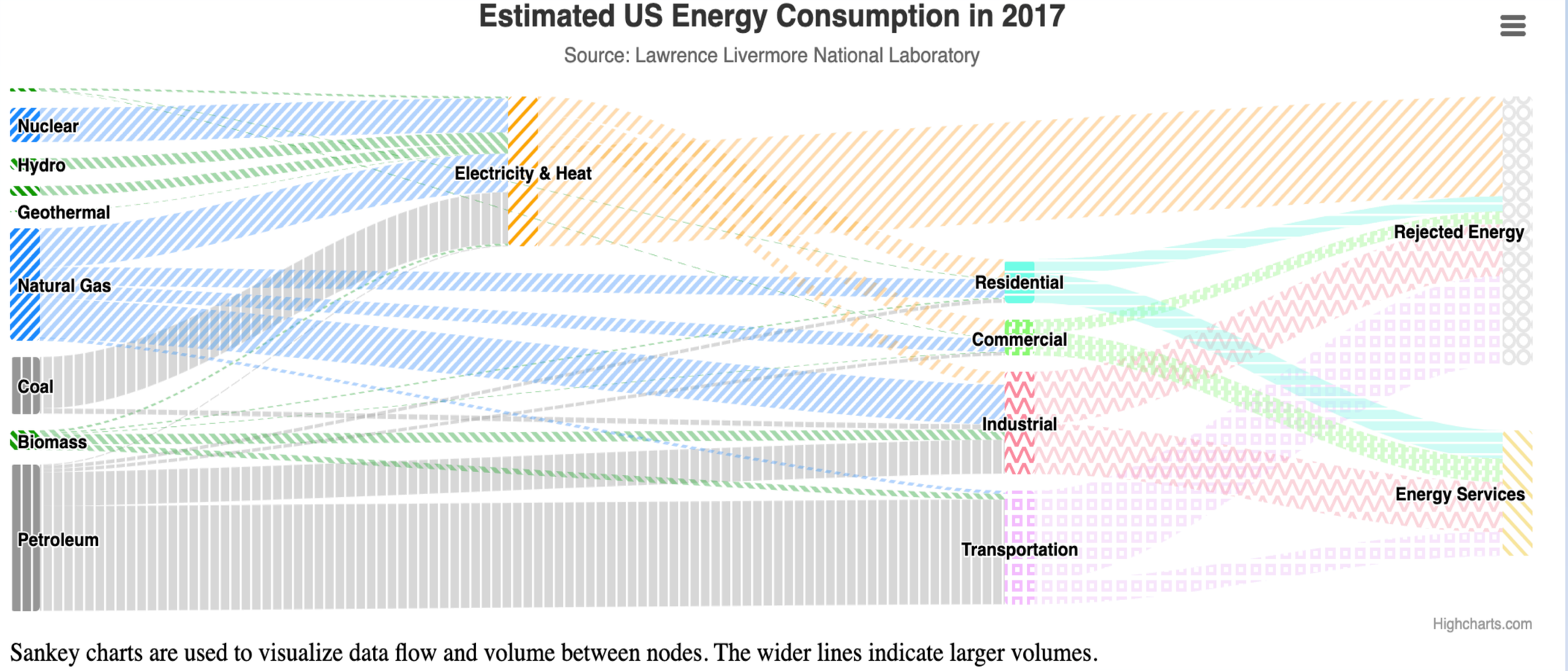
Tools for *agency*: Freedom to go beyond the bounds of the tool

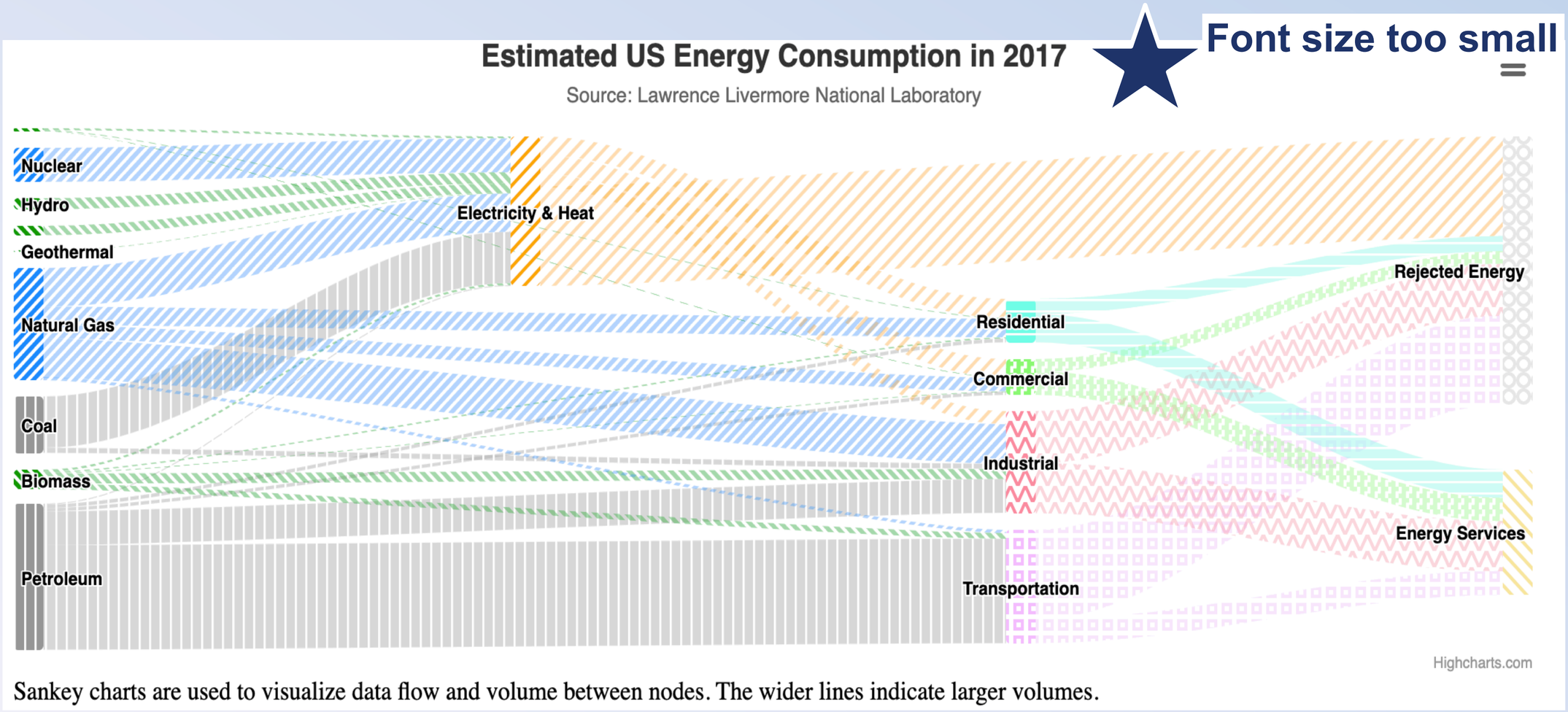


What about this visualization might be a barrier?



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

What about this visualization might be a barrier?



