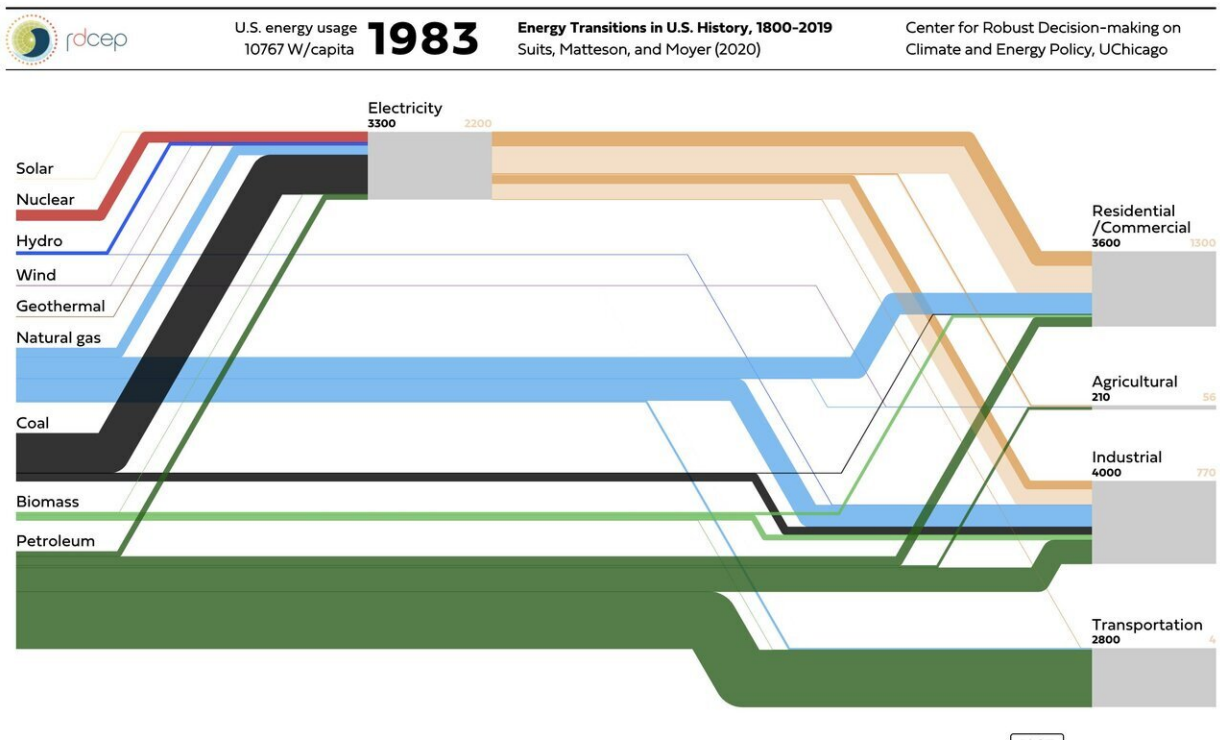
Two centuries of US energy usage, one interactive graphic

December 9 2020, by Rob Mitchum



U.S. energy usage in 1983. Credit: University of Chicago/Robust Decision-making on Climate and Energy Policy (RDCEP)

From wood-burning stoves to coal-fired factories to the gas and oil of the Automobile Age, the history of energy in the United States is marked by many shifts. Visually portraying these transitions over hundreds of years can offer new insights about the historic road to today's energy

landscape and the possible paths toward a cleaner energy system in the future.

