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Clean Manufacturing in America

Congressional Climate Camp

Wednesday, February 26, 2025

About EESI



Nonpartisan Educational Resources for Policymakers

A bipartisan Congressional caucus founded EESI in 1984 to provide nonpartisan information on environmental, energy, and climate policies



Direct Assistance for Equitable and Inclusive Financing Program

In addition to a full portfolio of federal policy work, EESI provides direct assistance to utilities to develop “on-bill financing” programs



Commitment to Diversity, Equity, Inclusion, and Justice

We recognize that systemic barriers impede fair environmental, energy, and climate policies and limit the full participation of Black, Indigenous, people of color, and legacy and frontline communities in decision-making



Sustainable Solutions

Our mission is to advance science-based solutions for climate change, energy, and environmental challenges in order to achieve ***our vision of a sustainable, resilient, and equitable world***

Policymaker Education



Briefings and Webcasts

Live, in-person and online public briefings, archived recordings, and written summaries

Climate Change Solutions



Bi-weekly newsletter with everything policymakers and concerned citizens need to know, including a legislation and hearings tracker



Fact Sheets and Issue Briefs

Timely, objective coverage of environmental, clean energy, and climate change topics



Social Media (@EESlonline)

Active engagement on Bluesky, Facebook, LinkedIn, X, and YouTube



Upcoming Briefings



EESI
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Congressional Climate Camp

4

Navigating Climate Information for Effective Policy-Making

Recording available @ eesi.org

Understanding the Budget and Appropriations Process

Recording available @ eesi.org

**Clean Manufacturing in America
Today!**

The Process and Path Forward for a Bipartisan Surface Transportation Bill

Thursday, March 13, 2025, 3-4:30 PM

Sign up for our *Climate Change Solutions* newsletter here: eesi.org/signup

Briefing RSVP here: eesi.org/2025climatecamps



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Wednesday, February 26, 2025



Clean Technology Manufacturing in the U.S: Reflections and Next Steps




Why is Clean Technology Manufacturing Important?

1. Ensures U.S. workers capture the economic gains of innovative industries;
2. Redresses the economic impacts resulting from the decline of manufacturing jobs;
3. Builds reliable and affordable supply chains;
4. Counters the pollution and worker exploitation that plague some overseas clean technology supply chains; and
5. Provides U.S. leadership for the technologies of the future.



Growth of Clean Technology Manufacturing

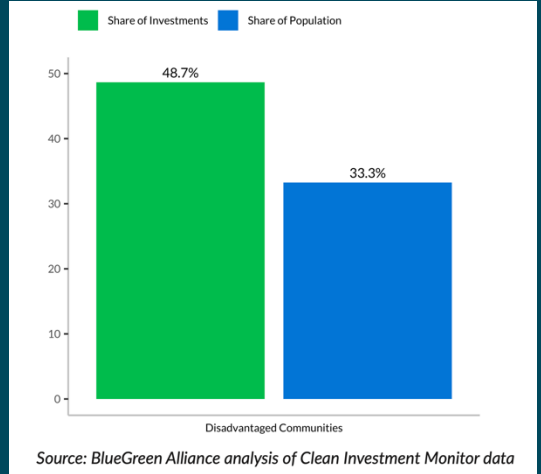
- Increased manufacturing announcements
 - \$388B of investment for batteries, electric vehicles, solar, wind, and semiconductors
- Manufacturing construction growth
 - \$237B spent in December 2024, up from \$128B in July 2022, and \$80B in October 2019.
- Business and consumer investment in manufacturing and deploying clean technologies is rising
 - \$493B for 2023-2024
 - 71% increase from the previous two-year period
- Job creation is expanding in the clean technology sector
 - Study finds anticipated 336,000 manufacturing jobs per year


FRED  **Total Construction Spending: Manufacturing in the United States**


Source: U.S. Census Bureau via FRED®
Shaded areas indicate U.S. recessions.

Clean Tech Manufacturing & Job Growth

- Two-thirds of job creation is expected to occur in manufacturing and construction
- This contrasts with the sectors of the economy where growth has trended
- Electrical, electronic, and electromechanical assemblers are the manufacturing occupations most impacted



FRED  — All Employees, Manufacturing

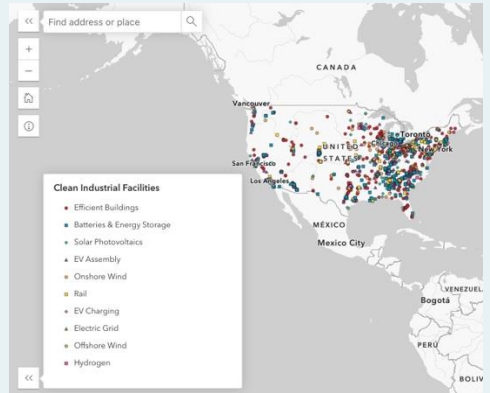
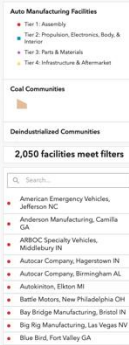
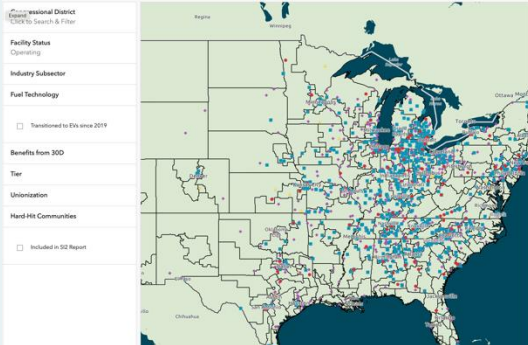

Source: U.S. Bureau of Labor Statistics via FRED®

Shaded areas indicate U.S. recessions.

fred.stlouisfed.org

Fullscreen 

Supply Chain Mapping



Supply Chain Gaps

Framework:

- Evaluate domestic manufacturing capacity
- Analyze degree that domestic production meets domestic demand
- Spotlight most notable gaps

Gaps:

1. PV wafers and cells
2. Offshore wind
3. Transformers

1	Supply Chain	Component	Description of Component	State of U.S. Supply Chain	Description of U.S. Supply Chain	45X & 48C Eligibility	Description of 45X Coverage
	Solar	Metallurgical-Grade Silicon (MGS)	Metallurgical-grade silicon (MGS) is the primary input material for polysilicon (it is also called silicon metal).	Significant	There are currently 6 plants producing MGS in the	48C only	While 45X covers polysilicon refining, the language does not mention that primary inputs for polysilicon
49	Solar	Solar-grade polysilicon	Polysilicon is the high-purity product obtained by refining MGS. PV is the primary consumer of	Moderate	Four operating polysilicon facilities are listed in the	45X & 48C eligible	This is one of the solar energy components eligible for 45X
50	Solar	PV wafer	A thin slice, sheet, or layer of semiconductor material of at least 240 square centimeters that comprises the	None	The DOE Solar Deep Dive report notes that the United	45X & 48C eligible	This is one of the solar energy components eligible for 45X
51	Solar	PV cell (crystalline or thin-film)	The PV cell is the smallest semiconductor element of a solar module. It performs the immediate conversion of	None	No operational facilities producing PV cells are listed	45X & 48C eligible	This is one of the solar energy components eligible for 45X
52	Solar	Polymeric backsheet (laminators)	A sheet on the back of a solar module that serves as an electric insulator and protects the components of	Significant	Backsheets for solar modules are typically made	45X & 48C eligible	This is one of the solar energy components eligible for 45X
53	Solar	Backsheet materials (film extrusion)	Nearly all backsheets use polyester (PET), often in combination with polyvinyl fluoride (PVF).	Limited	The DOE notes that PVDF-based backsheets dominate	48C only	While 45X covers polymeric backsheets, the language does not mention coverage of subcomponents or
54	Solar	Backsheet materials (PVF resins)	Nearly all backsheets use polyester (PET), typically in some combination with polyvinyl fluoride (PVF).	Limited	PVF resin is manufactured at two U.S. facilities, located	48C only	While 45X covers polymeric backsheets, the language does not mention coverage of subcomponents or
55	Solar	Encapsulant film	Encapsulant film forms a protective barrier around the PV cells, essentially laminating the cells. The main	Moderate	While the United States has significant capability to	48C only	45x does not mention the encapsulant film component for PV modules. 48C covers investments in facilities that
56	Solar	PV Module	Connected and laminated PV cells within a protected final assembly, ready for installation. Module	Significant	U.S. module assembly (with imported cells) scaled up	45X & 48C eligible	This is one of the solar energy components eligible for 45X
57	Solar	Inverter - general	Inverters convert direct current (dc) electricity from the modules into alternating current (ac) for connection to	Significant	There are 16 domestic inverter facilities listed	45X & 48C eligible	This is one of the solar energy components eligible for 45X
58	Solar	Torque tube	A structural steel support element that is part of a solar tracker. Torque tubes are rotated by a drive	See trackers and steel tubes		45X & 48C eligible	This is one of the solar energy components eligible for 45X
59	Solar	Steel tubes	A structural steel support element.	Significant	There are at least 14 U.S. facilities that produce	45X & 48C eligible (for torque tubes only)	Torque tubes are covered under 45X but not other types of steel tubes used in solar installations
60	Solar	Structural fasteners	A component used to connect the mechanical and drive system components of a solar tracker to the	Moderate	Generally solar fasteners are standard parts that are	45X & 48C eligible	This is one of the solar energy components eligible for 45X
61	Solar	Inverter - subcomponents: optimizer	Components are generally manufactured in separate locations from where they are eventually assembled	Moderate	Only one domestic optimizer producer was	48C only	45x covers five types of inverters (central, utility, commercial, residential, and micro), but doesn't specify
62	Solar	c-Si ingot	Polysilicon is melted to grow monocrystalline silicon ingots. The monocrystalline silicon ingot then gets	None	The United States has not active c-Si ingot, wafer, or	Possibly 45X & 48C eligible	It is unclear whether this is covered under 45X. 45X covers solar grade polysilicon, as well as the wafers
63	Solar	Trackers - general	PV trackers are used to orient modules more directly toward the sunlight to increase energy production per	Significant	In total, there are about 26 U.S. facilities that produce	48C only	45x covers torque tubes and structural fasteners for tracking, but does not mention other components of the
64							

Policy Considerations:

1. Due to policy developments the U.S. lost manufacturing capacity.
2. Manufacturing is capital intensive and requires long time horizons for investment decisions.
3. Manufacturing productivity in the U.S. has undergone a slowdown.
4. Demand for new manufacturing workers means several occupations could face labor shortages
5. Capacity to produce supply chain research and support investment strategies





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ZETA

ZERO EMISSION TRANSPORTATION ASSOCIATION

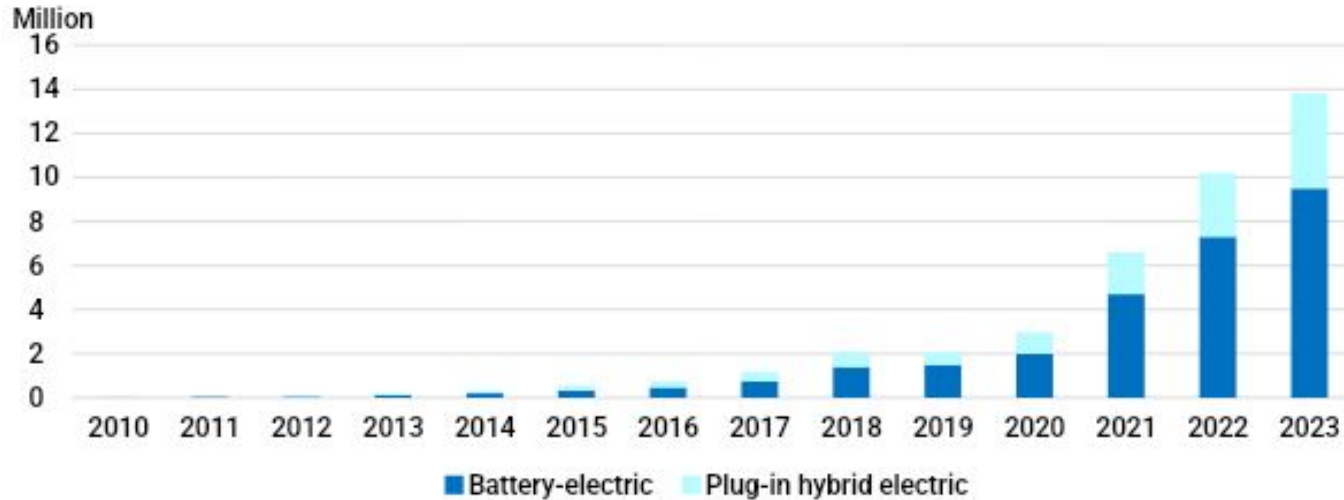
Clean Manufacturing in America Briefing Series: Congressional Climate Camp