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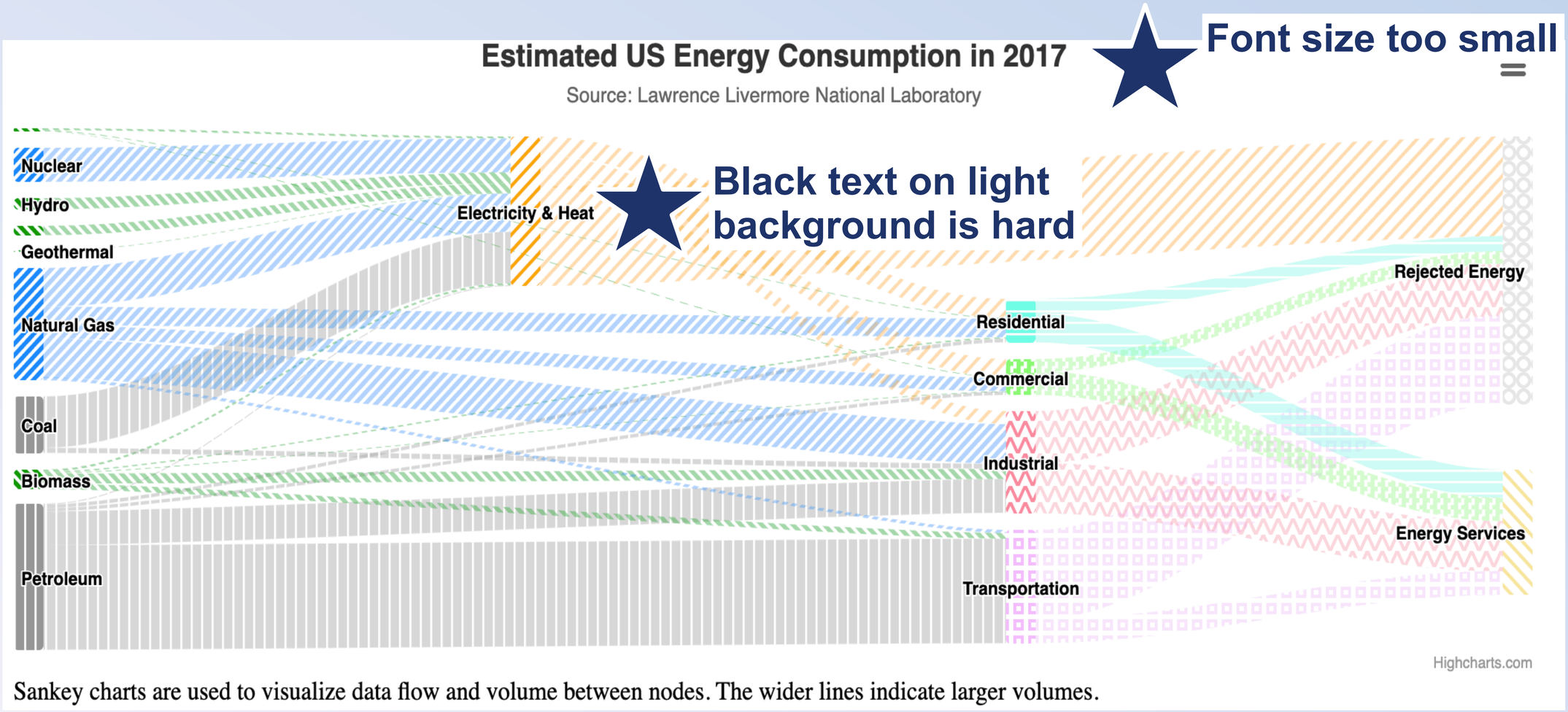

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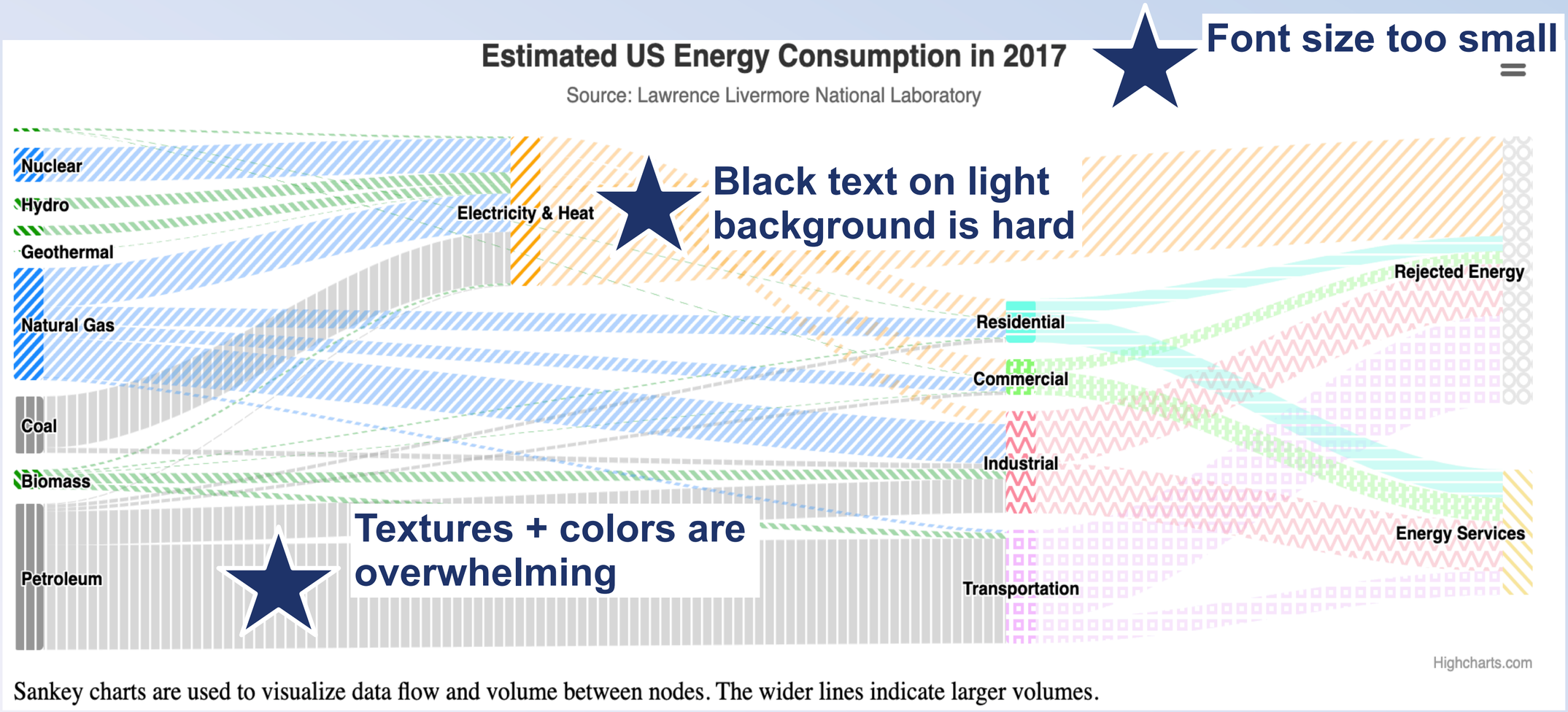

