Advances in U.S. Manufacturing

Congressional Climate Camp

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ACEEE
Smart Energy. Clean Planet. Better Lives.

About ACEEE:

The American Council for an Energy-Efficient Economy (ACEEE), is a nonprofit research organization that develops policies to reduce energy waste and combat climate change. Its independent analysis advances investments, programs, and behaviors that use energy more effectively and help build an equitable clean energy future.

Learn more at aceee.org

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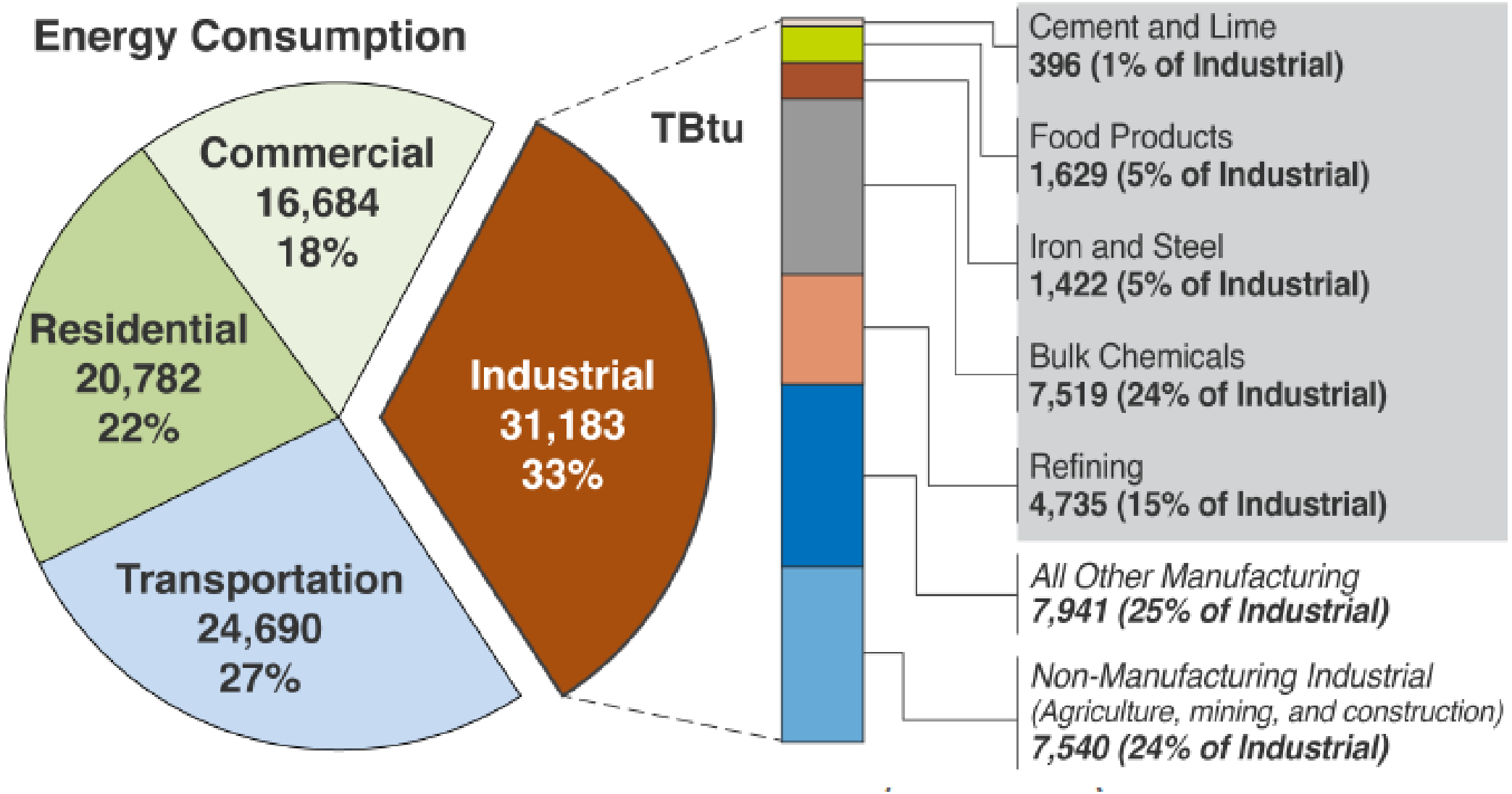
Presenter

Nora Wang Esram, Sr. Director for Research, ACEEE
Dr. Esram oversees ACEEE's research programs including Buildings, Industry, Transportation, Behavior, and Health and Environment. She joined ACEEE in 2020. Prior to ACEEE, she was a chief engineer and team lead at the Pacific Northwest National Laboratory and spearheaded multi-disciplinary projects advancing building energy efficiency and decarbonization.