Our Members



Global EV sales are on the rise

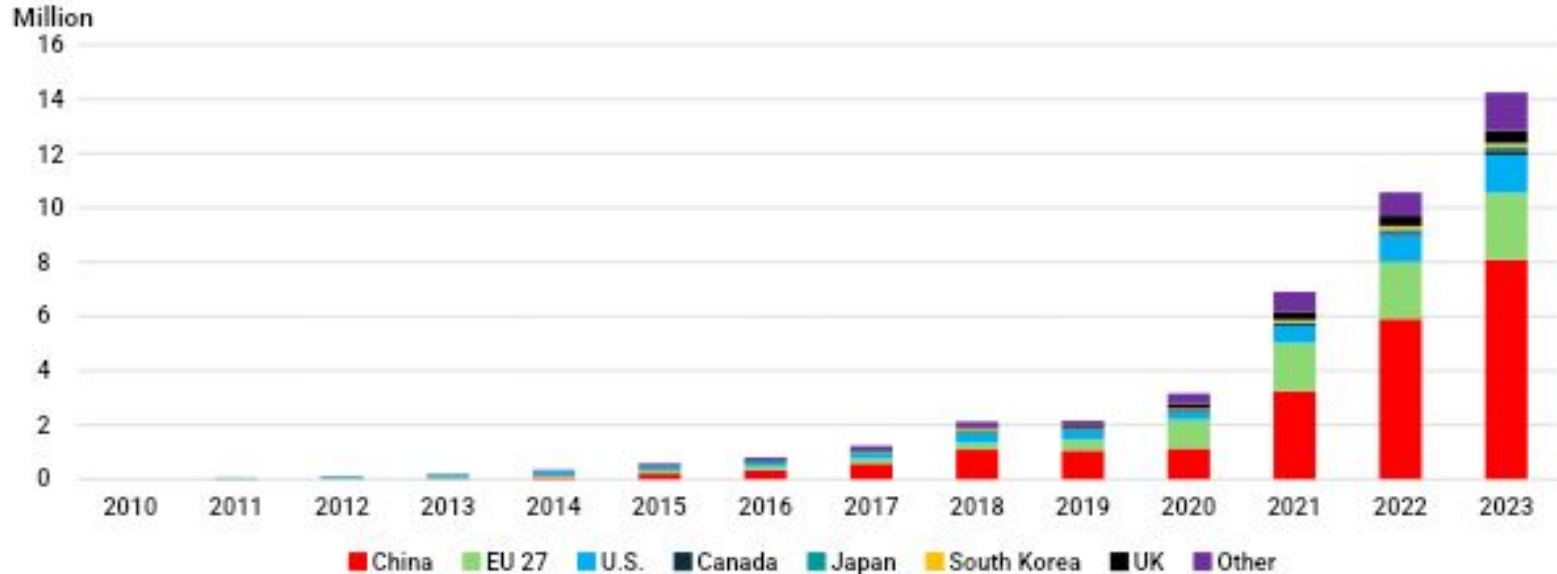
Global passenger EV sales by drivetrain



Source: IEA EV Outlook 2024.

China, Europe, and the U.S. have been the leading markets

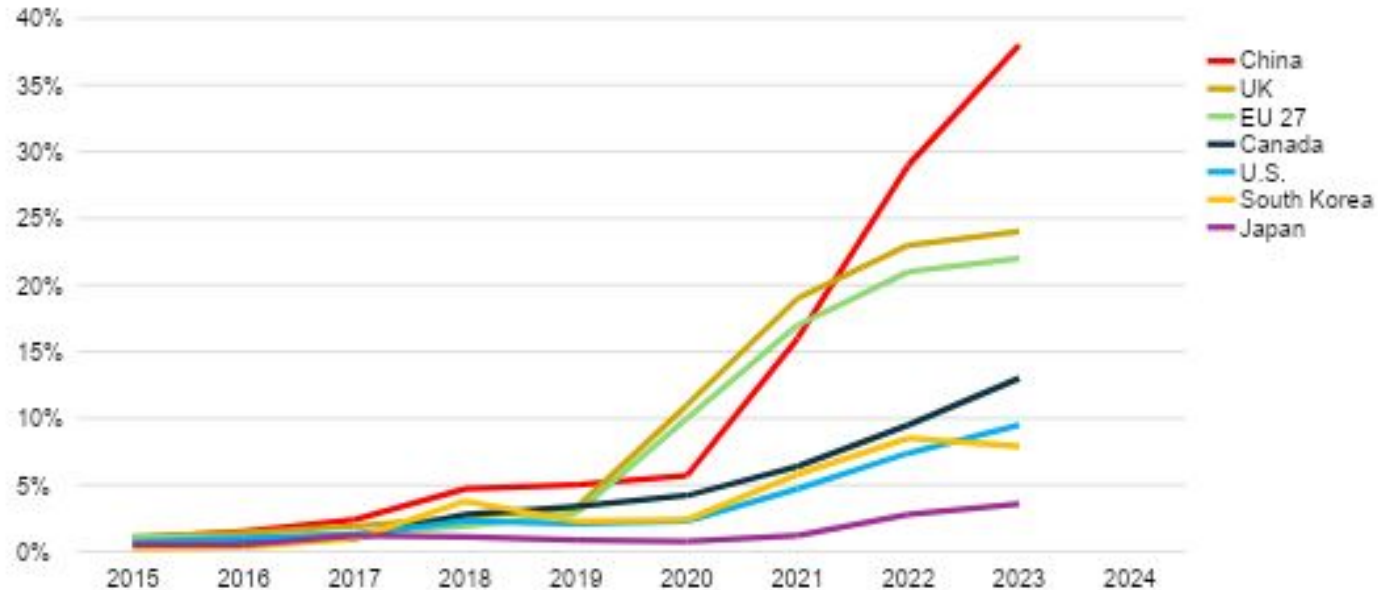
Global passenger EV sales by region



Source: IEA EV Outlook 2024. Note: includes battery-electric and plug-in hybrid electric vehicles.

... but other countries are clearly outpacing us

Passenger EV share of sales by each country



Source: IEA EV Outlook 2024. Note: includes battery-electric and plug-in hybrid electric vehicles.

The U.S. car market is unmistakably changing

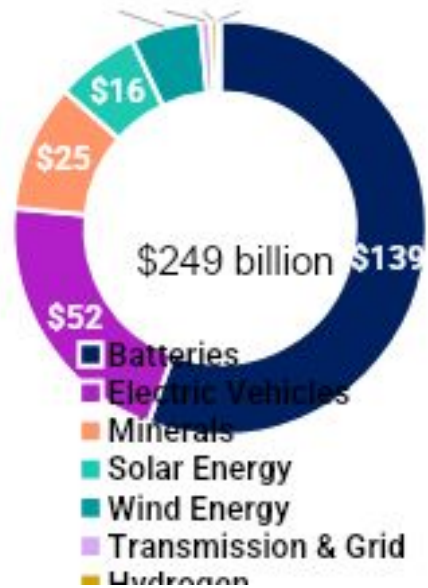
U.S. passenger car market sales (excluding ICE)

BEV CAGR: **42%**
PHEV CAGR: **42%**
HEV CAGR: **19%** (2015-2024)



Source: Edmunds. Note: CAGR is 'compound annual growth rate.'

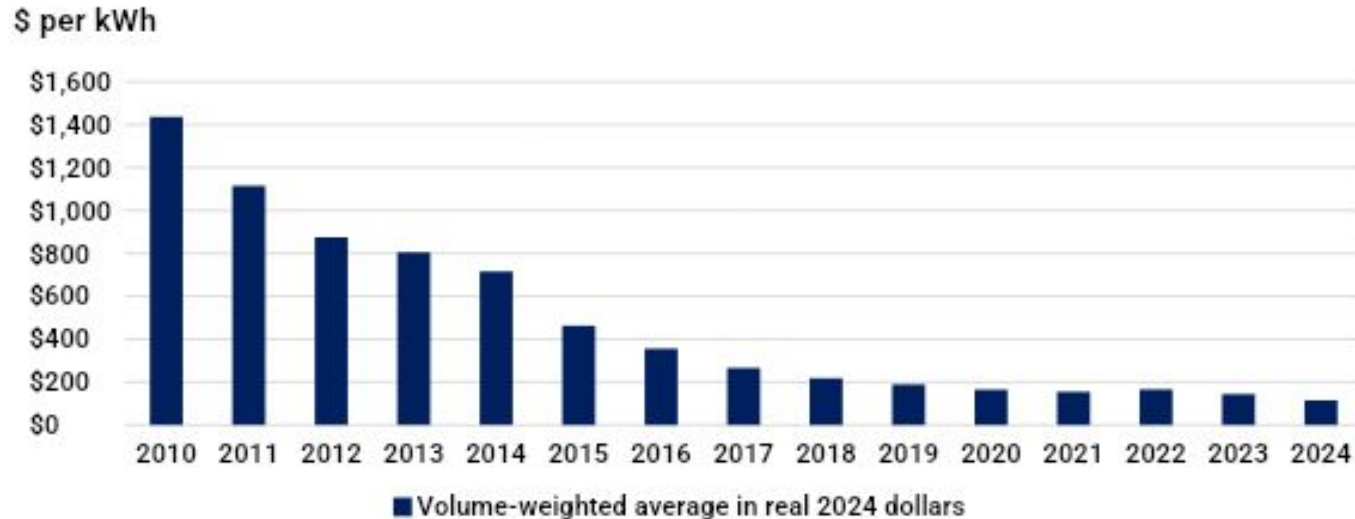
EV and battery investments make up a vast majority of US clean energy investment



Source: Atlas Public Policy.

Global battery prices have fallen to \$115 per kWh in 2024

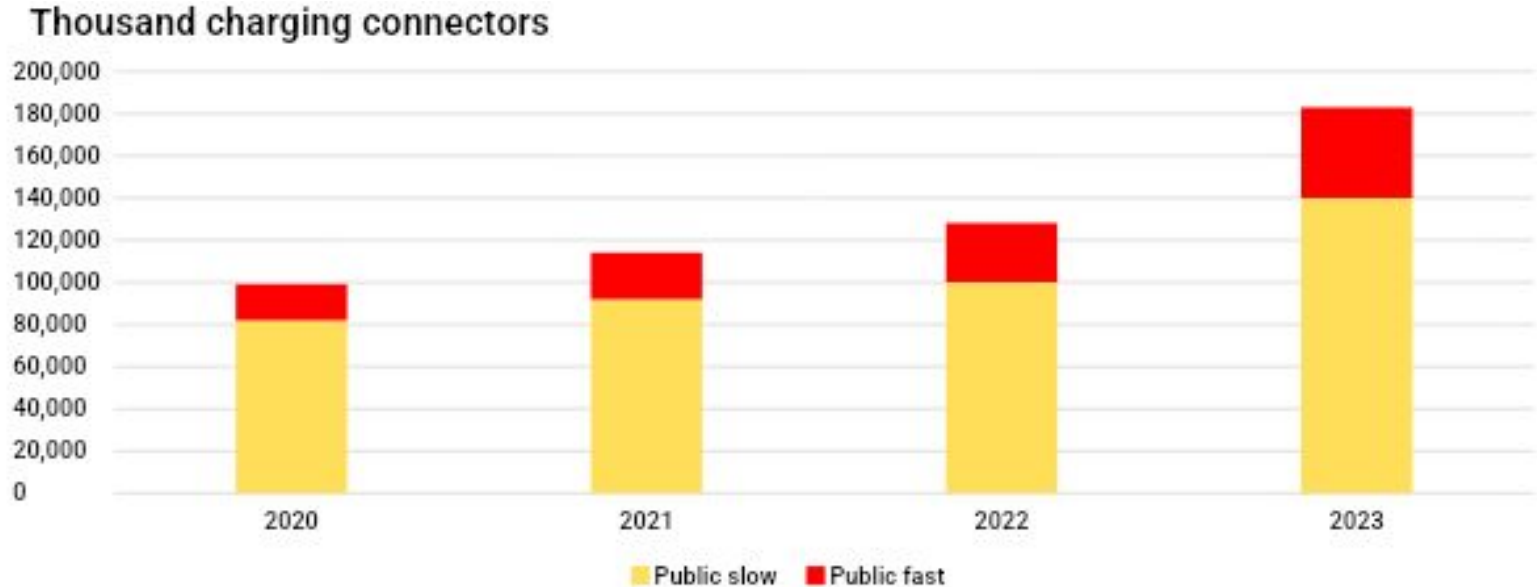
Lithium-ion battery pack prices (on a dollar per kilowatt-hour basis)



Source: BloombergNEF. Note: Prices are in real 2024 dollars.

Growth of US charging infrastructure

Public charging connectors by type in the US, historical

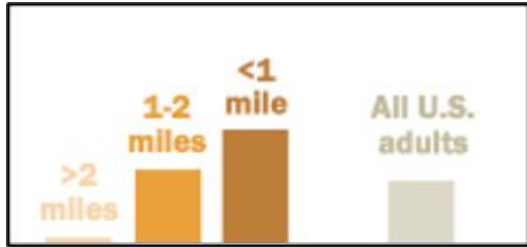


Source: IEA.

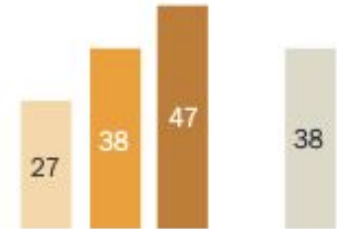
The closer you live to chargers, the more likely you are to want an EV

% of adults who lived __ from a charging station believe that they

Legend



Very/Somewhat likely to **seriously consider purchasing an electric vehicle** the next time they purchase a vehicle



Extremely/Very confident that the **U.S. will build the charging stations and infrastructure** needed to support large numbers of electric vehicles on the roads



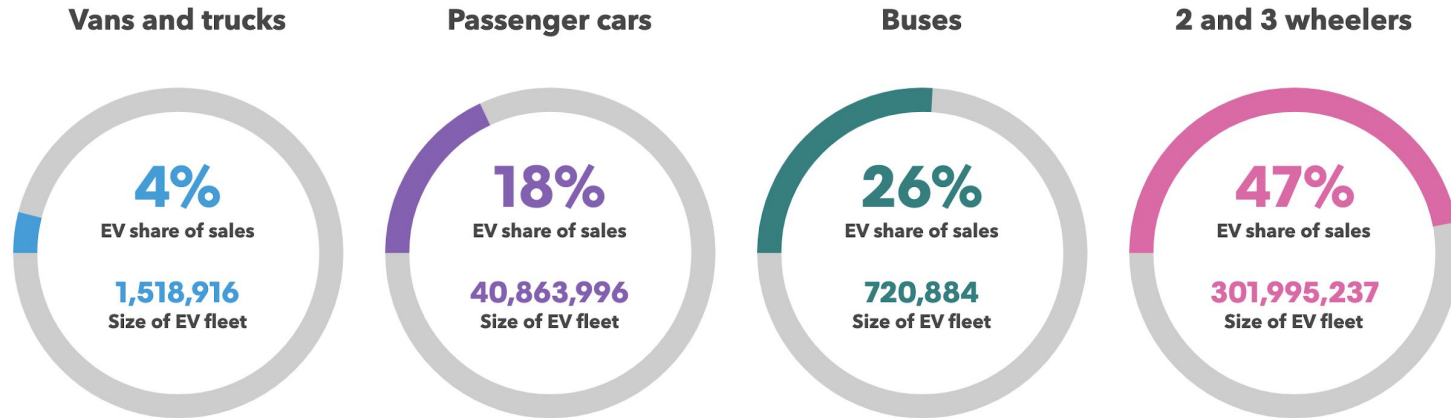
Currently own an electric or hybrid vehicle



Source: Pew Research Center. Note: Survey of US adults conducted May 30 – June 4, 2023.