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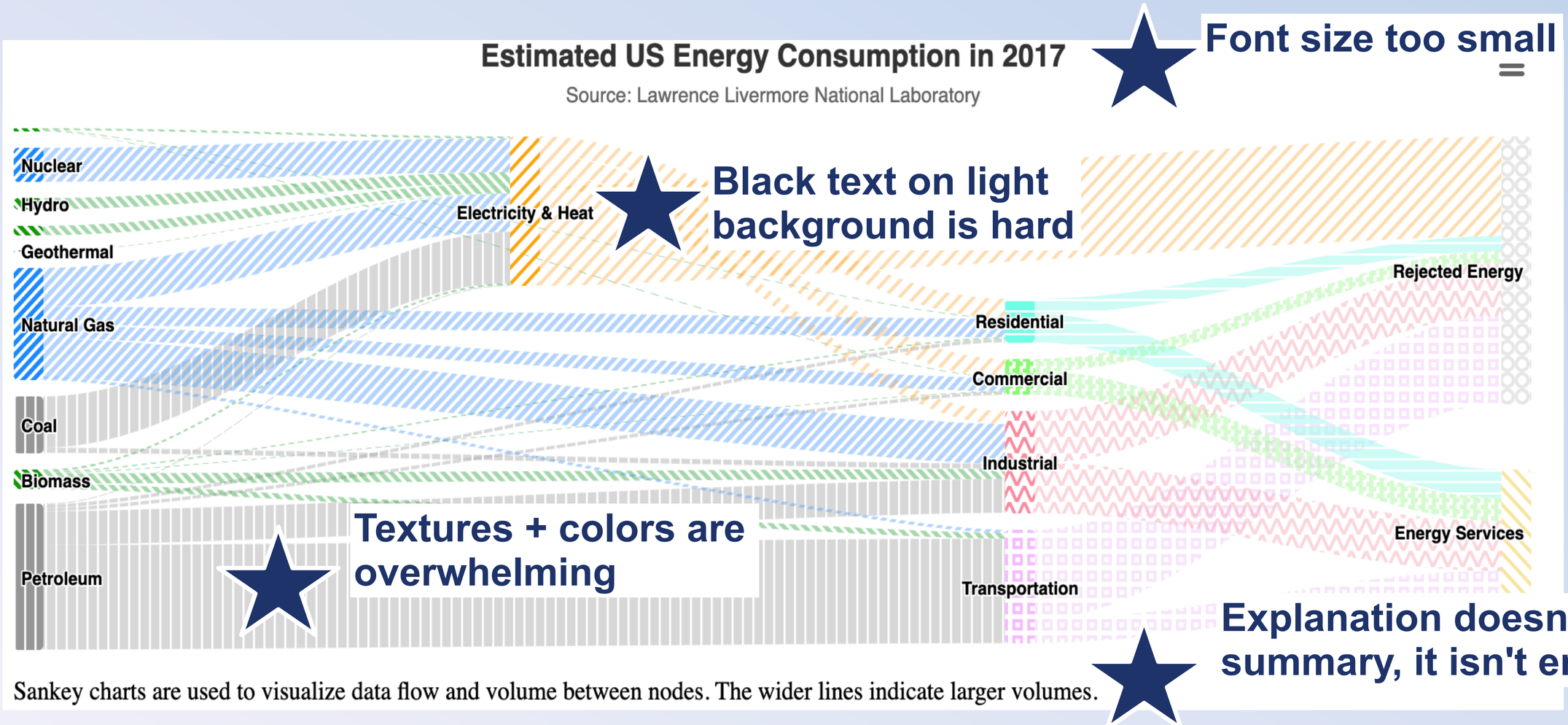
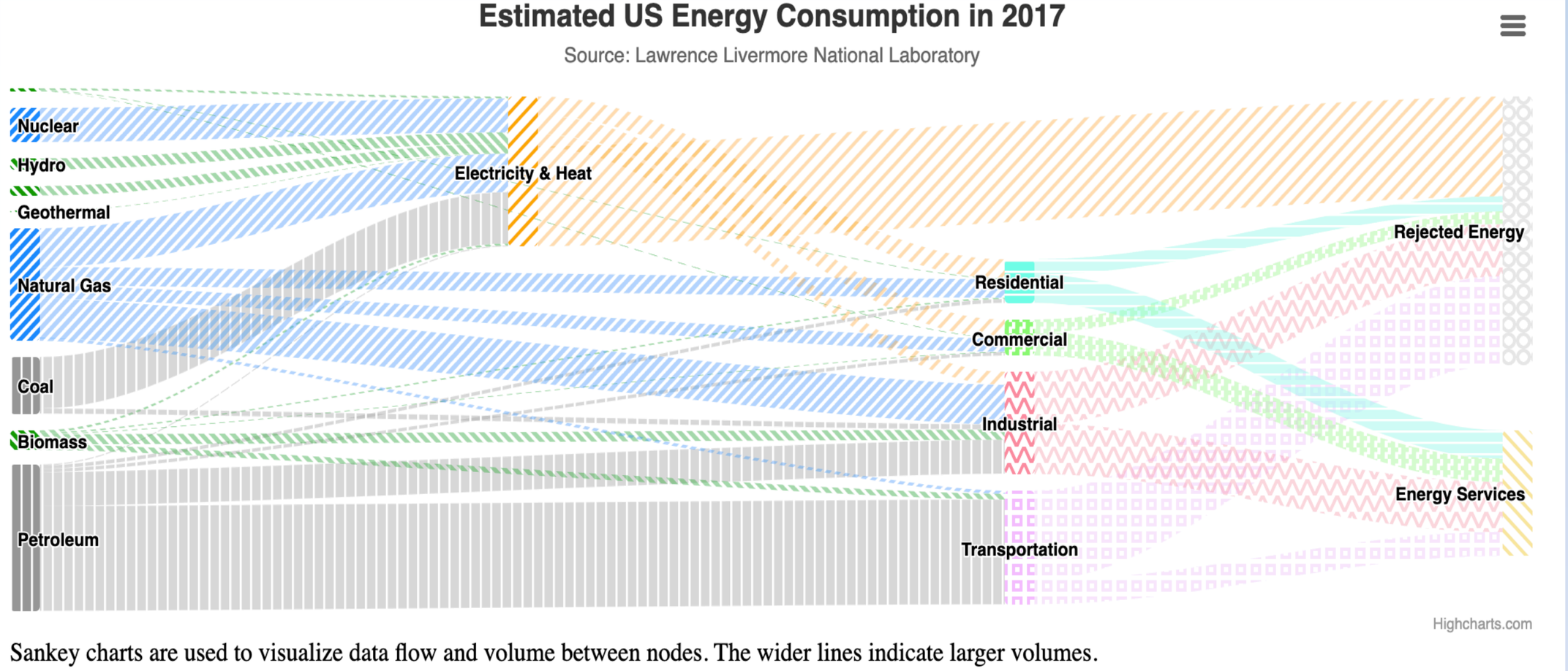
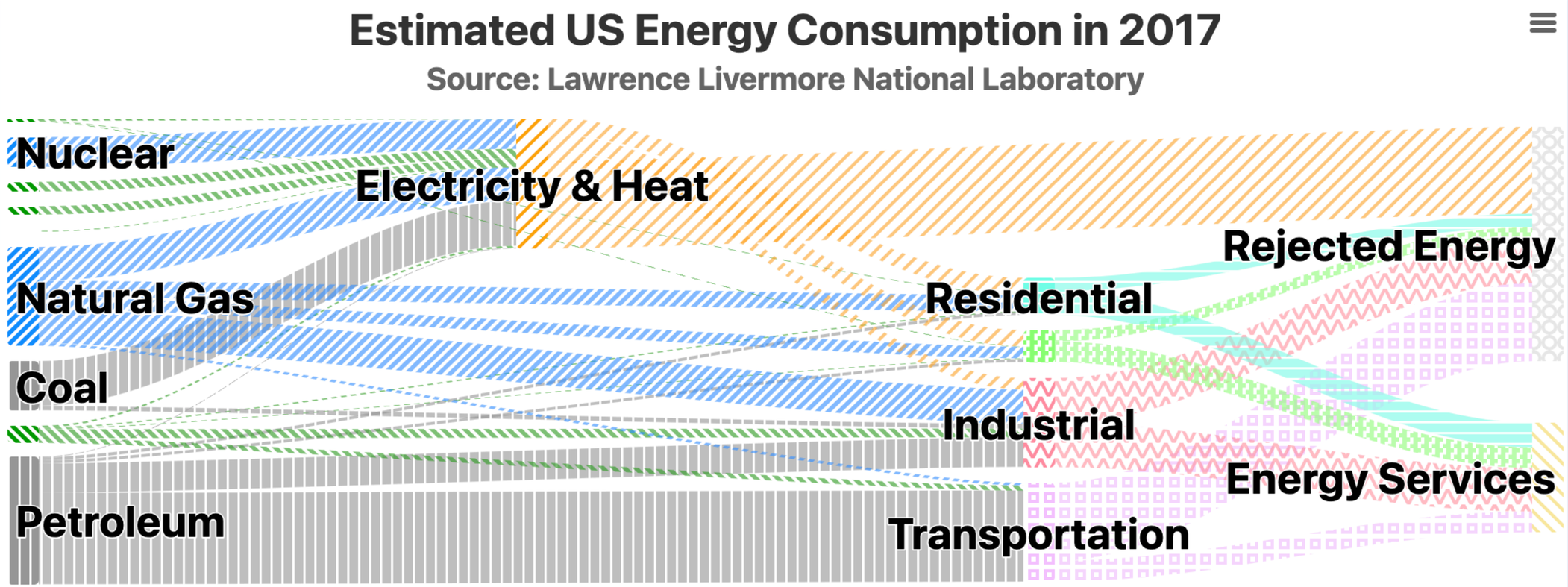