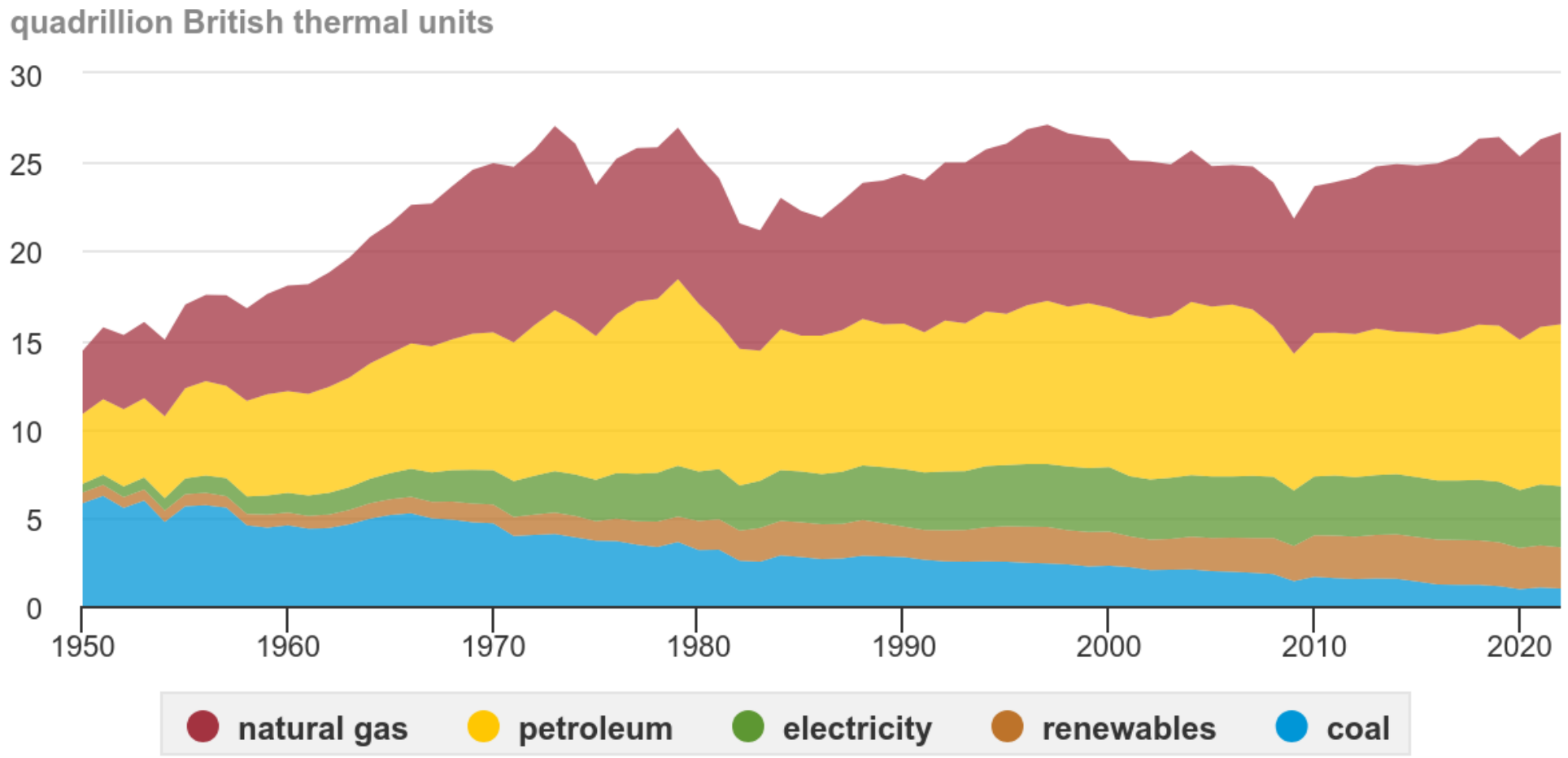
Industrial energy use and emissions

Industrial Sector Uses 33% of U.S. Energy



Source: DOE (2022), Industrial Decarbonization Roadmap, Figure 2

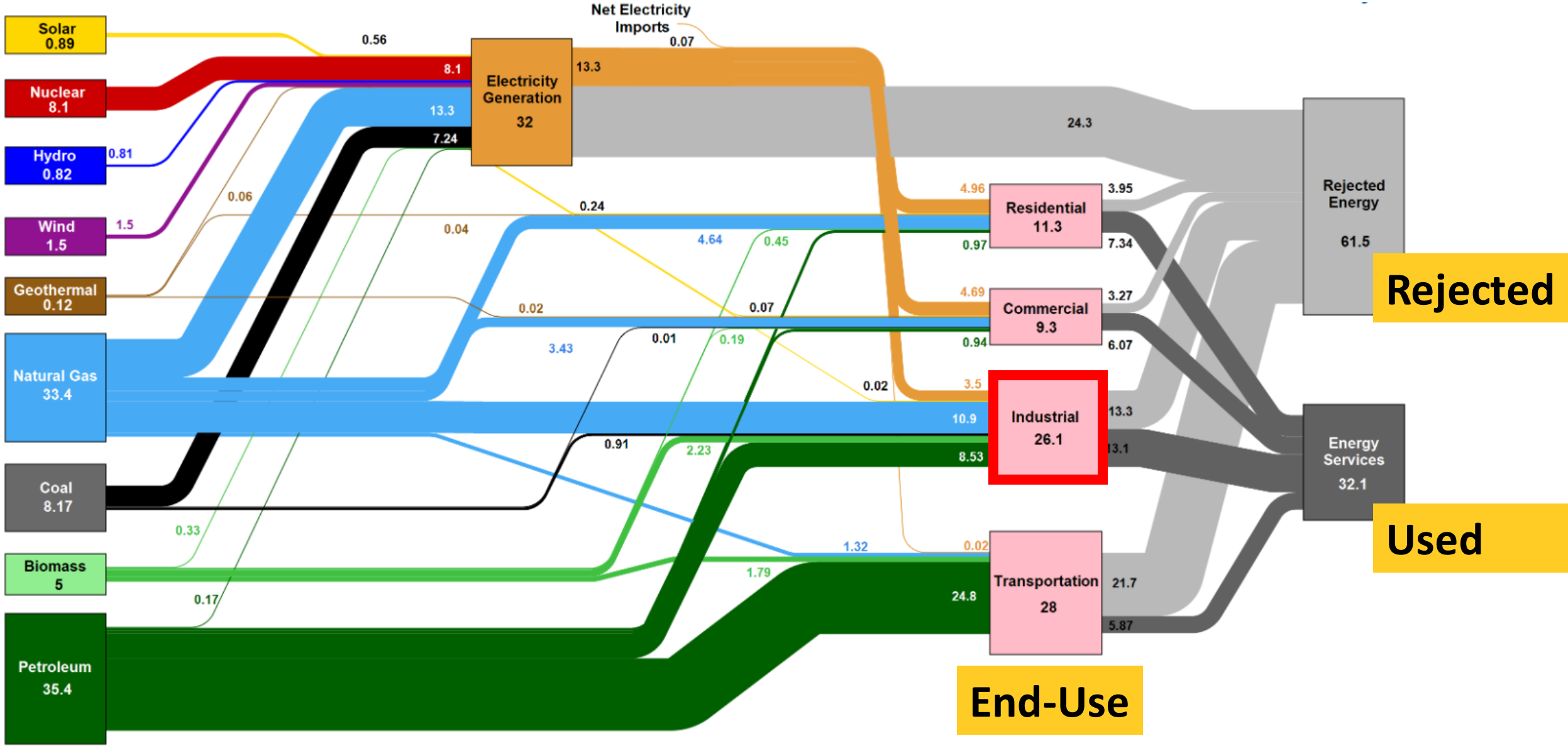
Industrial Energy Use is Mostly Fossil Fuels