The clean transportation transition is at different places in different segments

Global EV share of sales and fleet by segment at the end of 2023



Source: BloombergNEF.



THE KEY MINERALS IN AN EV BATTERY

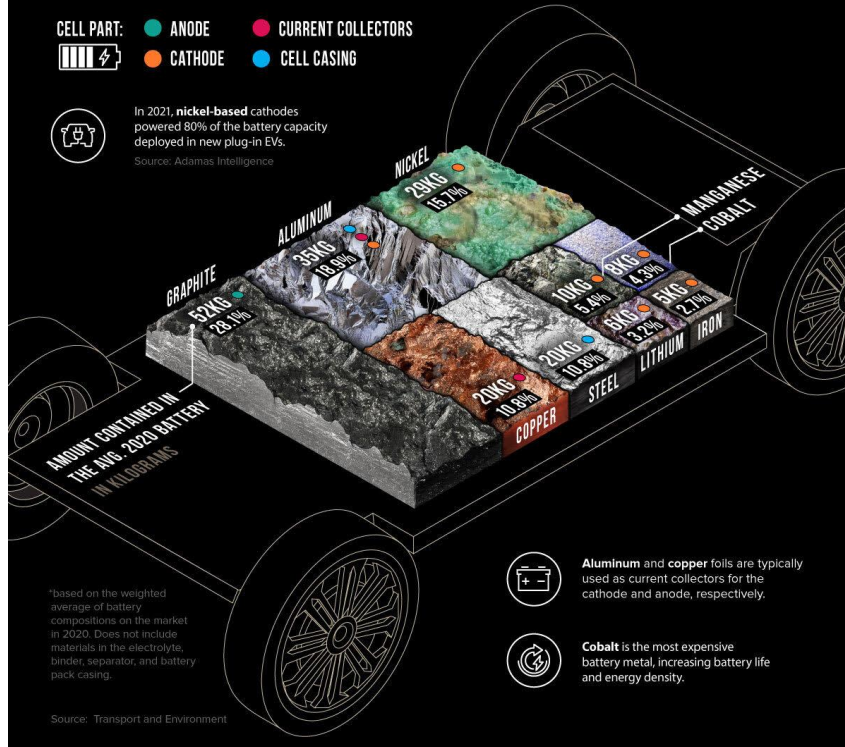
Lithium-ion batteries harness the properties of various minerals to power electric vehicles.

The cells in the average lithium-ion battery with a 60-kilowatt-hour (kWh) capacity contain around 185kg* of minerals.



In 2021, **nickel-based** cathodes powered 80% of the battery capacity deployed in new plug-in EVs.

Source: Adamas Intelligence



*based on the weighted average of battery compositions on the market in 2020. Does not include materials in the electrolyte, binder, separator, and battery pack casing.

Source: Transport and Environment



Aluminum and **copper** foils are typically used as current collectors for the cathode and anode, respectively.












Cobalt is the most expensive battery metal, increasing battery life and energy density.

Source: Visual Capitalist.

HOW BATTERY CHEMISTRIES DIFFER, BY MINERAL CONTENT FOR A 60KWH LITHIUM-ION BATTERY

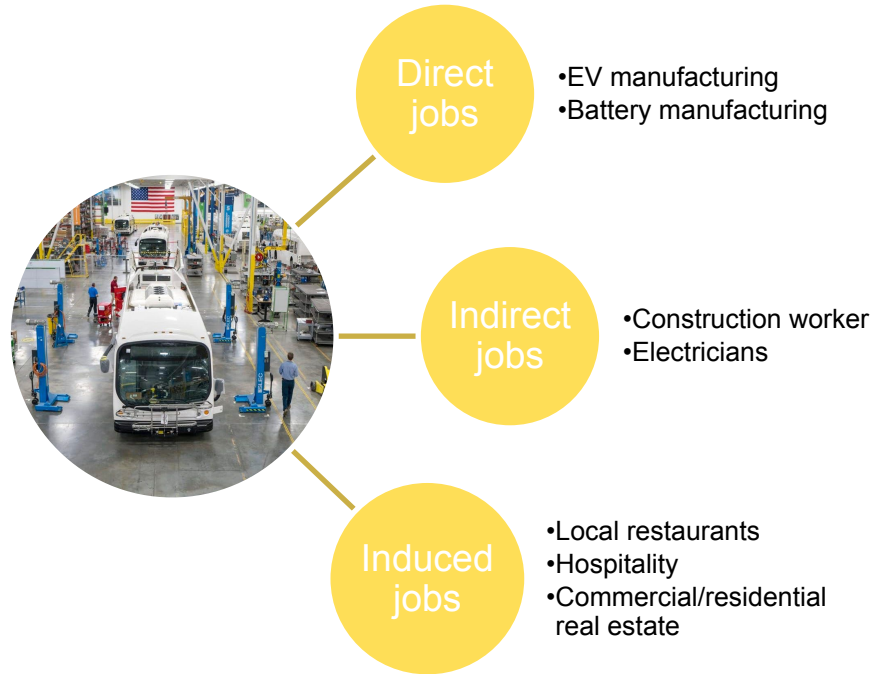
The name of the battery chemistry typically indicates the composition of the cathode.

	NMC811 Nickel (80%) Manganese (10%) Cobalt (10%)	NMC523 Nickel (50%) Manganese (20%) Cobalt (30%)	NMC622 Nickel (60%) Manganese (20%) Cobalt (20%)	NCA+ Nickel Cobalt Aluminum Oxide	LFP Lithium iron phosphate
 LITHIUM	5KG	7KG	6KG	6KG	6KG
 COBALT	5KG	11KG	11KG	2KG	0KG
 NICKEL	39KG	28KG	32KG	43KG	0KG
 MANGANESE	5KG	16KG	10KG	0KG	0KG
 GRAPHITE	45KG	53KG	50KG	44KG	66KG
 ALUMINUM	30KG	35KG	33KG	30KG	44KG
 COPPER	20KG	20KG	19KG	17KG	26KG
 STEEL	20KG	20KG	19KG	17KG	26KG
 IRON	0KG	0KG	0KG	0KG	41KG

ELEMENTS 

Source: Visual Capitalist.

What does this mean for domestic supply chains?





Daikin Group in the U.S.

EESI Clean Manufacturing in America
February 26, 2025

We are the largest global provider of Heating, Ventilation, Air Conditioning, and Refrigeration (HVAC&R) solutions, employing more than 98,000 globally and 22,000 talented colleagues in the U.S.

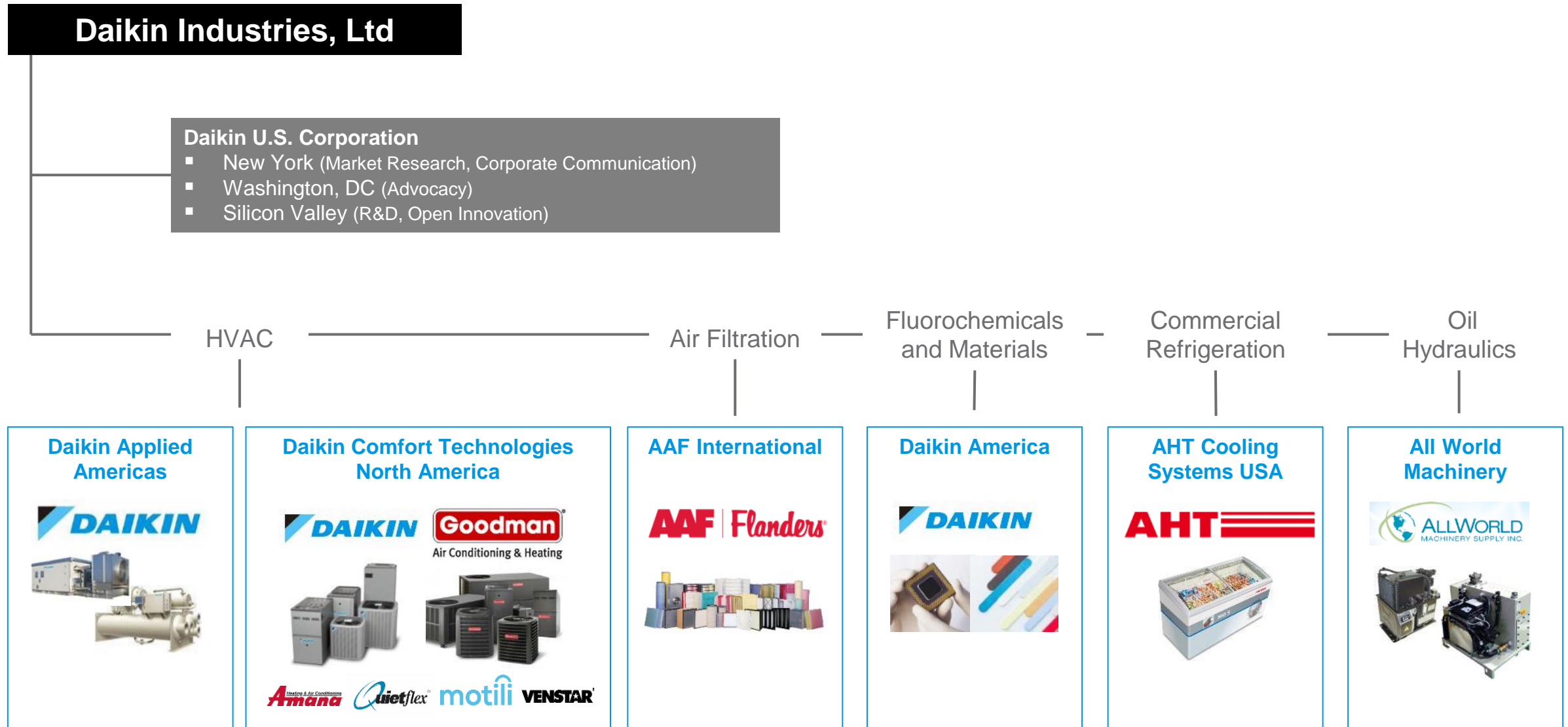
Daikin has played a leading role in transforming the HVAC&R industry and U.S. market for 30 years, through a relentless focus on:

- Open innovation
- Sustainability goals
- Indoor air and comfort
- And enabling stronger communities

With significant operations today across the U.S., Daikin is committed to fostering a better future for everyone – from businesses to consumers to society.



Specialized companies provide superior solutions to residential and commercial sectors across the U.S.



Key Stats in the U.S.

22,000+
employees

\$10.1B
FY23 Sales (¥1,474.4M)