Can we fix this?



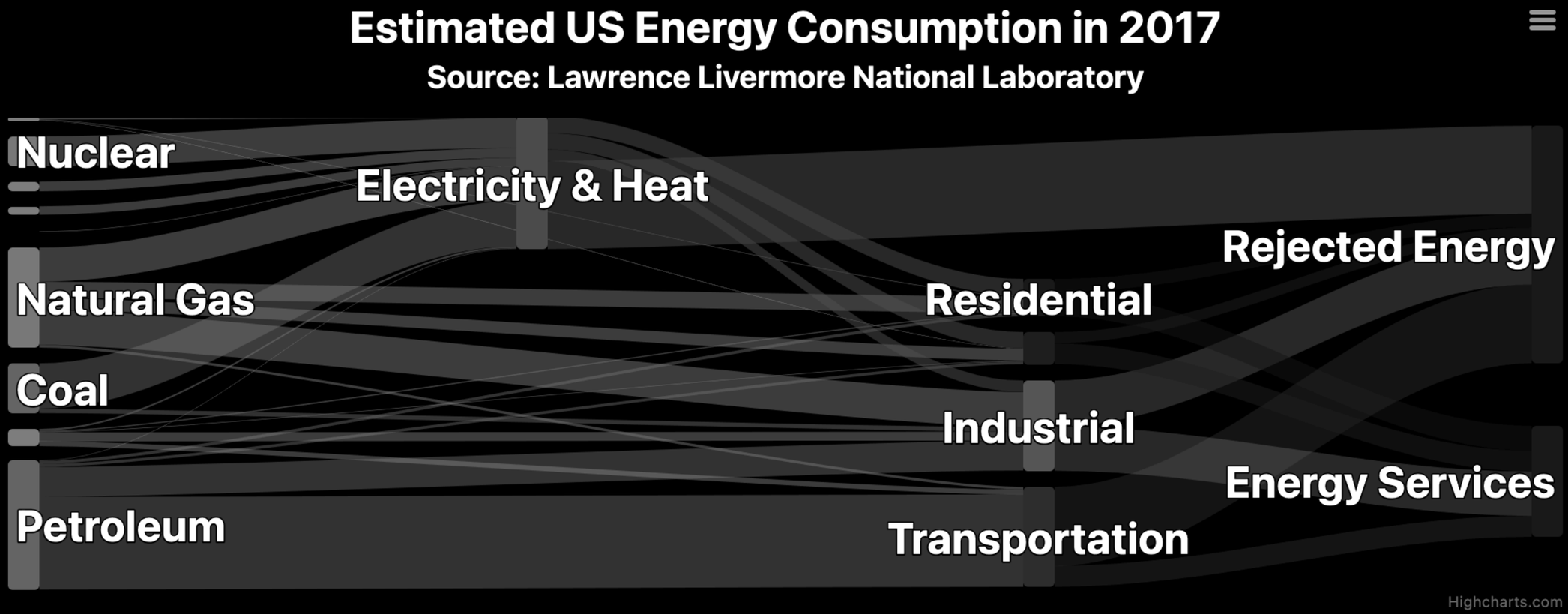
Sankey charts are used to visualize data flow and volume between nodes. The wider lines indicate larger volumes.

Maybe we can bump up the text size



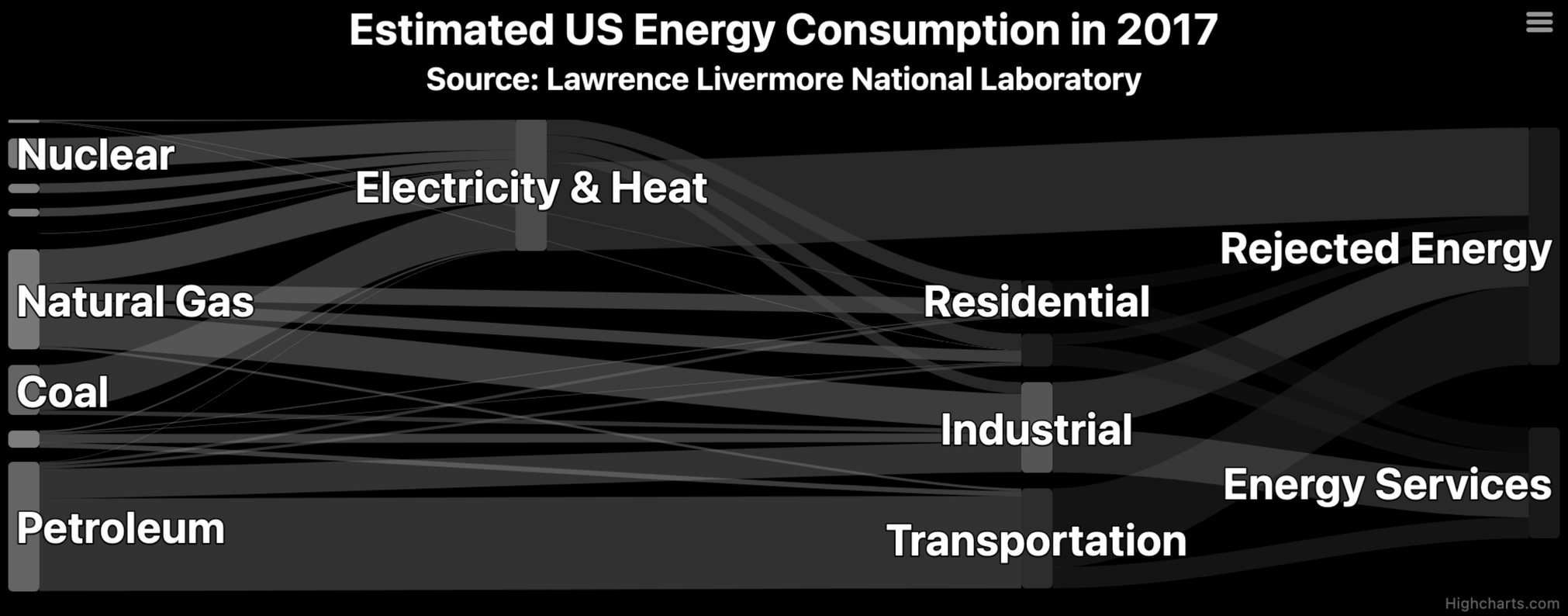
Sankey charts are used to visualize data flow and volume between nodes. The wider lines indicate larger volumes.