13%
electricity

Data source: U.S. Energy Information Administration, *Monthly Energy Review* , Table 2.4, June 2023 , preliminary data for 2022
Note: Includes energy sources used as feedstocks in manufacturing products. Electricity is retail sales of electricity to the sector and excludes electric system energy losses associated with the retail sales.

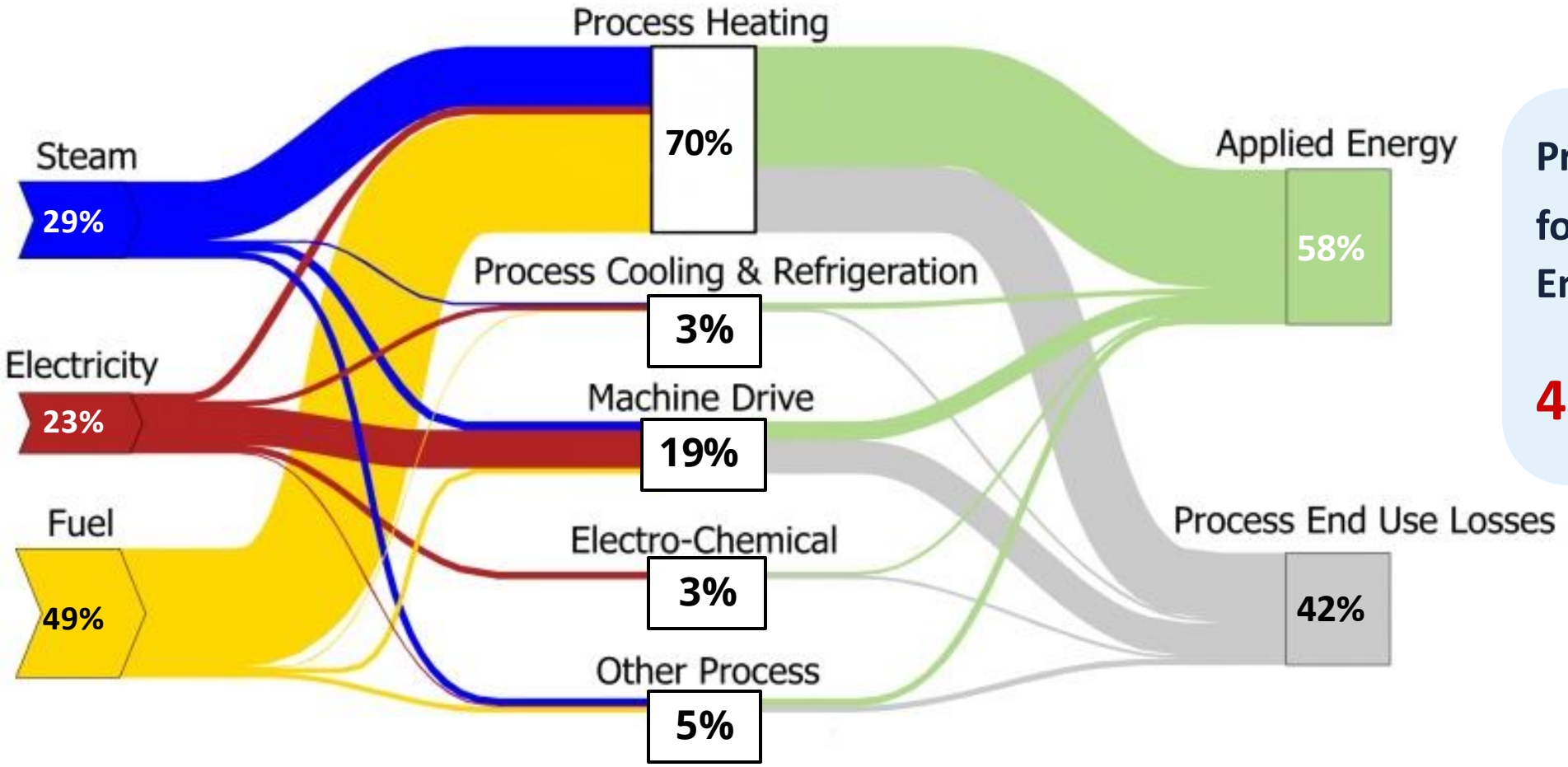
Wasted (rejected) energy is a huge problem: 50% wasted in Industry