\$9B+
total investment

Sales and services in
50 states

25
Production Bases

9
R&D Centers

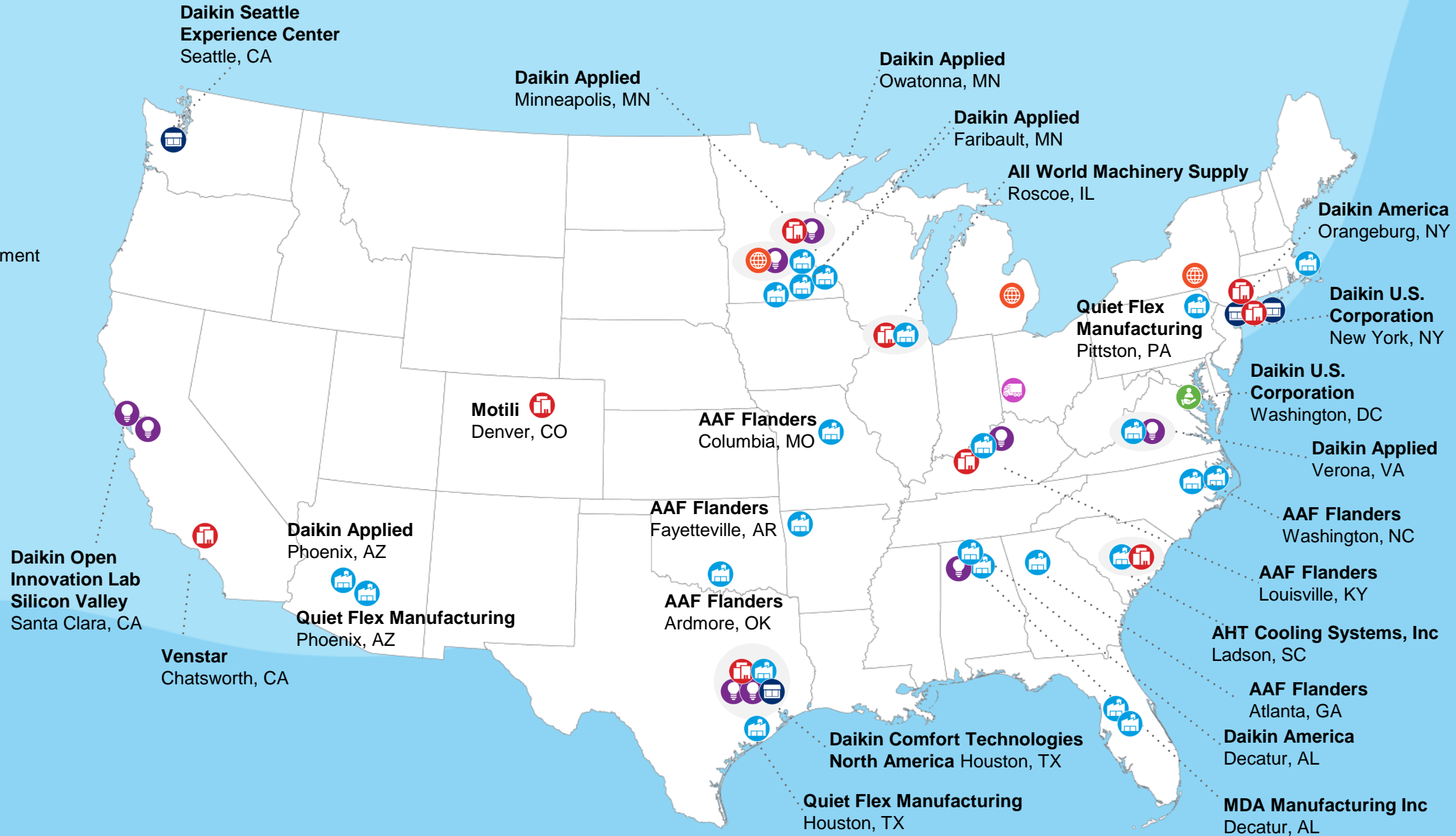
30 years
of business since 1994

400+
Sales Network

Key Locations Across the Nation

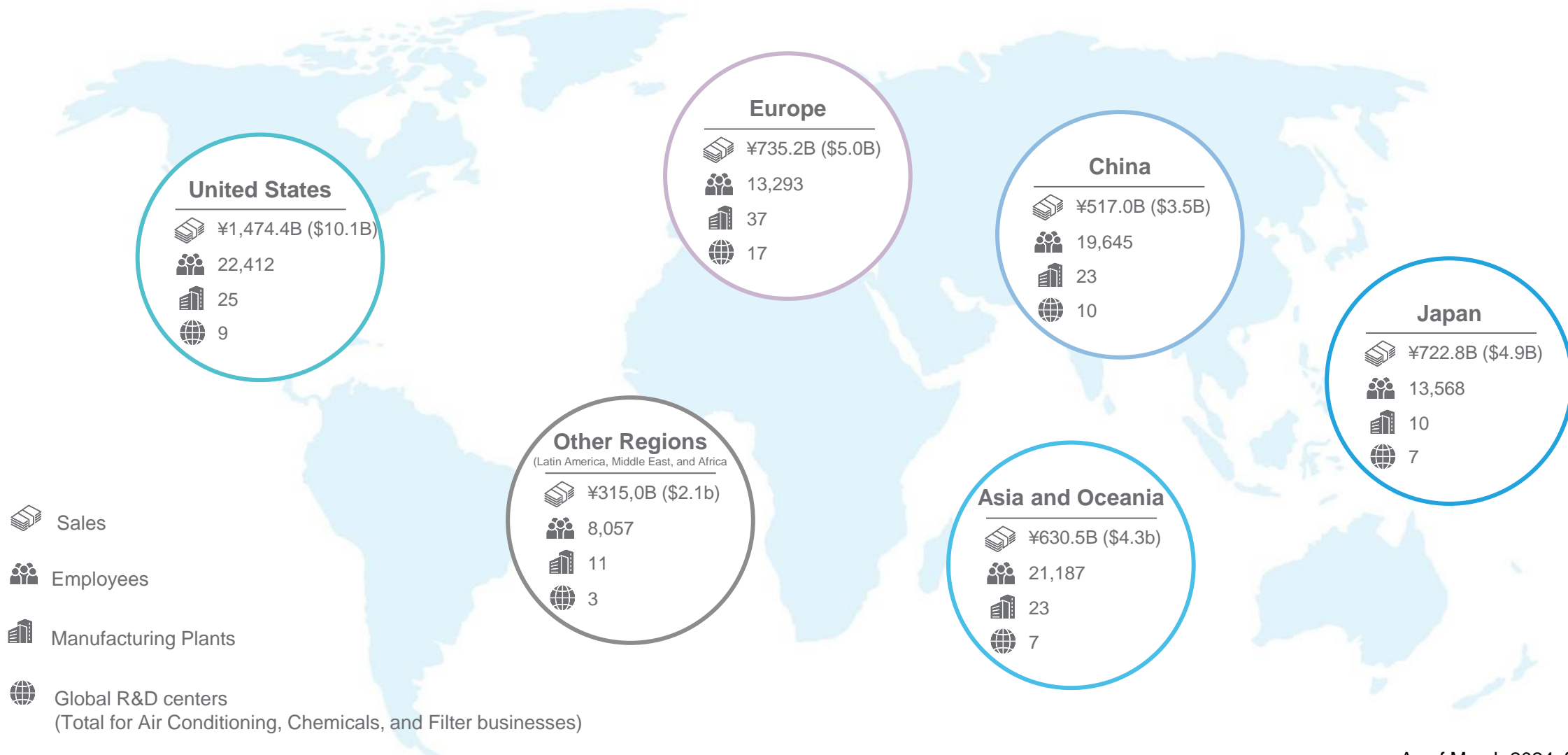
Daikin Key Locations

-  Headquarters
-  Production Bases
-  Research & Development
-  Showroom
-  Office/Operations
-  Distribution
-  Advocacy Office



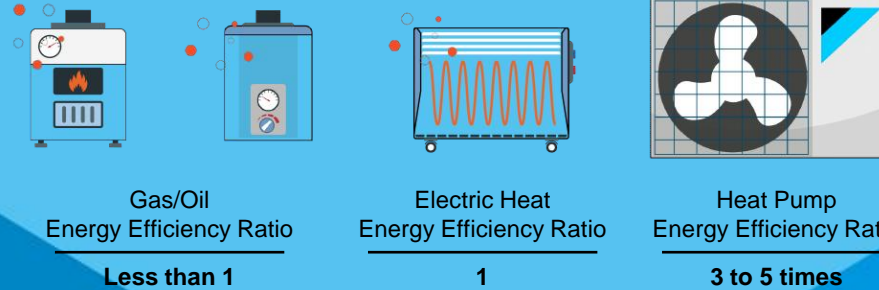
Global Presence in Regions

We conduct localized R&D and operations in numerous countries, providing solutions that meet the specific needs and challenges of each region.



1 HEAT PUMP

Heat pumps are more energy-efficient heating and cooling technologies than traditional combustion or electric systems, transferring heat into or out of the home or building without needing to generate heat itself

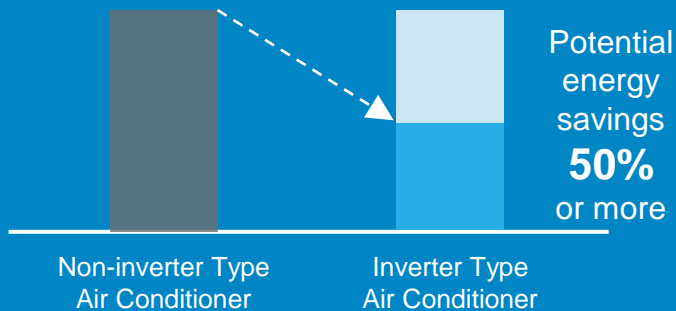


2

INVERTER

An inverter is an energy management and savings technology, eliminating wasted operation in air conditioners or heat pumps by efficiently controlling motor speeds

Immediate Impact by Inverter Technology



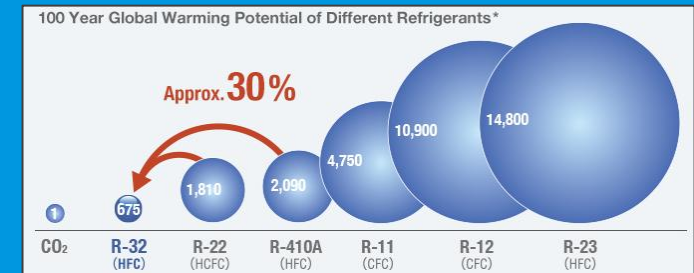
Daikin Core Technology

Approximately **10%** reduction in electricity consumption

3

R-32 REFRIGERANT

R-32 is a next-generation refrigerant with less Global Warming Potential and better efficiency than previously used R-410A. It has already been used in 280M units worldwide



A Heat Pump provides efficient and reliable heating and cooling, using only a small amount of electricity without the direct use of fossil fuels – supporting broad decarbonization initiatives in the U.S.

The Challenges

More than 40%

of U.S. energy consumption comes from heating and cooling houses, buildings and water

10 million+ homes

In the Northeast U.S. still rely on gas-fired furnaces

That accounts for

20% of U.S. greenhouse gas emissions



Heat Pumps enable building Decarbonization

Heat pumps are proven to be **3 to 5 x more efficient**

than comparable fossil-fuel-burning furnaces or electric heaters

How a Heat Pump Works

- 1 Heat energy is abundant in outside air, all the way down to -15°F



- 3 During cold months, the heat pump absorbs any heat from the outside air and transfers it into your home to heat your house



- 2 Heat is always attracted to something colder. Heat pumps use a small amount of electricity to compress refrigerant making it colder than the outside air

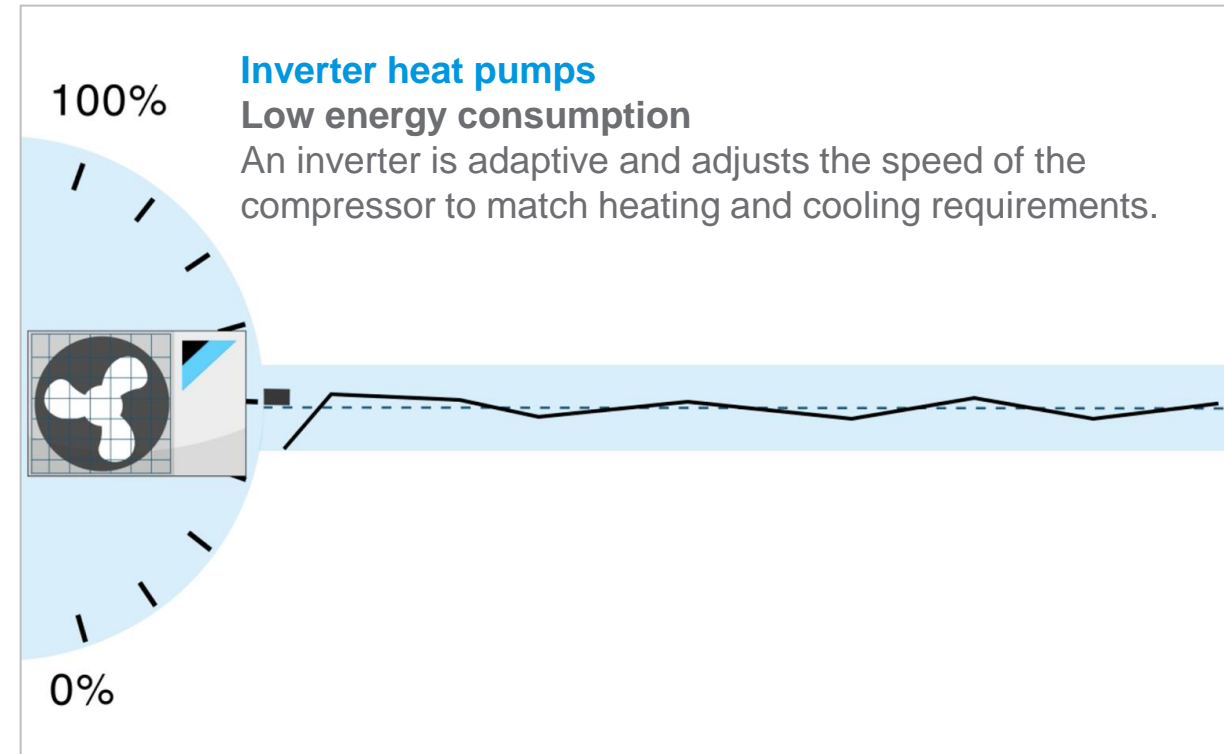
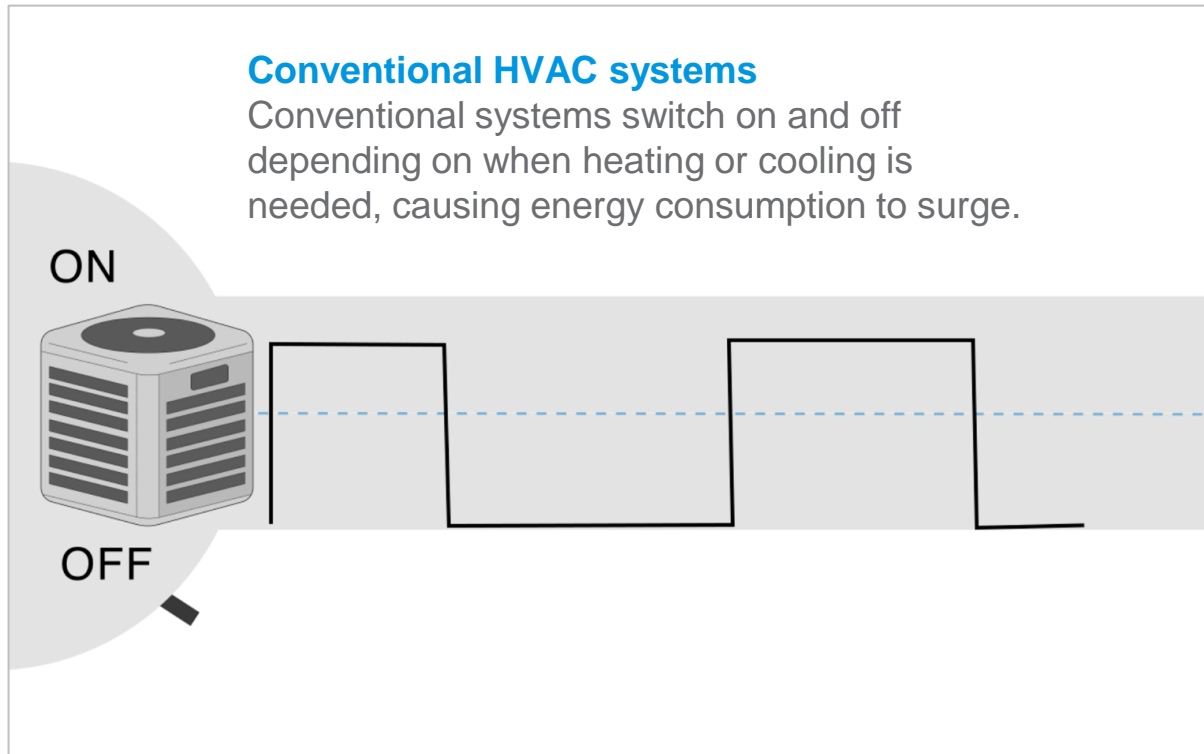