We can reduce visual complexity too



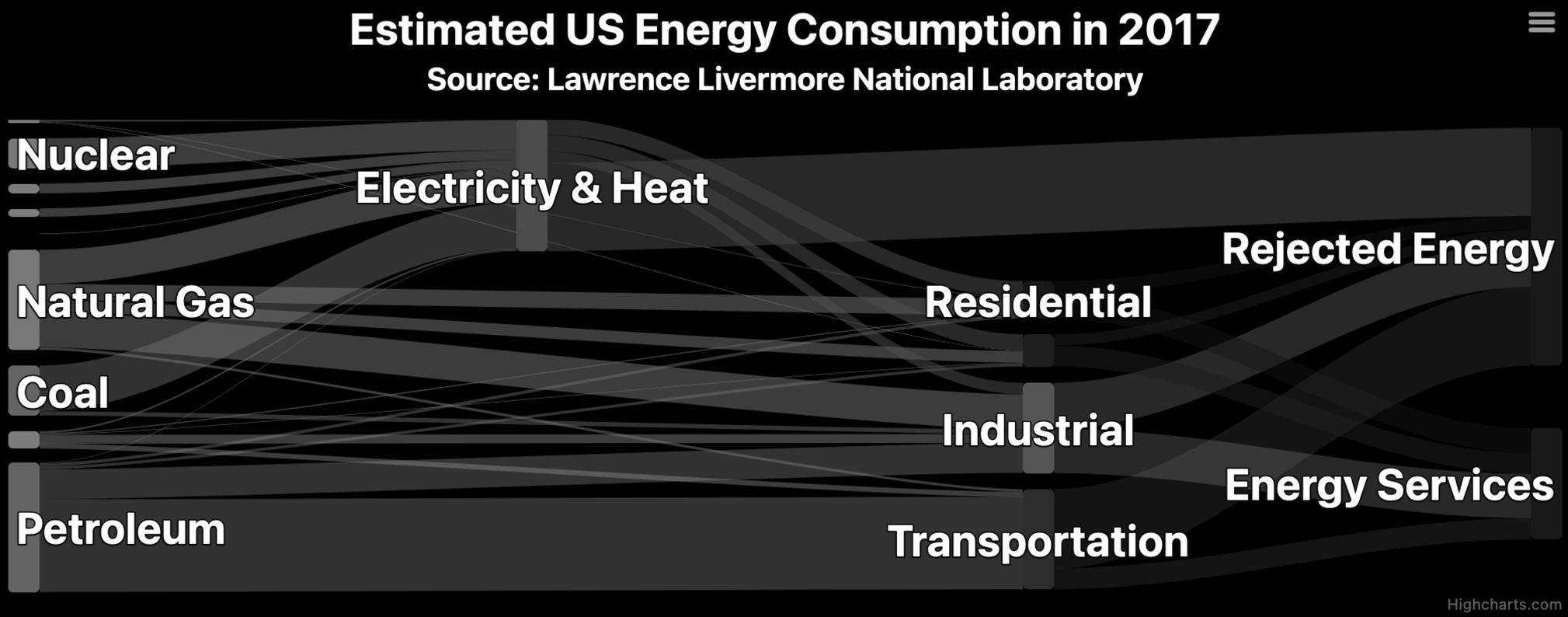
Sankey charts are used to visualize data flow and volume between nodes. The wider lines indicate larger volumes.

We can add a more descriptive explanation



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?



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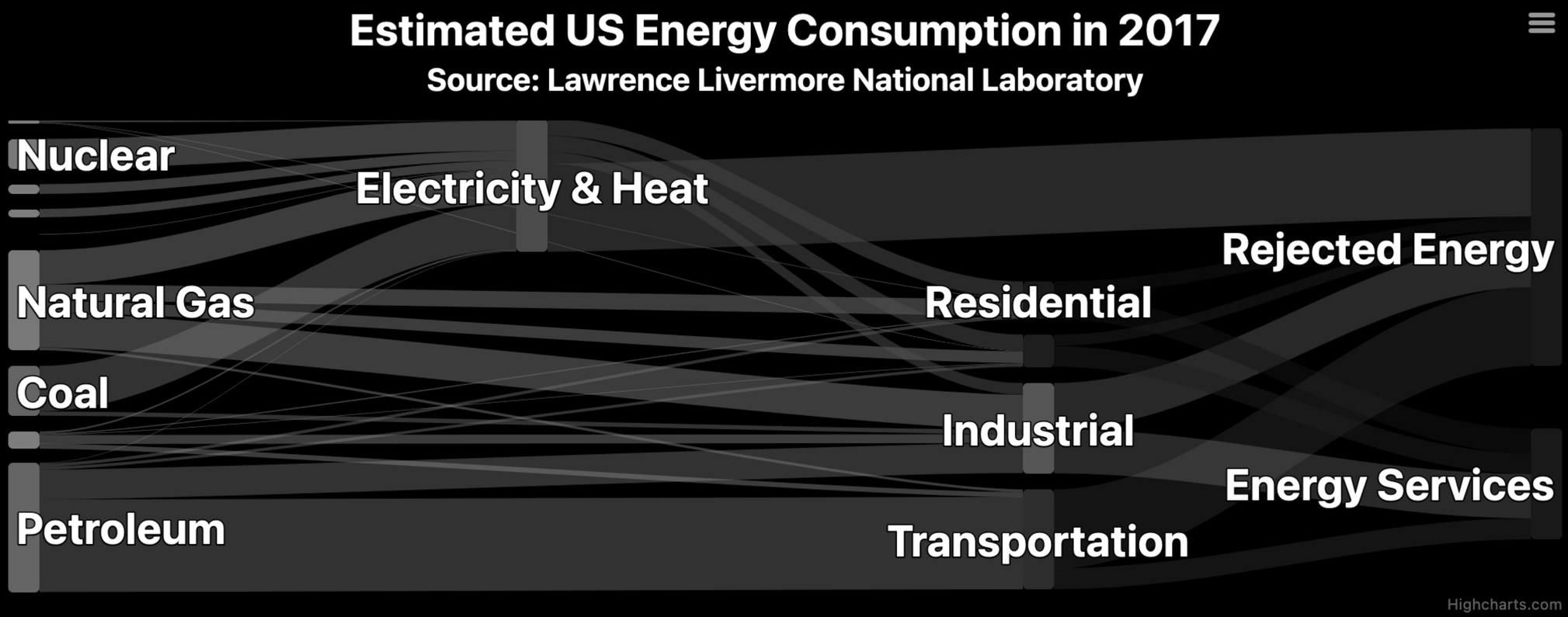
Bad news...