Source: LBNL - https://flowcharts.llnl.gov/

Industrial Energy Strategies

Minimize Energy Lost in U.S. Manufacturing Process

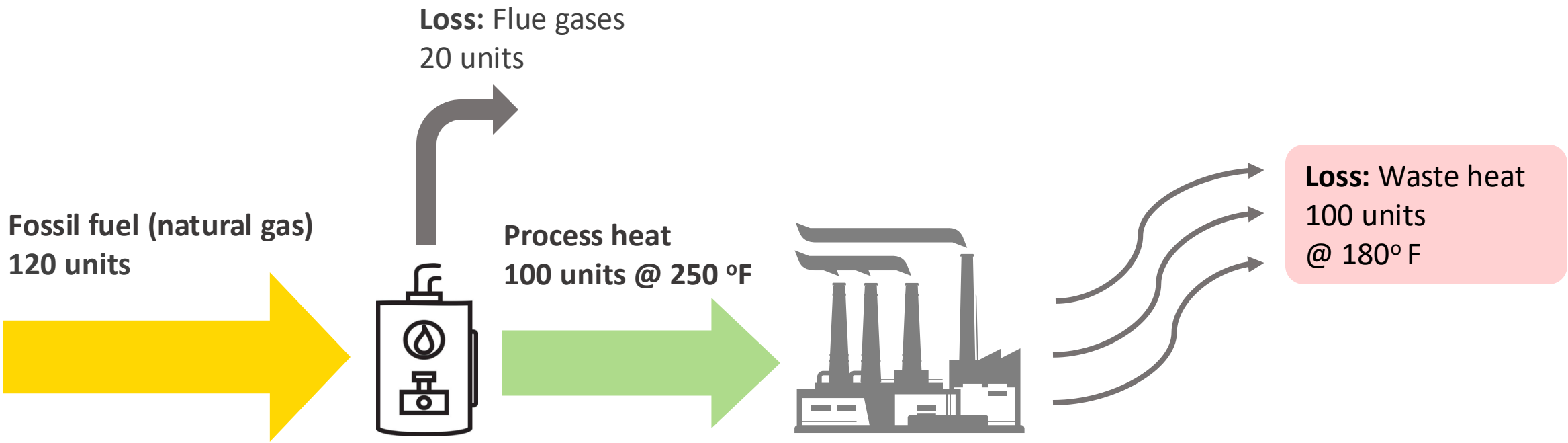


Process Heat Accounts for 70% Industrial Energy Use.

42% of energy is lost.

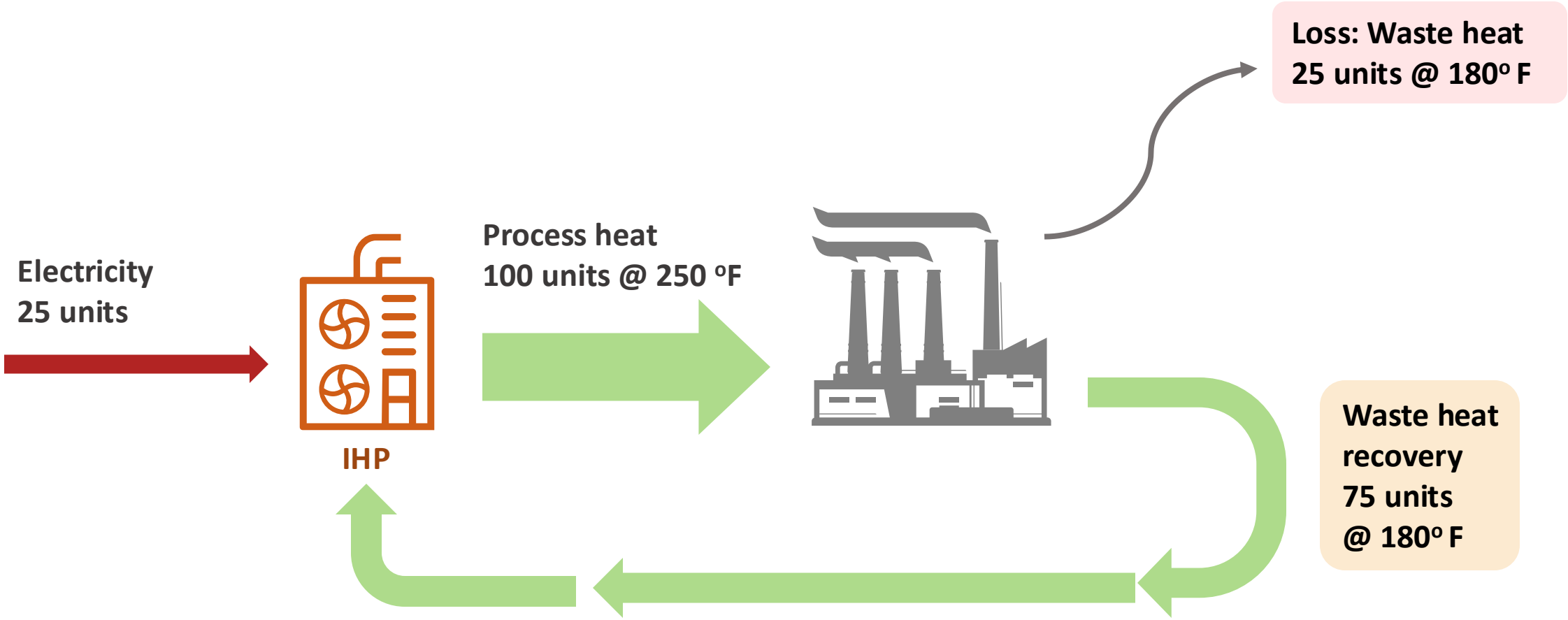
Source: www.energy.gov/eere/iedo/static-sankey-diagram-process-energy-us-manufacturing-sector-2010-mecs

Current Process: Steam Boiler since 1867…



Boiler Efficiency is 83%; the overall process efficiency is even lower.

Emerging Process: Industrial Heat Pumps (IHP)



IHP Efficiency is **400%**; the overall process efficiency can be higher.

IHPs can offer payback periods of less than 2 years.

Temperature range	Technology readiness?	Example process
<80 °C	**yes**	Paper Food Chemical
80 °C to 100 °C	**yes**	
100 °C to 140 °C	**Yes**	
140 °C to 160 °C	**Yes**	Paper Food Chemical Various industries: Steam production
160 °C to 200 °C	**Need Demonstration**	Various industries: High-temperature steam production
>200 °C	**Need Validation**	Various industries: High-temperature processes

Commercially available IHPs could serve 30% of industrial thermal demand, and higher-temp could increase this to 60%.