- 4 In warm months, the heat pump switches direction, extracting excess heat from inside your home and transferring it to the outdoors keeping the space inside cool



Inverter – Energy Efficient Technology

An inverter is an energy saving technology that eliminates wasted operation in air conditioners and heat pumps by efficiently controlling motor speed.



Benefits of Inverter



Lower monthly energy bills



Comfortable indoor conditions



Low operating sound levels



Consistent indoor conditions



Less Environmental Impact

Key Benefits of Inverter Heat Pump

Not all heat pumps are created equal! When integrated with innovative Inverter Compressor technology, a heat pump's annual costs and performance can be significantly improved.

Strong Performance in Cold Climates

By more effectively controlling the volume of heat transferred from outside ambient air, new inverter-based heat pumps can effectively operate without backup heating in temperatures as low as -25°F, making them ideal for cold climate applications.



Enabling Demand Response

During peak grid power usage in summer and winter, inverter heat pumps can dynamically keep running at lower capacities with reduced energy usage from the grid, while still enabling a degree of continuous indoor comfort.

Non-inverter or two-stage heat pumps may need to stop operating entirely in these situations, leaving spaces uncomfortable.



Reliability

With less on and off power cycling, more energy efficient indoor and outdoor operation, and the ability to perform in a wide range of low or high ambient temperatures, inverter heat pumps are simply far more reliable, reducing breakdowns and maintenance concerns.



Other Benefits

- Energy saving and lower annual energy costs
- Better indoor comfort due to less temperature swings
- Quiet and relaxing operation
- Smaller footprint (lowering manufacturing material and transportation needs)
- When using the industry-leading refrigerant “R-32”, systems require lower amounts of refrigerant than other available options

Daikin Texas Technology Park (DTTP)

One of the 10 largest U.S. manufacturing plants -- the headquarters of our residential business



\$500M
investment

26 lines
assembly line

100 Acres
(7 football fields)

Opened in
2017

10,000+
employees

Annual production
4.7M Units (FY22)

Function: Manufacturing, warehouse, office, showroom, home of North American R&D



Daikin Applied Facilities in Minnesota

Headquartered in Plymouth, MN, our commercial solutions are sold through a network of dedicated sales, service, and parts offices nationwide.

1,800
employees in MN

\$2M
worth of products each day

\$40M
Investment in Faribault North Facility

These locations manufacture products such as commercial air handlers used to condition and circulate large volumes of air throughout a space via ductwork.

Every product is designed to meet the customer's specific needs, thanks to our highly trained and skilled factory workers.



D.C. Office and Daikin Sustainability Innovation Center

Daikin's new hub fosters open innovation with government, NGOs, competitors, academia, and startups to advance new sustainable technologies and domestic manufacturing.



- Opened May 2023
- Located across from the White House demonstrating Daikin's commitments to the U.S.
- Showcasing Daikin's core technologies
- Advocacy base
- The hub of Open Innovation



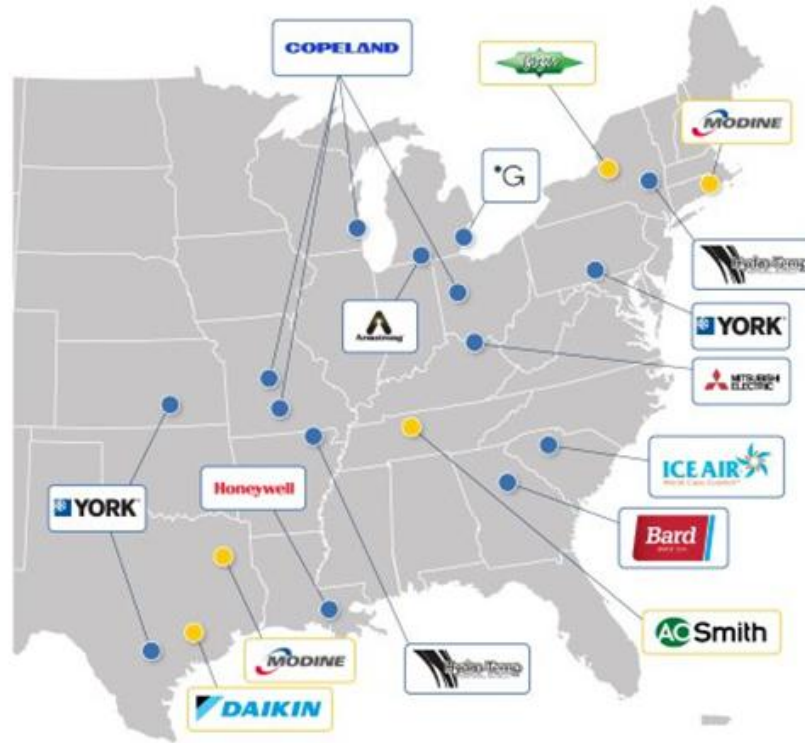
Daikin Sustainability Innovation Center (DSIC) Virtual Tour

Electric Heat Pump Manufacturing

ROUND 1 & 2 SELECTEES

- Round 1
- Round 2

ENERGY.GOV/MESC



Outdoor Product Type	Air to Air Cold Climate Heat Pump			Air to Water Heat Pump & Hot Water Solution		
	CCHP FIT (ZEAS)	CCHP Multi Mini-split (TBM)	DOE CCHP Challenge (GQI-Eco)	Altherma 3M (Monobloc Type)	Altherma 3H (Hydro split)	
H*W*D (mm)	990*940*320	871*1100*460	1430*940*320	737*1245*397	867*1378*520	1019*1270*530
Capacity	Up to 4 ton	Up to 3.5 ton	3 – 5 ton	Up to 2.3 ton	2.5 ton – 4.5 ton	Up to 5 ton
Production Base	DTPP /DMMX	DIT	DIT	DICz	DENV	DENV

Daikin received a \$39 million matching grant from the Department of Energy to expand production of Heat Pumps at DTPP Facility

- Daikin will bring Altherma, an air to water heat pump solution to the North American market.
- It will also bring three cold climate air to air heat pump models that will meet the requirements for the DOE/NRCAN Cold Climate Heat Pump Challenge.
- Benefits: new jobs, innovative new products, domestic manufacturing, lower energy costs, expanded equipment options.

Our HVAC Product/Solutions Lineup

Daikin offers a wide range of products and solutions from residential, commercial, to industrial.

Residential

T-Stat Platform
Communicating
Wi-Fi Interface
Daikin One Cloud Services



Commercial



HERO Cloud Services



iTM BACnet Client

SURVEYOR
Skyport Cloud



Industrial

Solutions (Energy Management, IAQ, Connected BAS, etc.)

Residential AC



Unitary
AC & HP,
furnaces



Unitary
IAQ



Single Zone
AC & HP



Multi-zone
AC & HP

Air Purifiers



Air Purifiers



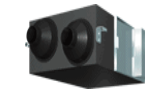
VRV Systems



VRV IDU



Ventilators



Applied ACs



Chiller



Air Handler



Fan Coils



Water Source
Heat Pump



Unit Ventilators

Applied Terminal Systems

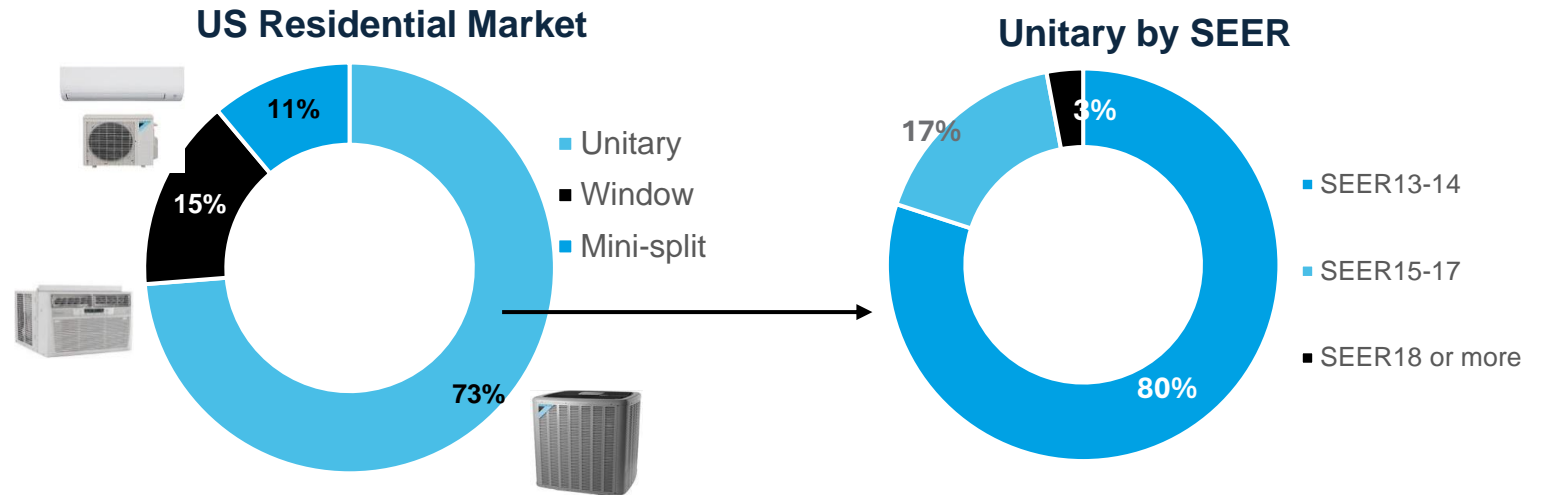
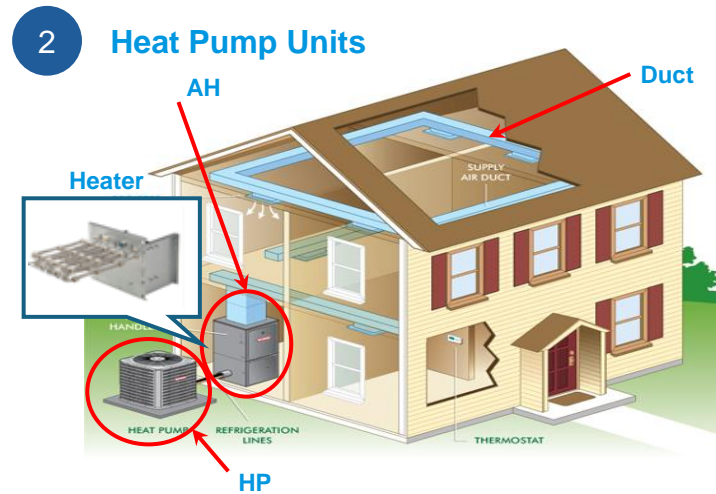
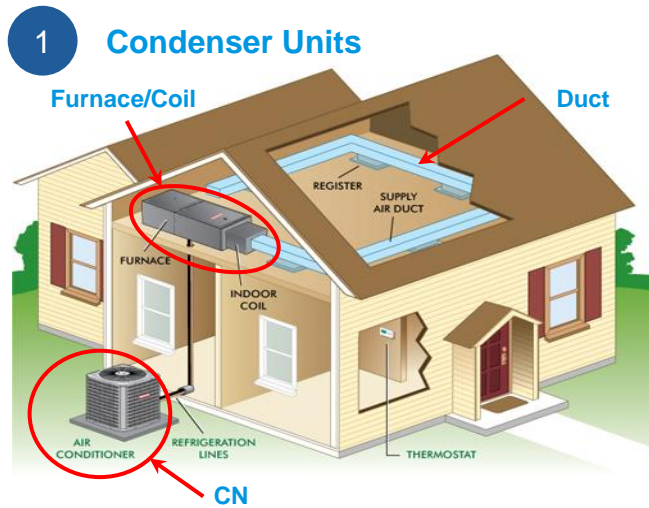
For Small Shops & Offices



Rooftops



Duct type air conditioning is common for United States and it is about 70% of the market. Inverters are used only in high-efficiency units (less than 3%)

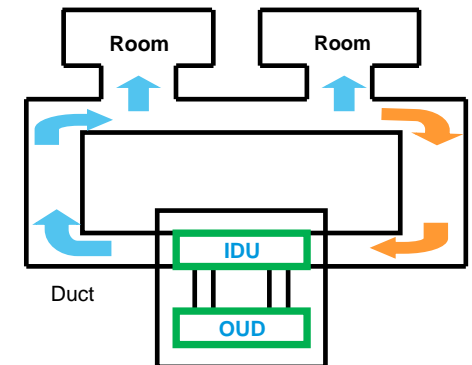


2016 BSRIA
 ※Not including Package units

Inverters are used only in high-efficiency units

Duct type

- This type of heating and cooling system heats and cools air or water in an air conditioner that integrates the indoor and outdoor units into one unit. Air-conditioned air is then conveyed to each room through pathways called ducts.
- Because it is extremely difficult to adapt equipment individually for a large-scale building where one floor is roughly more than 990 square meters, most large building use central air conditioning.