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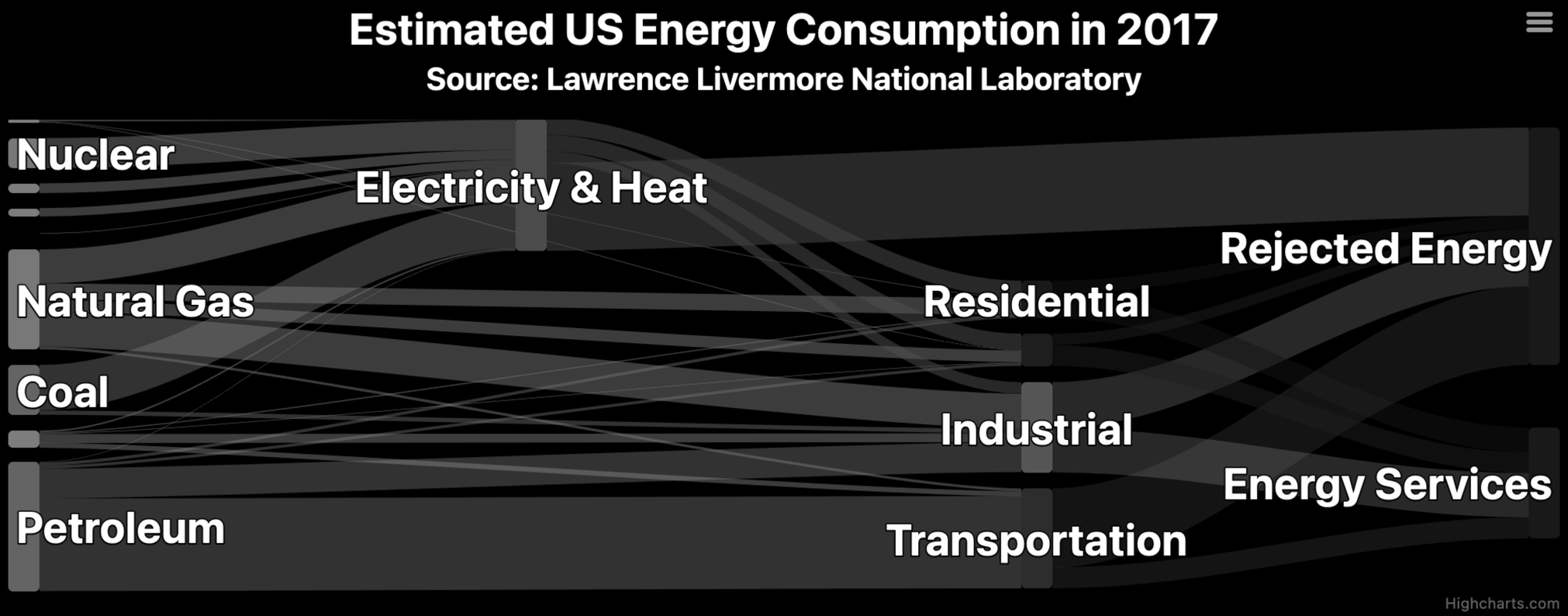
Bad news...

This design has accessibility issues too



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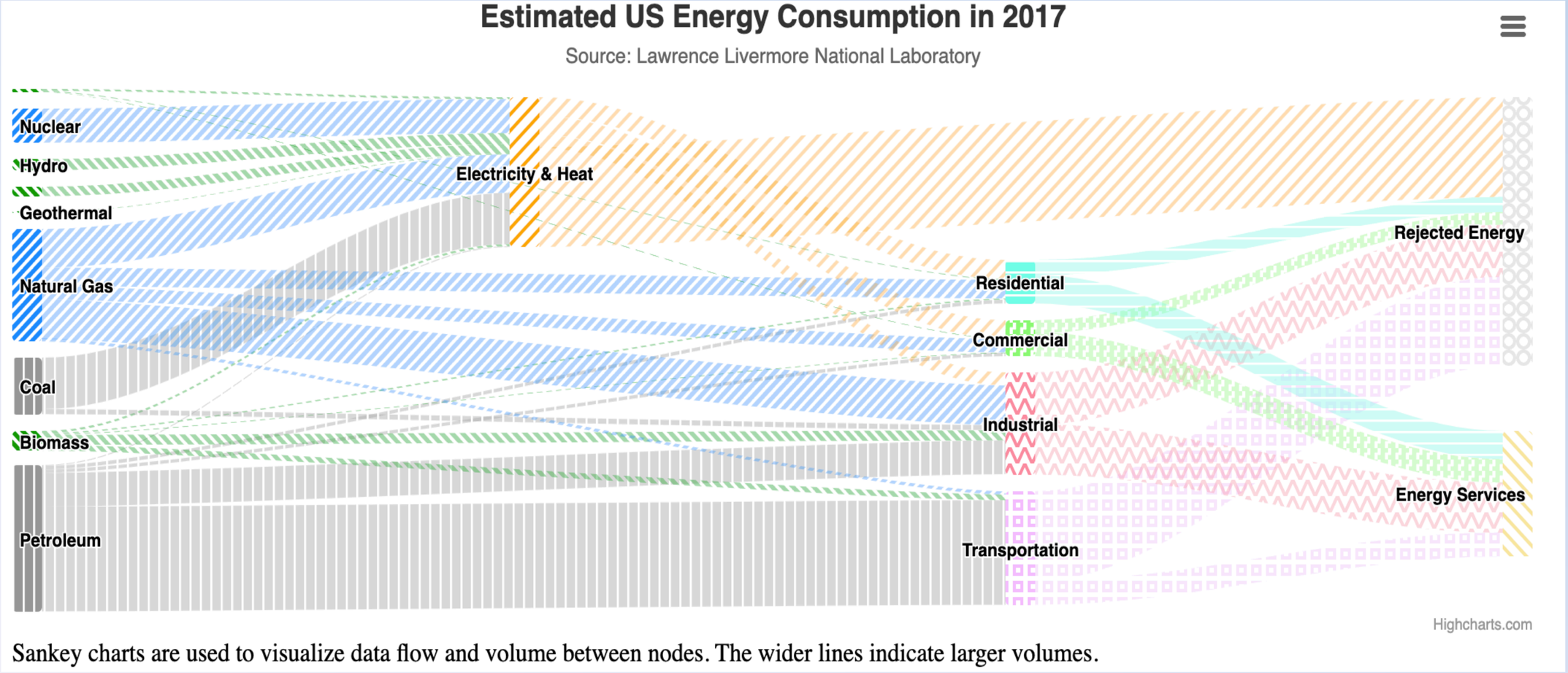
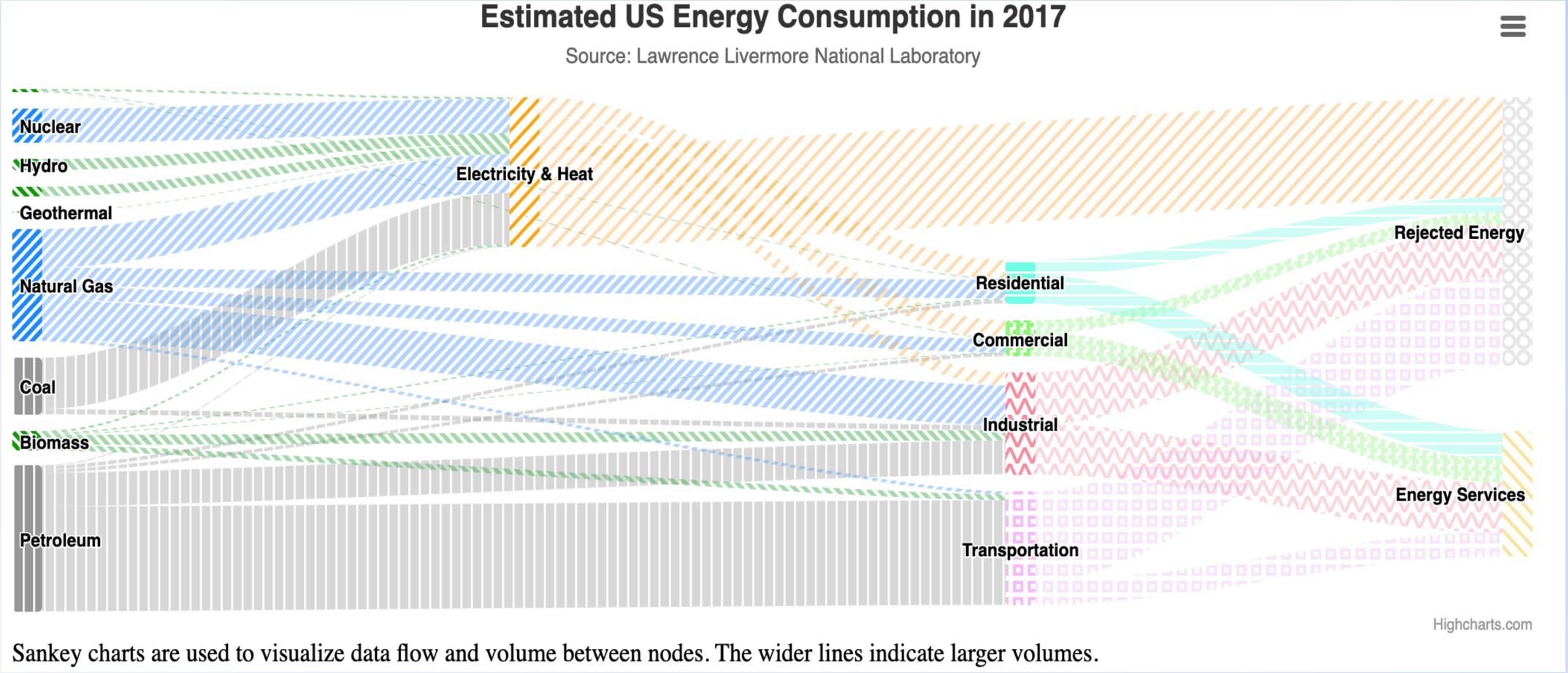
There is no such thing as a single, perfect design