Source: adapted from IEA 2022

Industrial Electrification Has Momentum

Source: https://www.aceee.org/industrial-electrification-across-united-states

We Need Integrated Strategies to Reimagine the US Industry

- **Energy Efficiency**
  - **Equipment-level:** variable frequency drives, optimizing boiler efficiency, avoiding energy losses.
  - **Facility-level:** right sizing equipment and pipes, waste heat recovery, combined heat and power, automation.
  - **Supply chain-level:** seeking out suppliers that achieve certain energy efficiency or emission metrics, locating production near suppliers or markets.
- **Electrification**
  - **Low-temp:** heat pumps
  - **Medium-temp:** electric resistance, infrared heating, dielectric heating (microwave, radio wave)
  - **High-temp:** electric arc (arc furnaces, arc welding, plasma cutting, plasma torches), induction, lasers, electron beams (for precision applications)
  - **Thermal batteries**
- **Alternative Fuels, Feed Stocks, Energy Sources**
  - Strategies include fuel flexible processes, clean hydrogen fuels and feedstocks, biofuels and feedstocks, nuclear, concentrating solar energy, and geothermal

Opportunities and Challenges

Challenges

- **Complexity:** Industrial Heterogeneity
  - Tailored implementation and integration is needed.
  - Manufactures needs vary with size, resources, and workforce capabilities.

- **Competition:** Incumbent Technologies
  - Equipment replacement requires years of planning.
  - Validated performance of new technologies is needed.

- **Costs:** Upfront Costs and Scale-Up
  - Reaching industrial scale is a challenge.
  - Vendor support for scaling and integration is needed.

Policy instruments meet different needs

Grants
(R&D, FOAK, Supply Chain, State Govt)

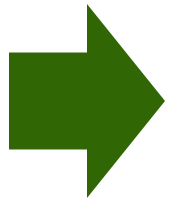
Tax Credits
(Investment, Production)

Loans
(DOE, Green Banks)

Performance Incentives
(Energy, Carbon)

Technical Assistance
(Nat. Labs, Colleges, Implementers)

Regulation (state / local)
(Carbon, NOx, Fossil Gas)



Cleaner Economy

Cleaner Plants

- ACEEE industrial decarbonization resource page: https://www.aceee.org/program/energy-efficiency-in-industry
- A. Johnson, K. Campbell and N. Elliott, 2023. *Sustainable Metals Manufacturing Opportunities in Indiana*. Washington, D.C.: ACEEE.
- N. Esram, A. Johnson, and N. Elliott . 2024. How to Decarbonize Industrial Process Heat While Building American Manufacturing Competitiveness. Washington, D.C.: ACEEE.
- Rissman, et al, 2019. *Technologies and policies to decarbonize global industry: Review and assessment of mitigation drivers through 2070*. Applied Energy; 266 (202) 114848.
- Rissman, 2024. Zero-Carbon Industry: Transformative Technologies and Policies to Achieve Sustainable Prosperity. Columbia University Press.
- U.S. Department of Energy, 2022. *Industrial Decarbonization Roadmap*. Washington, D.C.
- U.S. Department of Energy, 2023 (a). THE PATHWAY TO: INDUSTRIAL DECARBONIZATION COMMERCIAL LIFTOFF. Washington, D.C.
- U.S. Department of Energy, 2023 (b). Pathways to Commercial Liftoff: Carbon Management. Washington, D.C.
- DOE Industrial Clean Energy Demonstration awards: https://www.energy.gov/oced/industrial-demonstrations-program-selections-award-negotiations

Additional Slides (Discussion)

IHP and Other Clean Manufacturing Have Many Other Benefits beyond Energy Savings and Cost Reduction

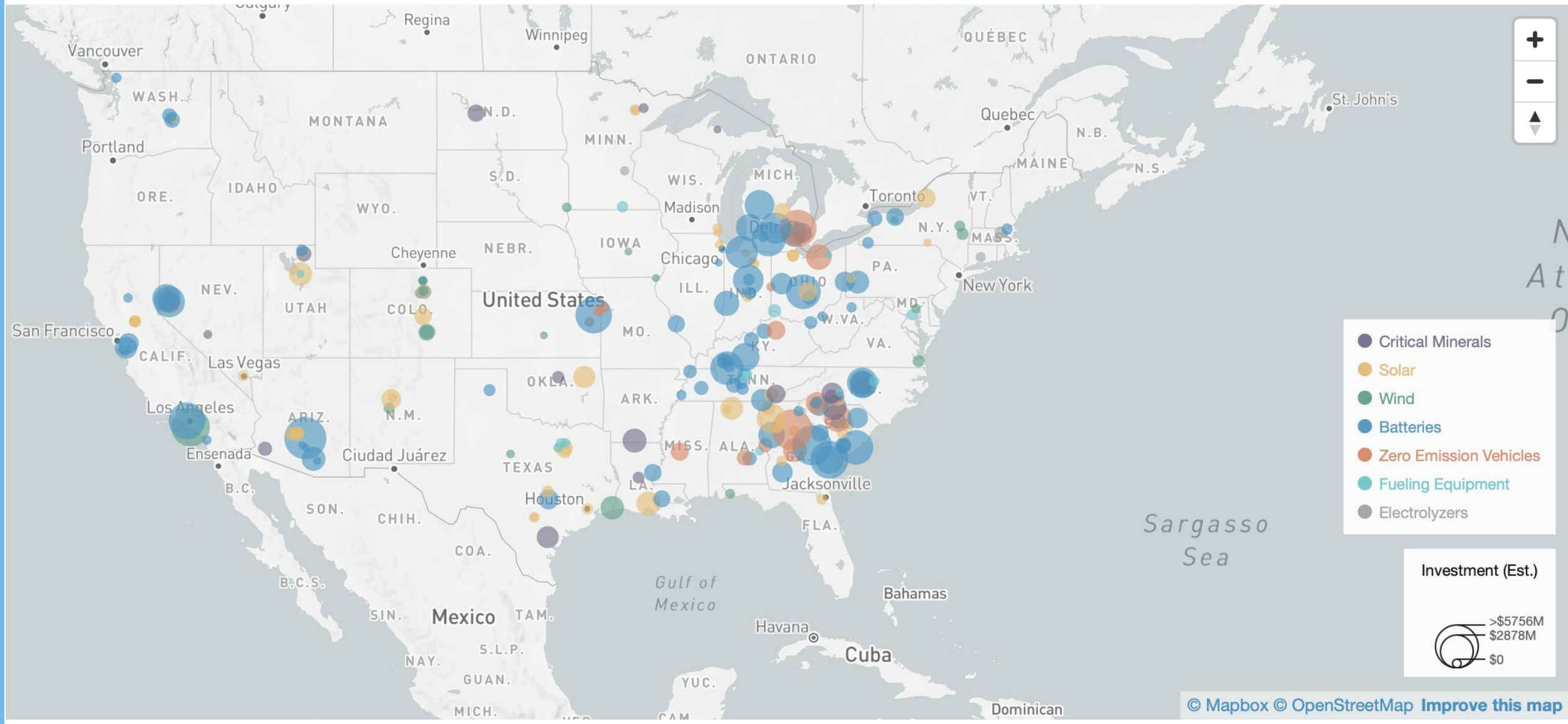
Benefits that accrue to implementing facilities