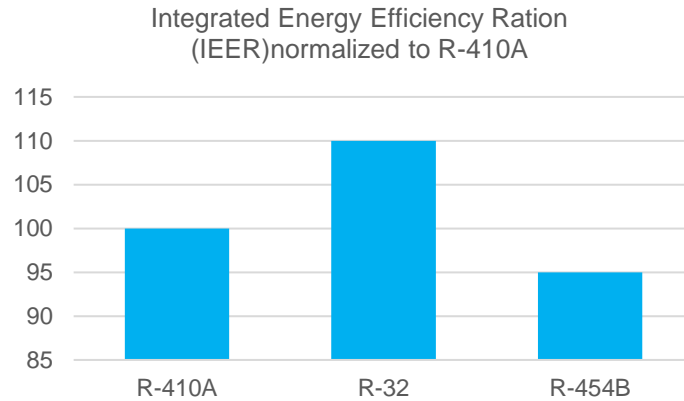
R-32 – Next Generation Refrigerant

The U.S. is focused on lower GWP refrigerants – R-32 products are already proven and in use in 280 million units across the globe, offering many environmental benefits.

EFFICIENT

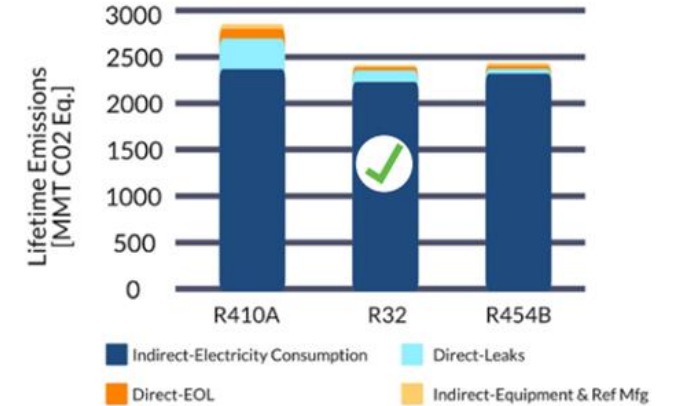
R-32 provides excellent efficiency and capacity;

Better than R-410A and R-454B



LOWER EMISSIONS

R-32 has lower lifetime CO2 eq. emissions



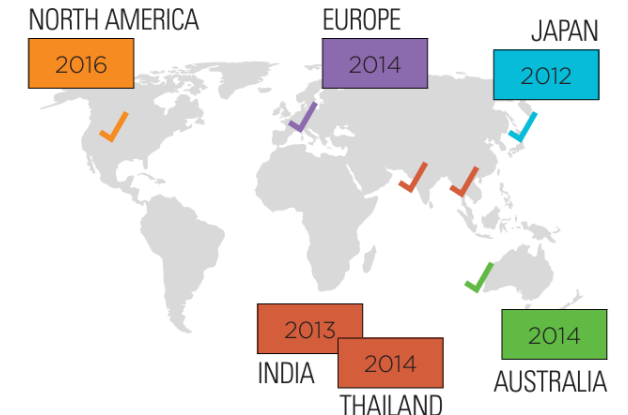
EASY

Unlike blends, R-32 is a pure, single component refrigerant. It is easy to reuse, and reclaim, and recycle.



PROVEN

R-32 has been safely used in over 280 million units in the US and around the world by more than 50 OEMs.



Advances in U.S. Manufacturing

Congressional Climate Camp

Nora Efram, PhD. (nesram@aceee.org)

February 26, 2025



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](https://www.aceee.org)



Presenter



Nora Wang Eram, Sr. Director for Research, ACEEE

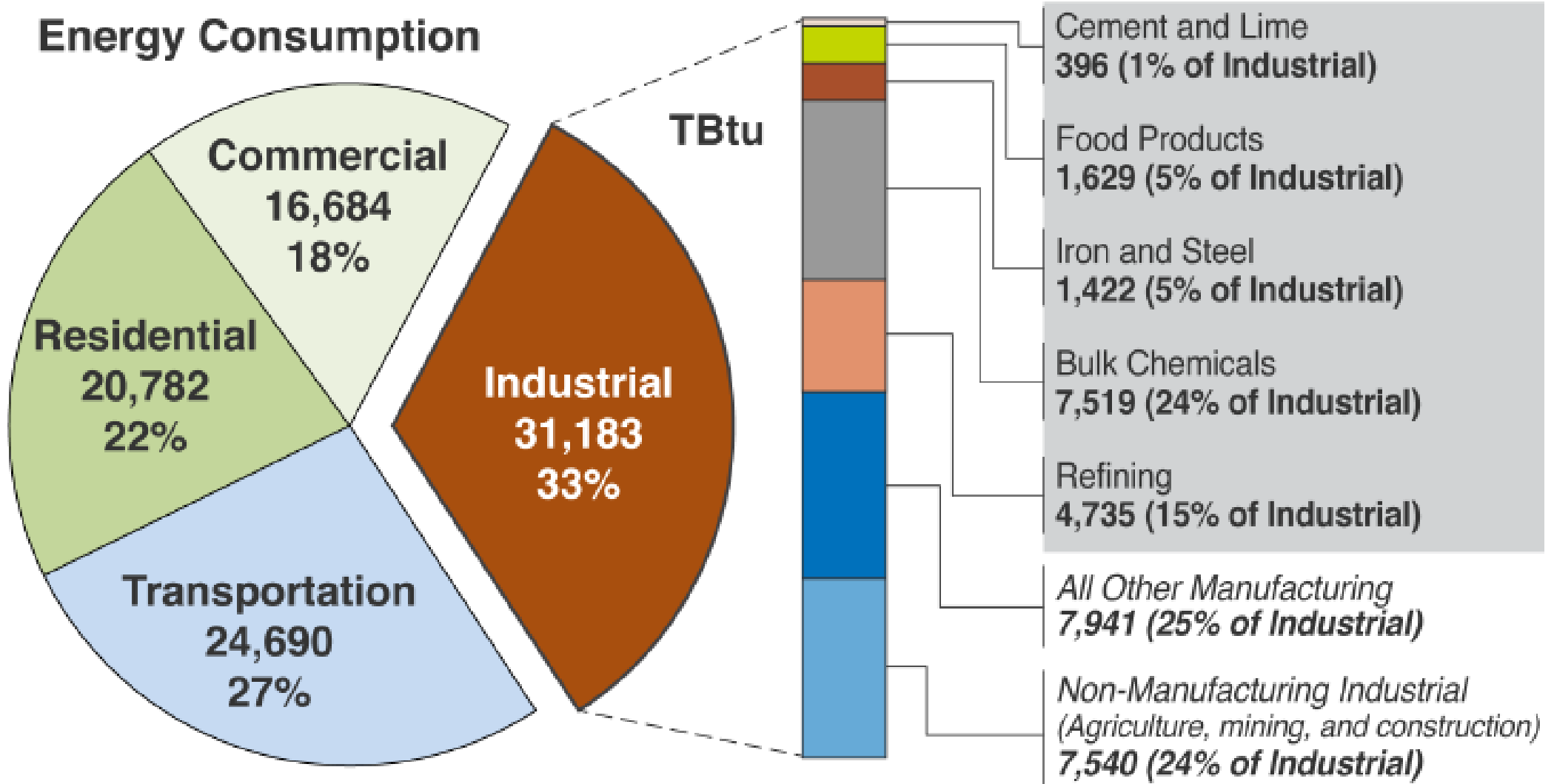
Dr. Eram oversees ACEEE's research programs including Buildings, Industry, Transportation, Behavior, and Health and Environment. She joined ACEEE in 2020. Prior to ACEEE, she was a chief engineer and team lead at the Pacific Northwest National Laboratory and spearheaded multi-disciplinary projects advancing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

Industrial energy use and emissions

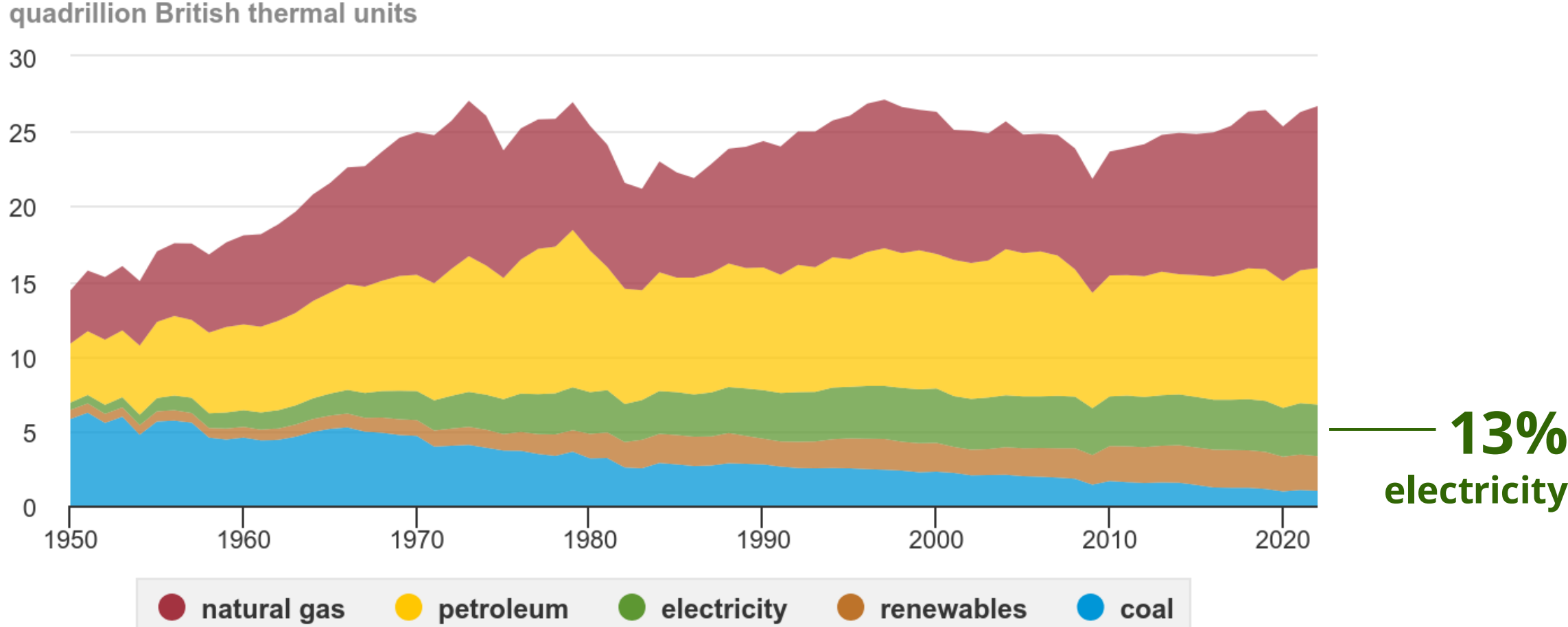
ACEEE::