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

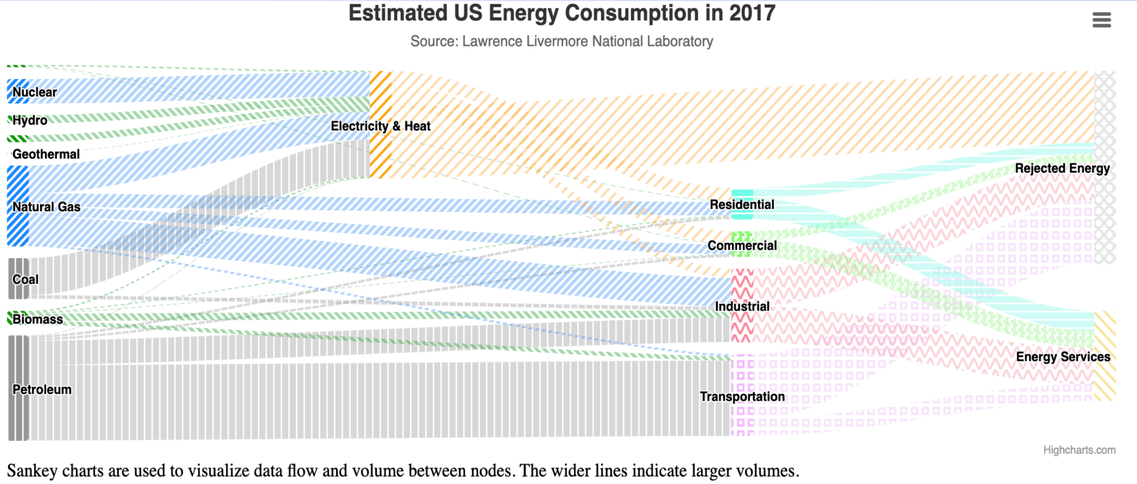
One design *cannot* fit all



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

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

What if we let users personalize?



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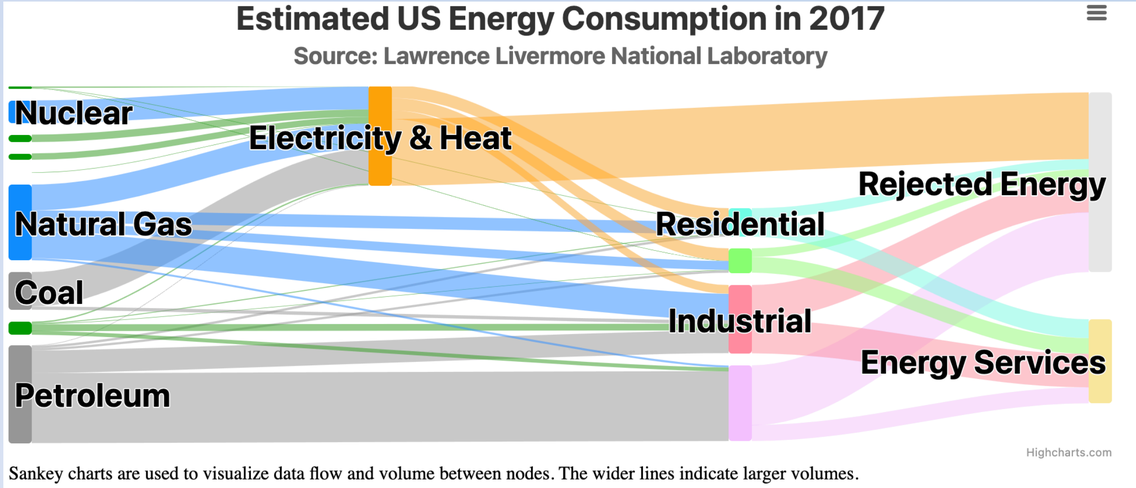