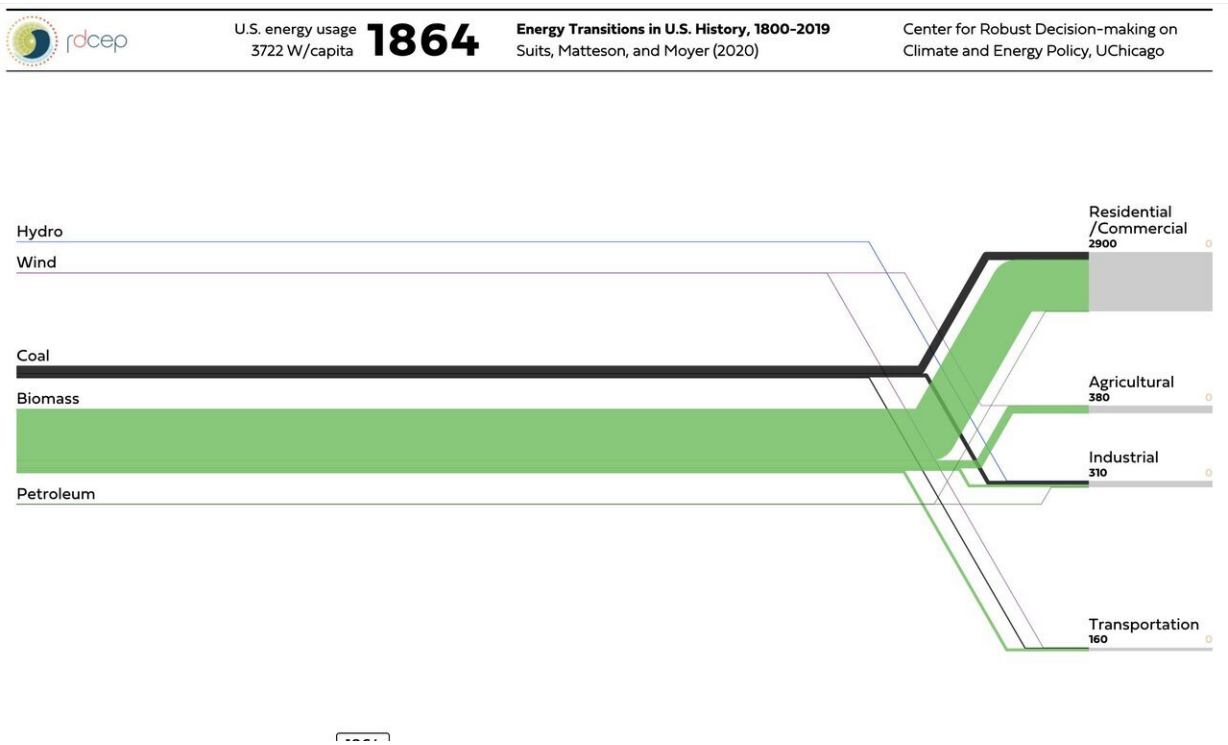
A new interactive visualization built by a unique collaboration of researchers in geosciences, history, and data science creates a vivid and comprehensible tale of how energy use evolved over 220 years of American history. Combining a classic form of data visualization called a Sankey diagram with an interactive web animation, the graphic illustrates the flow of different energy sources into the residential/commercial, agricultural, industrial, and transportation sectors from 1800 to 2019.

In under a minute, the visualization shows how the United States changed from using almost entirely biomass—such as wood for stoves or feed for horses—in the early 19th century to today's diverse energy system, dominated by petroleum and natural gas but with still-significant contributions from coal and nuclear, while renewable energy usage remains small. As major historical changes such as the Industrial Revolution, the harnessing of electricity, and the construction of the U.S. interstate system occur, the tributaries of the graphic fluidly fluctuate in thickness and hop between economic sectors.

Those motions illustrate the history of energy transitions at a time when the world is considering a new transition towards cleaner fuels, said Elisabeth Moyer, associate professor in the University of Chicago Department of Geophysical Sciences and leader of the UChicago Center for Robust Decision-making on Climate and Energy Policy, who built the graphic with Department of History Ph.D. student Robert Suits, Nathan Matteson of the DePaul University College of Computing and Digital Media, and programmers from the UChicago Research Computing Center.

"What we wanted to do with this tool is make something that people

would be equally comfortable using in a science class, a history class, as a research aid, or in a policy discussion," Moyer said. "We want it to remind the physical scientists that the history of energy use is a human issue, and to remind the historians that you can gain insight into the relative scales of importance and the overall working of the system by using numbers and aggregating up."



U.S. energy usage in 1864. Credit: University of Chicago/Robust Decision-making on Climate and Energy Policy (RDCEP)

The project drew inspiration from a series of static Sankey diagrams created by the Lawrence Livermore National Laboratory, illustrating energy usage in each year since 2000. For her UChicago course "Energy: Science, Technology, and Human Usage," Moyer desired a more