Industrial Sector Uses 33% of U.S. Energy



Industrial Energy Use is Mostly Fossil Fuels

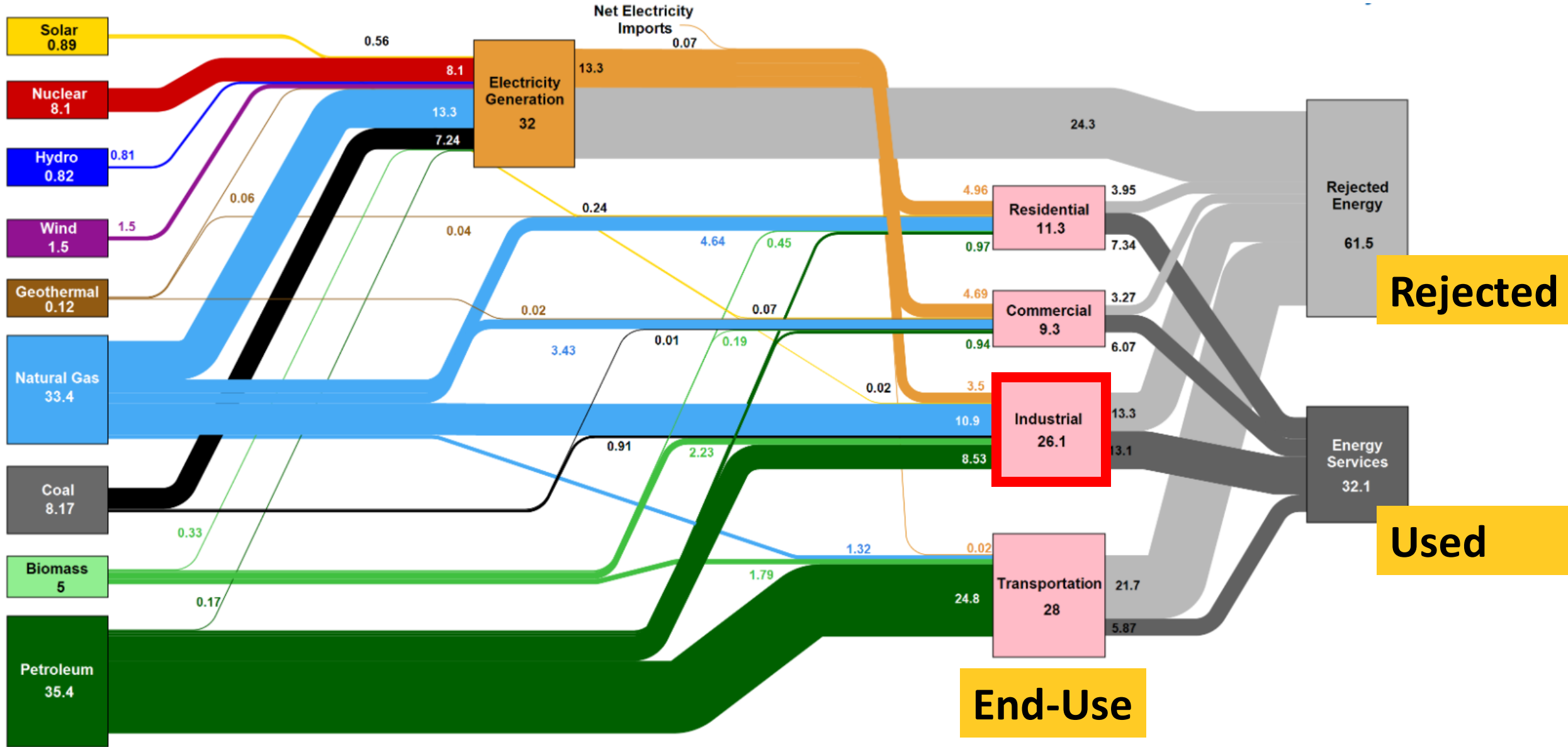


Data source: U.S. Energy Information Administration, *Monthly Energy Review*, Table 2.4, June 2023, preliminary data for 2022



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



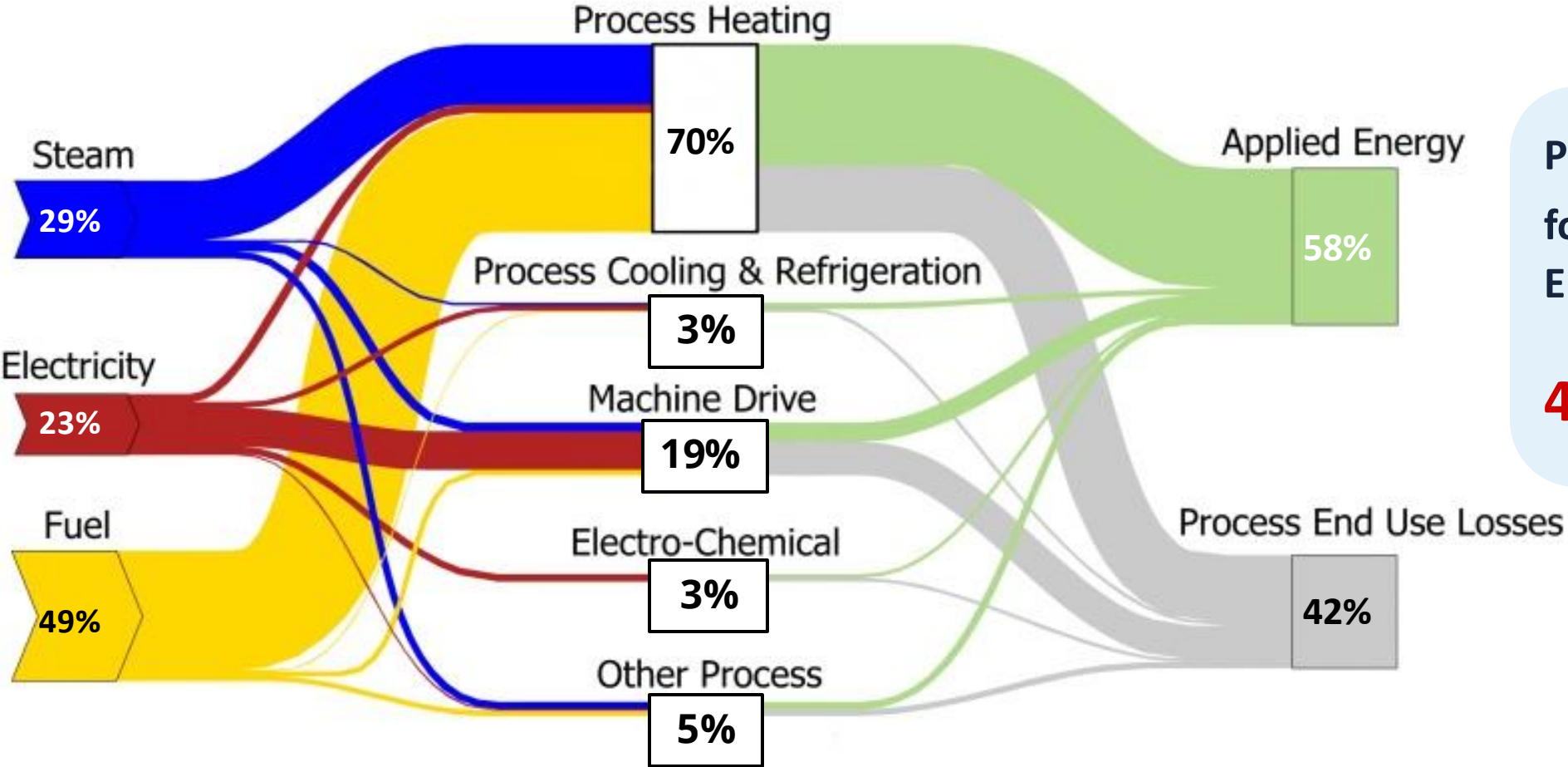
Generation

Industrial Energy Strategies

ACEEE::



Minimize Energy Lost in U.S. Manufacturing Process

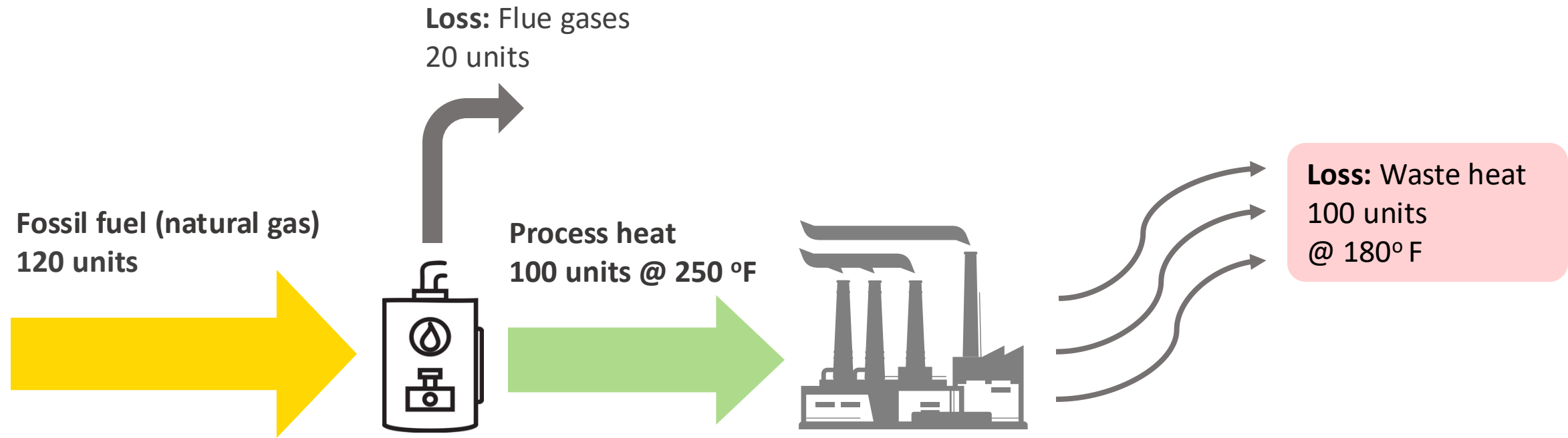


Process Heat Accounts for **70%** Industrial Energy Use.

42% of energy is lost.

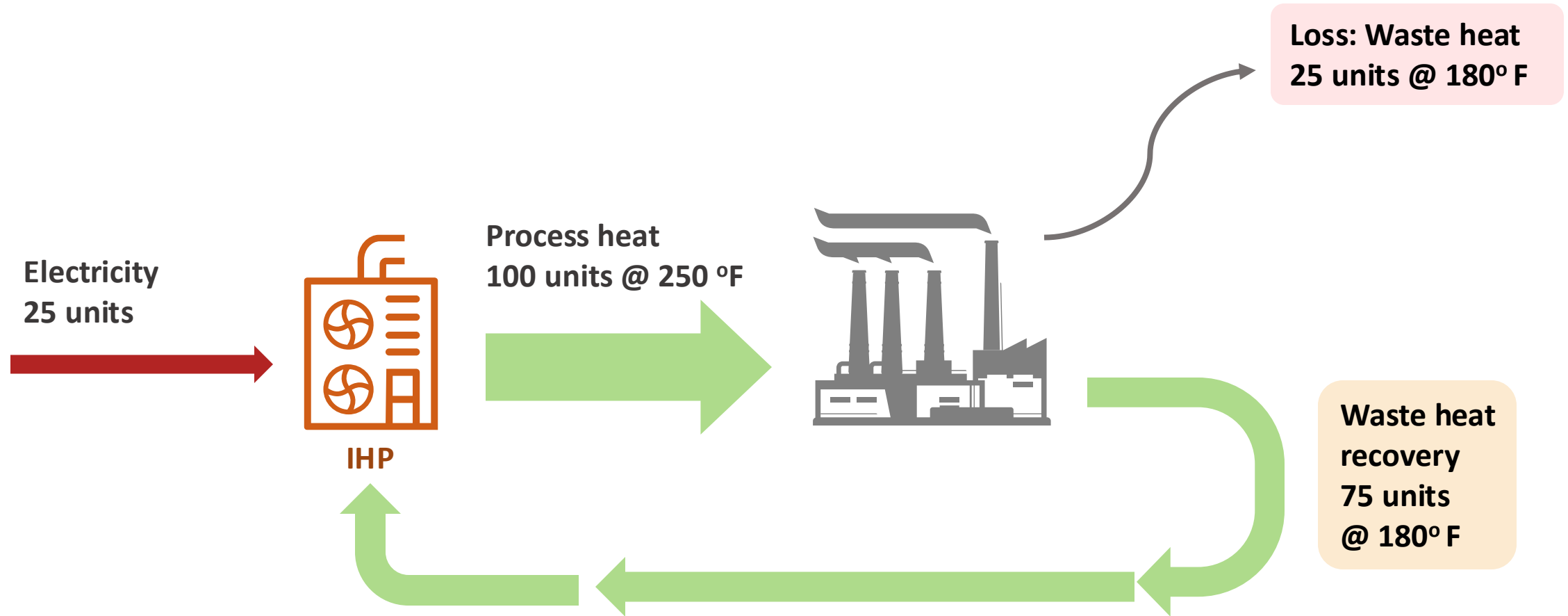
Source: www.energy.gov/eere/iedo/static-sankey-diagram-process-energy-us-manufacturing-sector-2010-mecs

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



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

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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

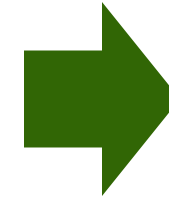
(Energy, Carbon)

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. Efram, 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)

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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 permitting costs and risks