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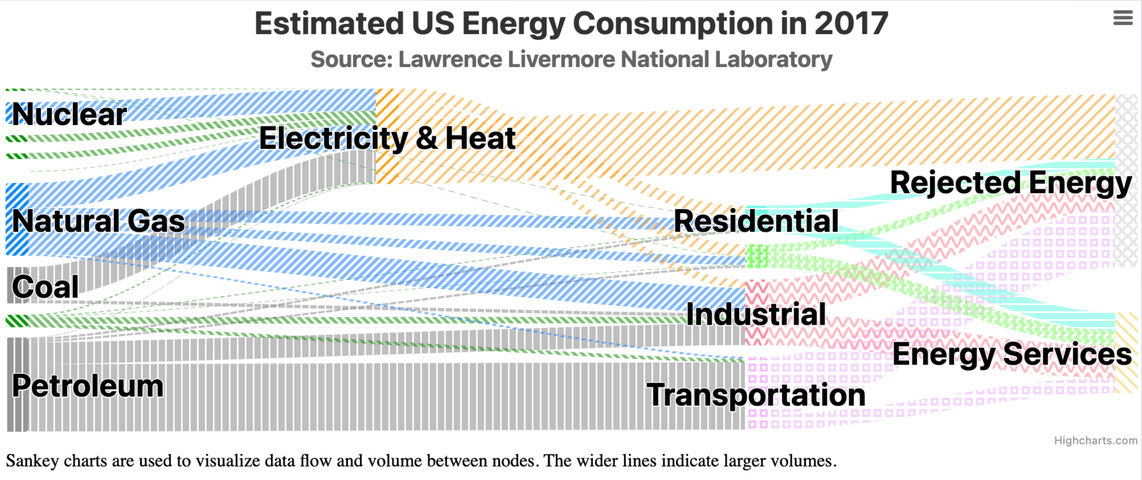

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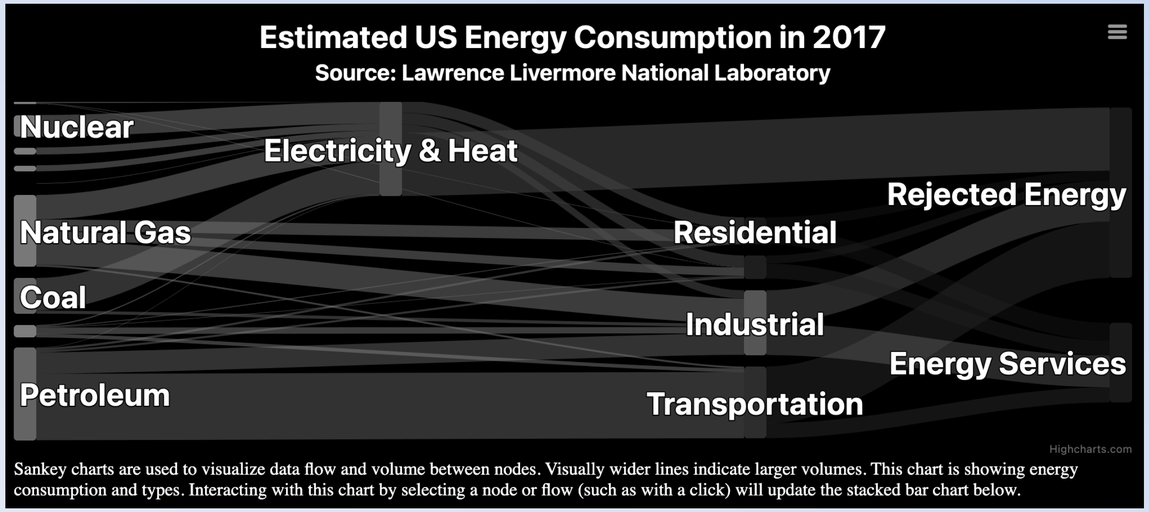

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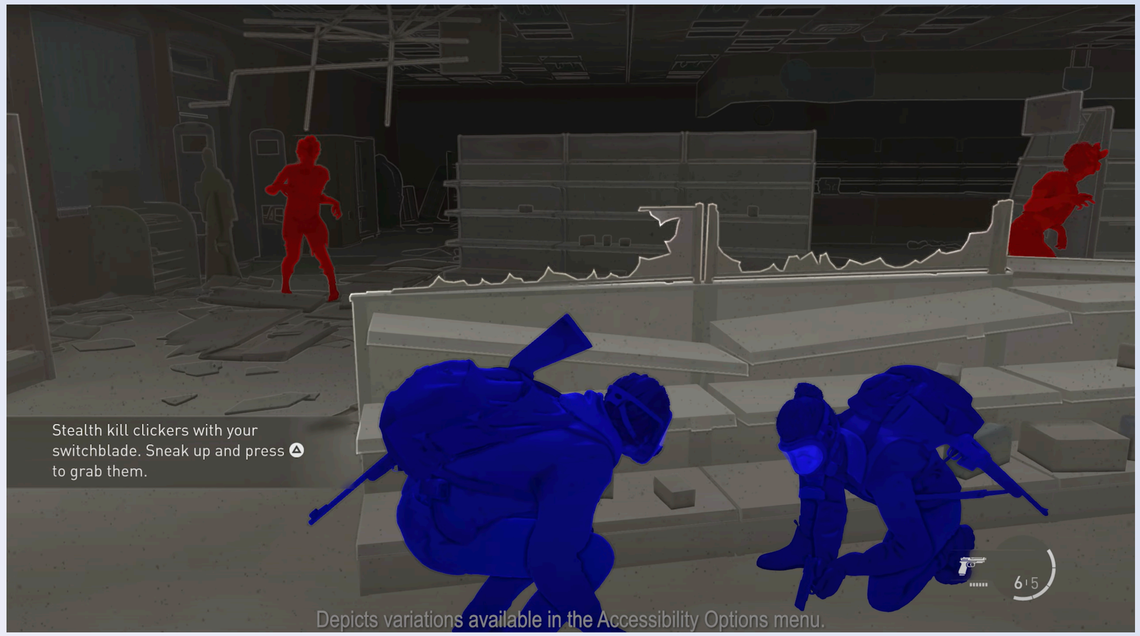
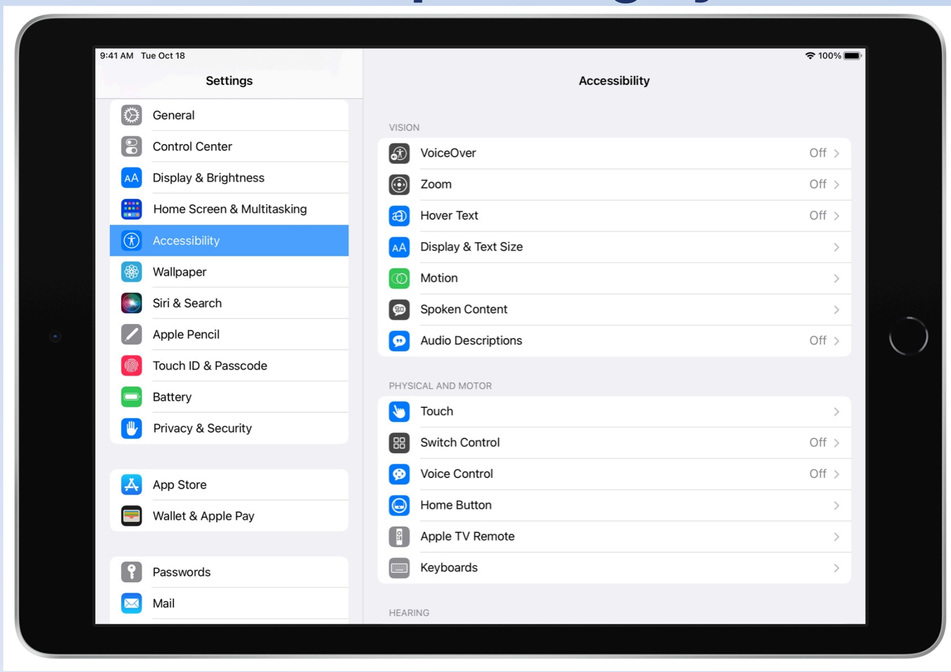
We have been enabling personalization for years

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