- Workplace health and safety
- Reduced insurance costs
- Reduced maintenance costs
- Resource conservation
- Reduced permitting costs and risks
- Future proofing and modularity
- Improved product quality

Benefits that accrue to the workforce, economy, and neighboring communities

- Lower pollution, improved air quality
- Local jobs with job retention
- Reduced noise pollution
- Wider economic benefits

Manufacturing Investment Announcement (Oct 2021–Sep 2023)

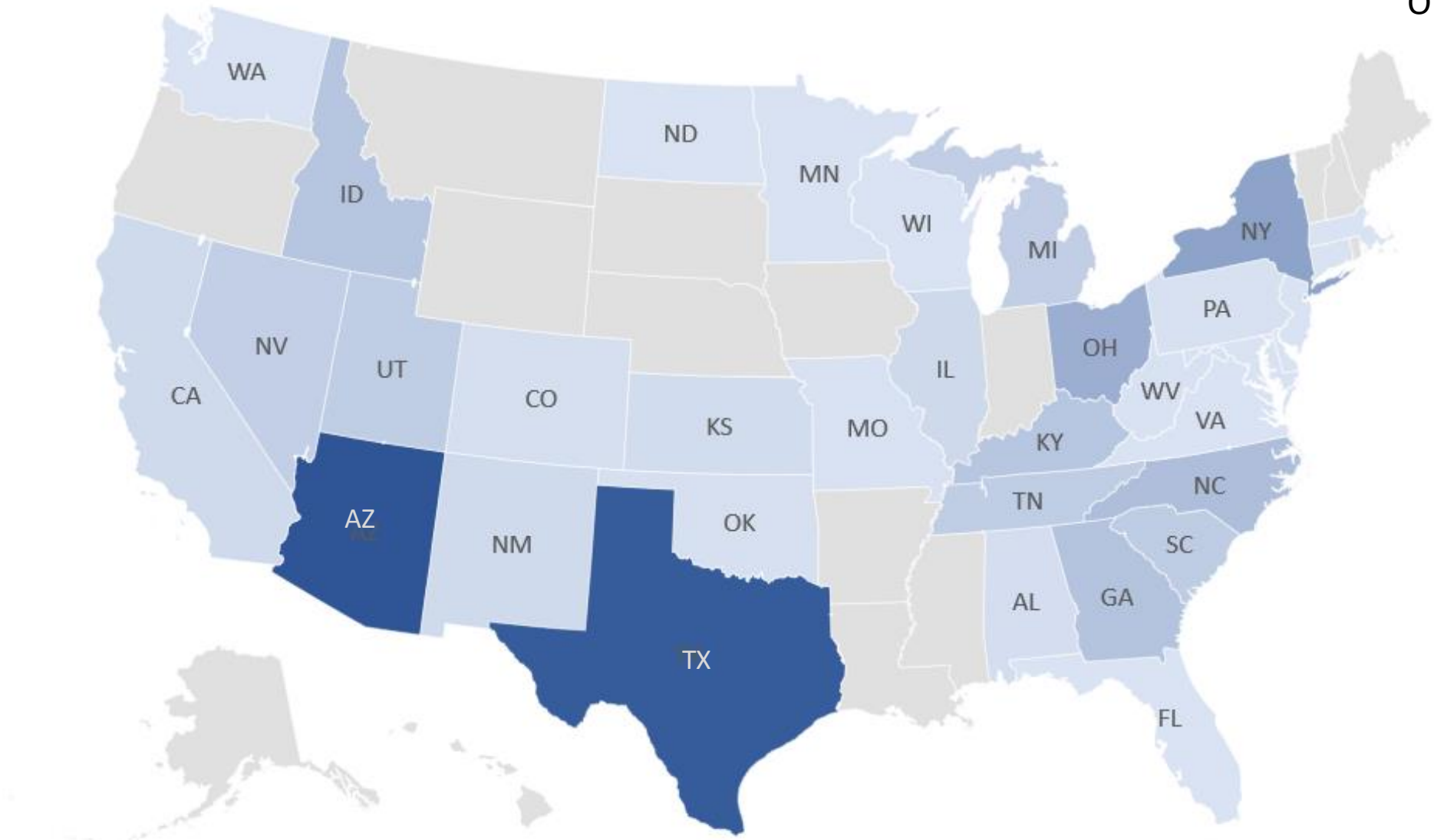


Source: www.cleaninvestmentmonitor.org/database

(NOT including Semiconductors)