Reduced insurance costs



Future proofing and modularity



Reduced maintenance costs



Improved product quality



Resource conservation

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



Lower pollution, improved air quality



Local jobs with job retention

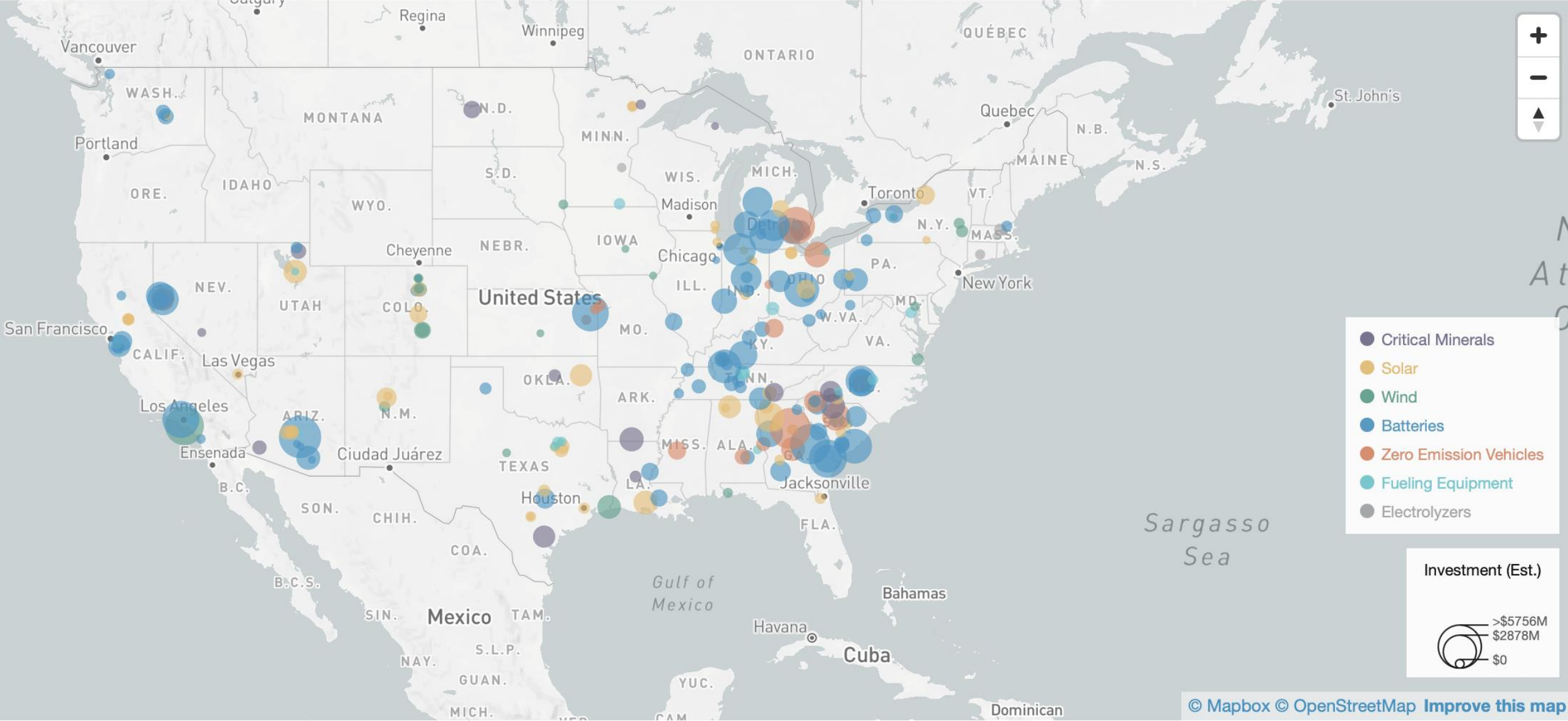


Reduced noise pollution



Wider economic benefits

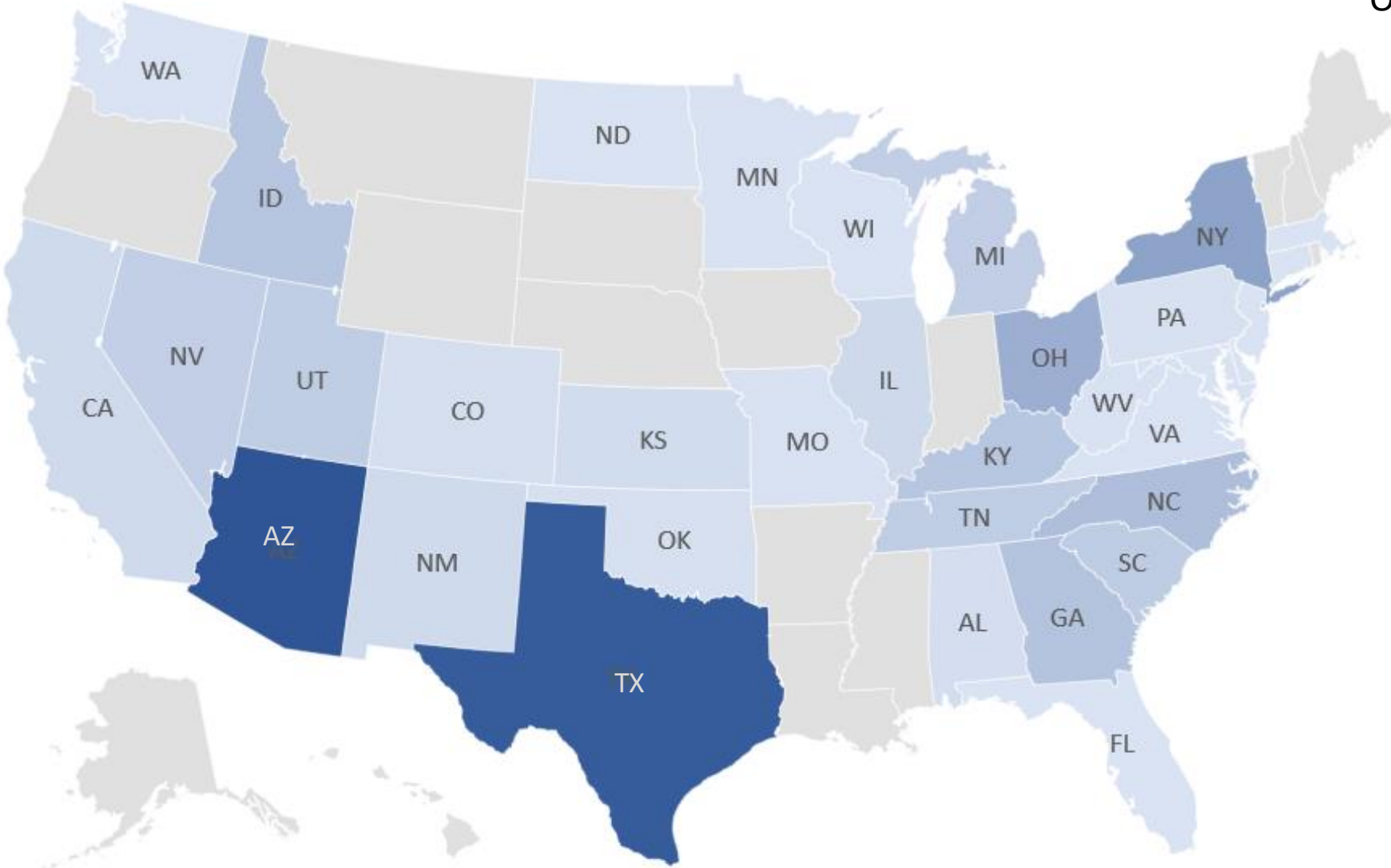
Manufacturing Investment Announcement (Oct 2021–Sep 2023)



Economic Development Opportunities



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



Electricity Demand Growth in Industry

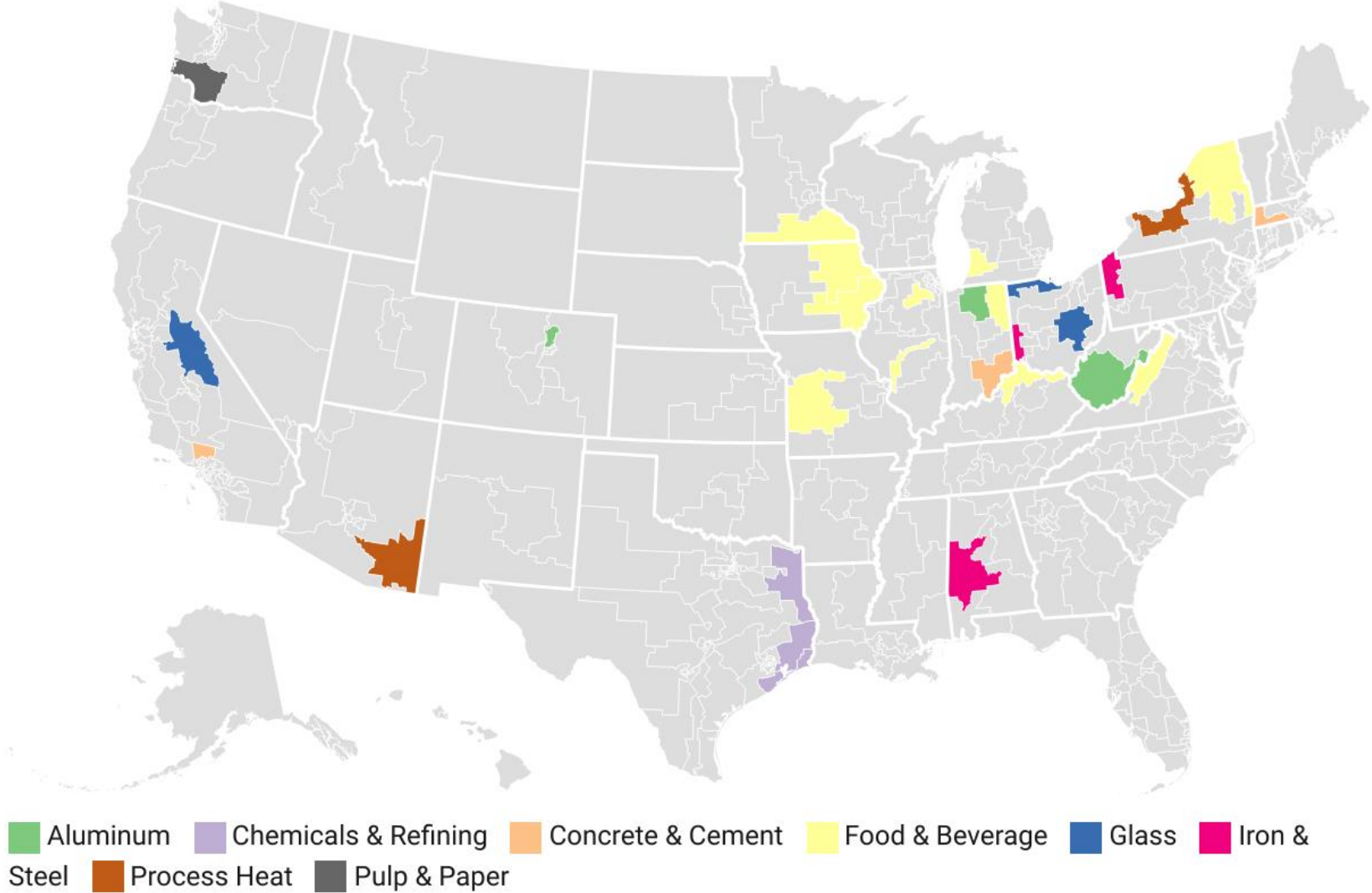


Grid planners forecast peak demand growth of **38 GW** through 2028.

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

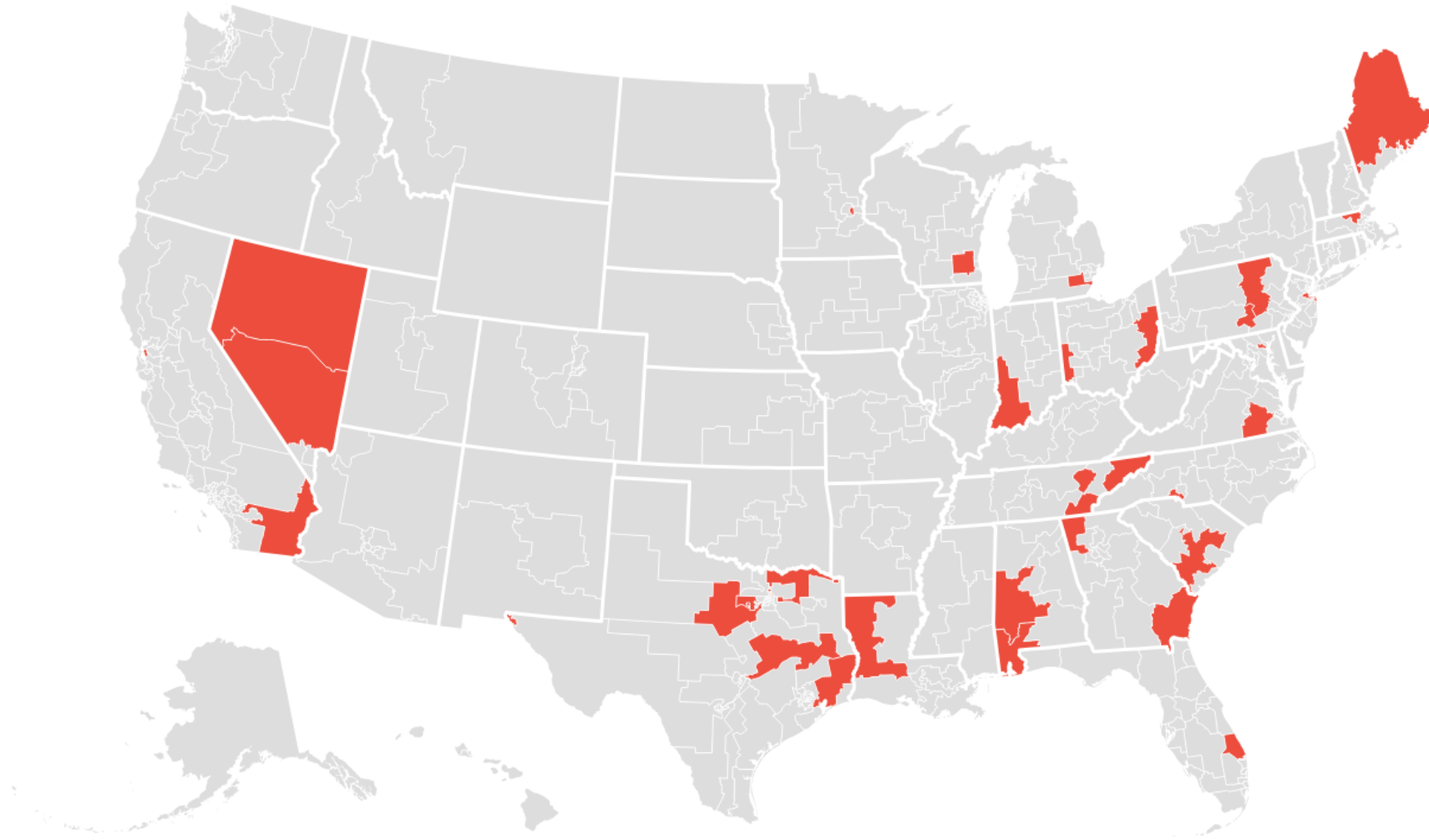
Key drivers include data centers (crypto and AI) and **industrial** facilities (battery and automotive sectors).

Congressional Districts with IDP Projects



Created with Datawrapper

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