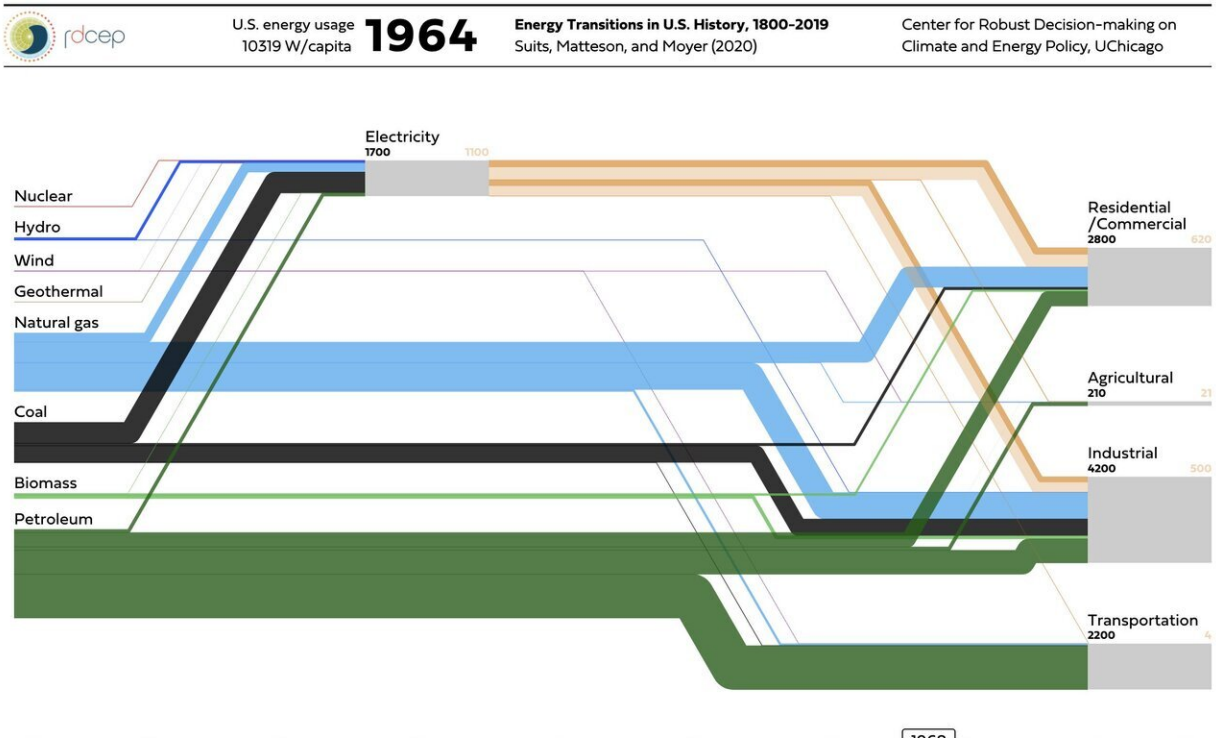
cohesive visualization that showed changes from year to year, and wanted to expand the timeframe deeper into the past.

To do so, she needed design direction and innovative programming from Matteson and research by Suits, who dug into historical records to estimate the amount and sources of energy used by Americans as far back as the early 1800s. That search involved some strange calculations, such as the energy consumption of a horse and how it changed as horses were bred larger for transportation. Suits' research added a completely new dimension to the data of historical U.S. energy use before the 1950s, determining not just how the energy was generated but who consumed it: households and stores, factories, farms, or transportation.

That point proved critical, not just for the look of the visualization, but also for the lessons learned from its narrative.

By breaking down energy use by sector, the researchers could see how new energy sources entered American use in stages, with individual sectors providing critical early markets. Later transitions could then occur much faster as infrastructure for distributing the new fuel was built. Coal, for example, found its first major use in home heating in the 1850s, but didn't fully displace wood in homes for over 50 years. By contrast, in the 1940s and 50s households could rapidly drop coal in favor of oil and gas heaters, because the pipeline network was already in place.

"When you look at the overall bar chart, it looks like energy transitions are slow, but our graphic visualization revealed that, within a sector, they can be fast," Moyer said. "The limitation is really the infrastructure. Even when the overall usage of a fuel shows very slow transitions—sometimes many, many decades long—rapid changes can happen once those barriers are gone."



U.S. energy usage in 1964. Credit: University of Chicago/Robust Decision-making on Climate and Energy Policy (RDCEP)

The deeper historical data also helps explain a quirk of U.S. energy history: in contrast to other industrialized nations, the country's wealth has grown massively even as its per capita energy usage has barely budged. But the early dominance of biomass energy and consumption by residences and farms, which persists until after the Civil War, holds the answer.

"We don't think of domestic energy use as being the driver, but almost all of the energy use in early U.S. history is residential heating: people had basically free wood and they built really energy-inefficient houses," Moyer said. "So all of these complicated theories about how structural

changes in the economy were driving the long-term reduction of energy intensity in the end boiled down to just that people were using more efficient stoves."

The visualization has already attracted interest from media and from outside researchers who want to modify it to show the energy history of other countries. The team continues to work with the UChicago Research Computing Center on building it out as a flexible platform for scientists to visualize their own data, creating a powerful new research tool as well as an educational aid.

"Our next iteration with the Research Computing Center is to make this into a more robust platform that can serve a larger community, so that people can upload their own data to animate their own country or region of interest," Moyer said. "For people doing energy development studies, we will give them a platform for showing their data, a reason to collect it in a certain way, and the motivation to think about the historical factors that went into those changes. I feel this tool can help us rethink energy transitions in every respect—not just their history, but also their future."

More information: View the visualization and learn more about the project here.

In addition to Moyer, Suits, and Matteson, the graphics were built by members of the UChicago Research Computing Center, including Ramesh Nair, Milson Munakami, Kalyan Reddy Reddivari, Sergio Elahi, and Prathyusharani Merla, with the assistance of Benjamin Kleeman, DePaul University. Funding was provided by the National Science Foundation, through a grant under the Decision-Making Under Uncertainty (DMUU) program, #SES-0951756.