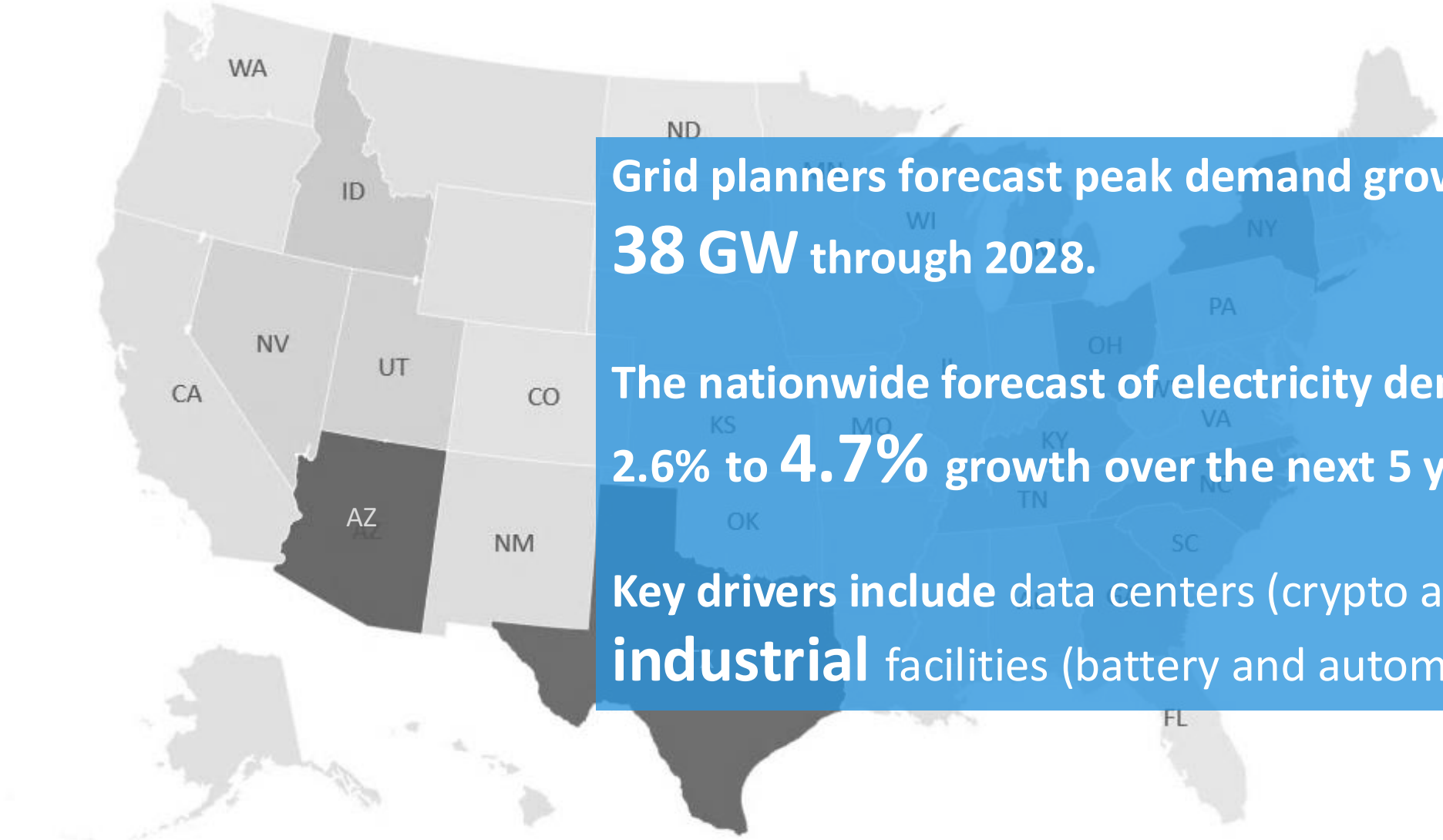
Economic Development Opportunities

$ 70,000 million investment
OR 1 million jobs (if $70K = 1 job)



Data Sources: Conness, J 2024; Semiconductor Industry Association 2024; EERE 2024; LPO 2024

Electricity Demand Growth in Industry



Grid planners forecast peak demand growth of 38 GW through 2028.

The nationwide forecast of electricity demand shot up from 2.6% to 4.7% growth over the next 5 years.

Key drivers include data centers (crypto and AI) and **industrial** facilities (battery and automotive sectors).

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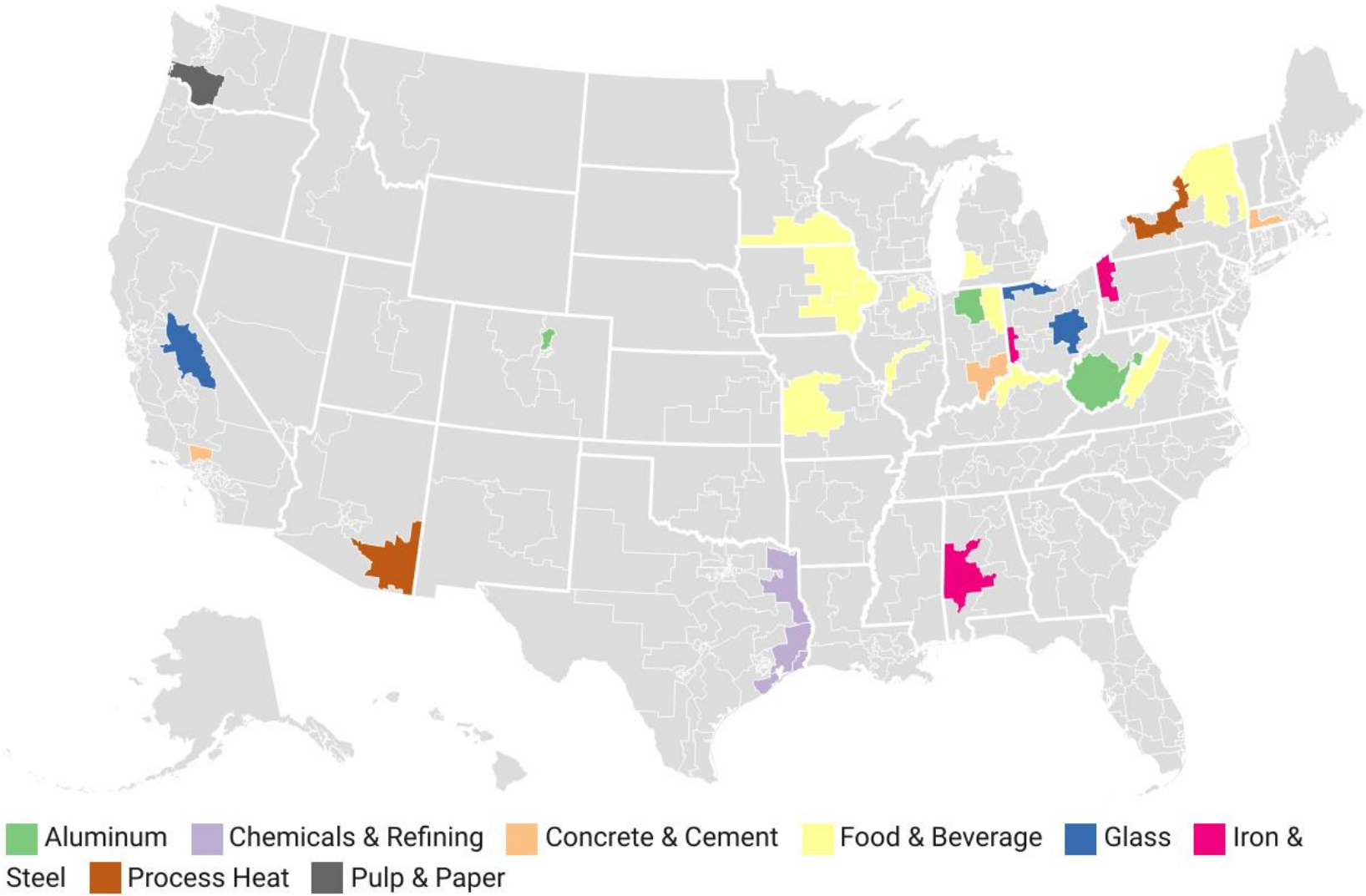
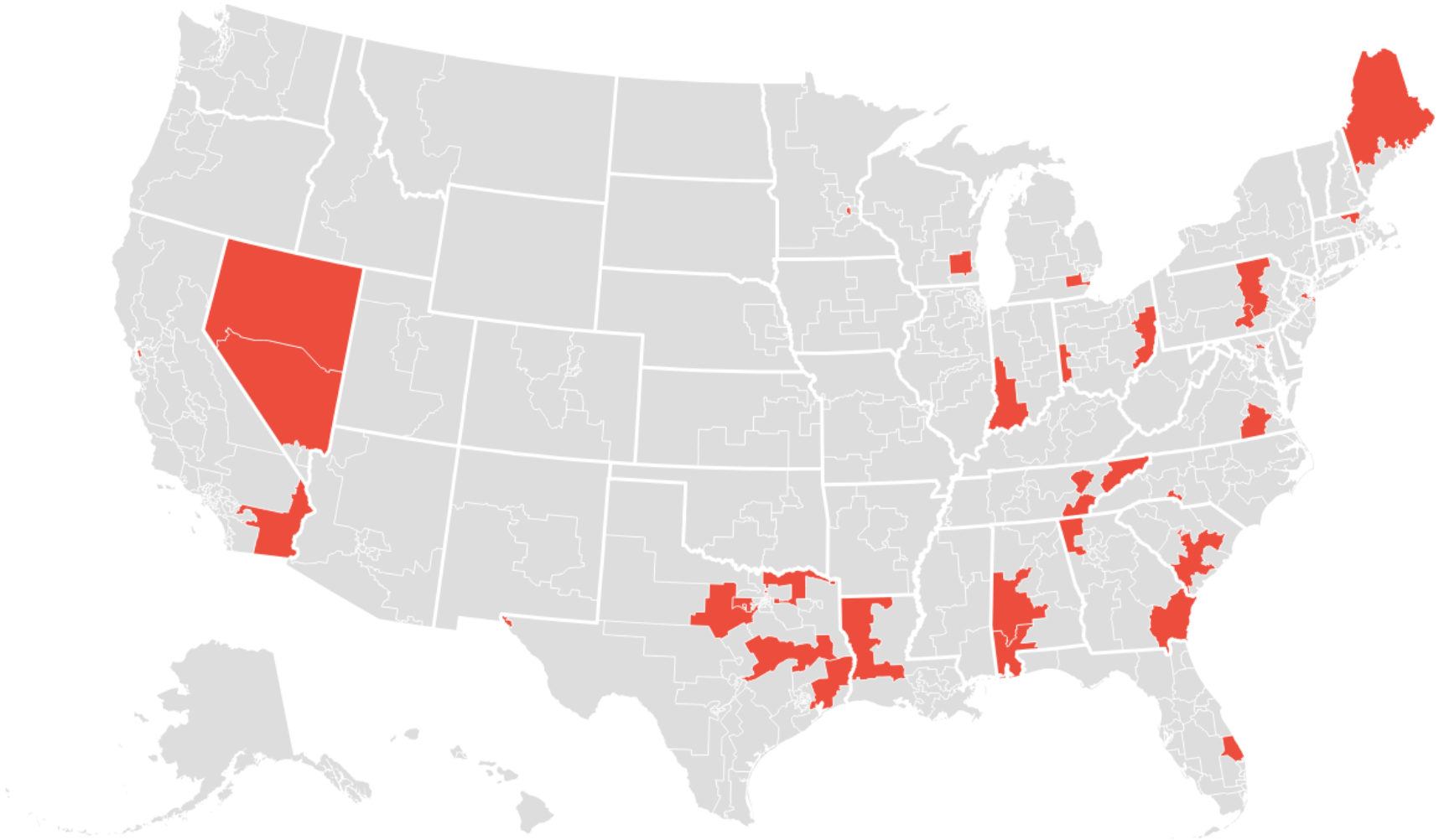
Sources: Grid Strategies, 2023; Utility Dive 2023

Congressional Districts with IDP Projects



Congressional Districts with disclosed 48C projects



Created with Datawrapper

Main Points to Remember

- Make plants **efficient**
- **Electrify** as much as possible
- Reduce **embodied carbon**
- Stop the **emissions** from flames and leaks
- Ensure transition benefits **communities**
- Make **smart** interventions