OpenMinds

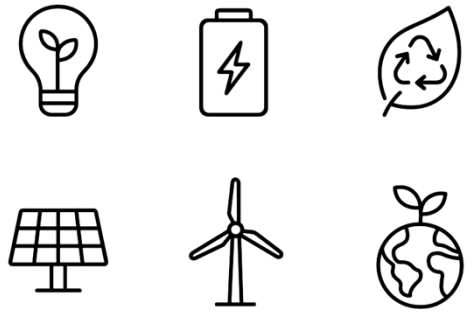
NextGen Dual Challenge Progress

Creating an Energy & Climate Progress Dashboard

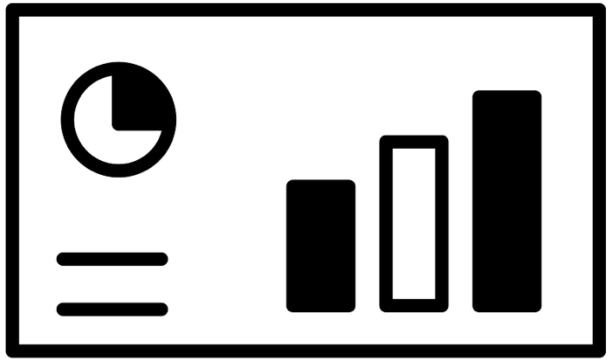
Problem Statement

We were asked to design a global dashboard that tracks progress on the Dual Challenge: **Expanding energy access** and **reducing CO_2 and methane emissions**.

To meet this mandate, our team needed to:



1. **Build a measurement framework for global progress**
   - Track CO_2, methane, and electrification using a consistent, repeatable method.
2. **Create a dashboard architecture future cohorts can maintain**
   - Define robust data sources and a clear annual update process.
3. **Evaluate the Top 10 Solutions using a structured approach**
   - Apply a consistent readiness/viability framework and document how future teams can extend it.



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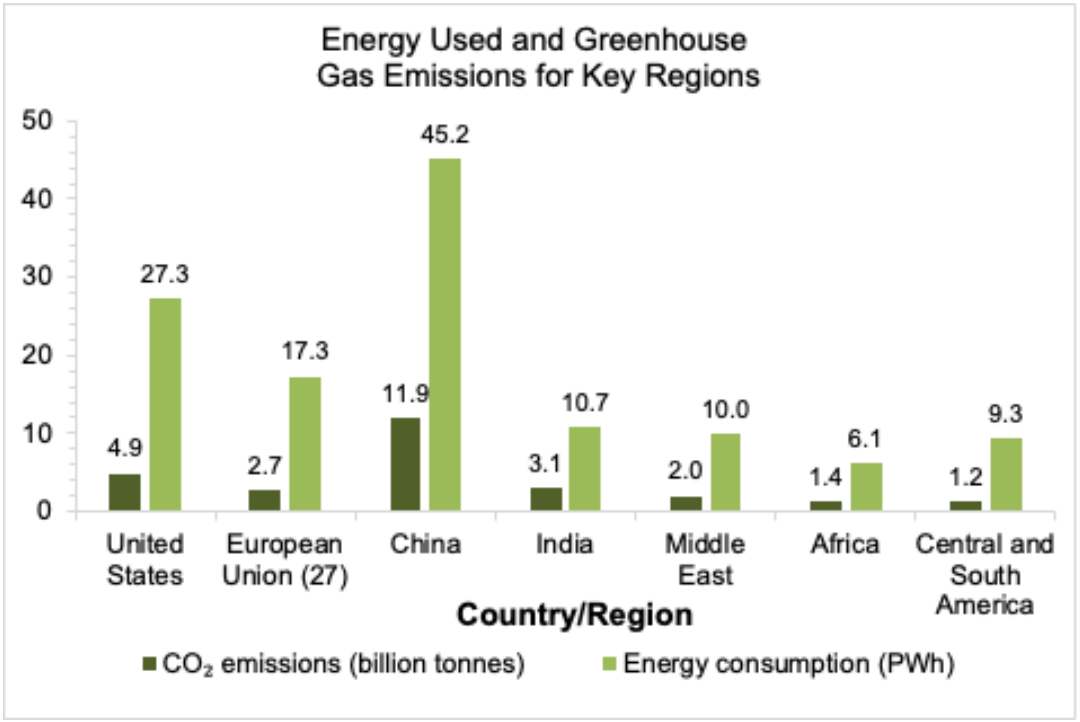
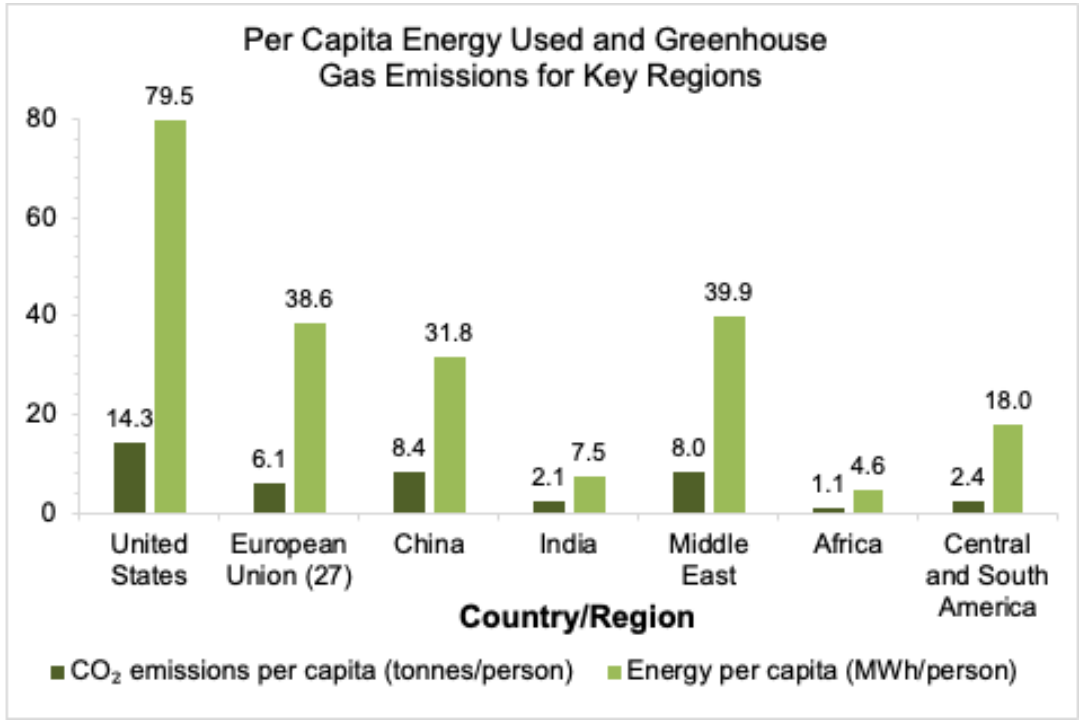
China is both the largest energy consumer and CO_2 emitter on absolute basis; per capita, U.S. consumes 2.6x more energy and emits 1.7x more





[1] Most recent available data is used, which ranges from 2021-2023 depending on both country/region and metric.

U.S. also consumes energy and emits approximately 2.5 times more per capita than similarly developed EU

Source: Our World in Data

The Kaya Identity: Understanding the drivers of CO_2 emissions from energy

An equation showing how population, per capita income, the share of energy in the economy, and the carbon intensity of energy determine carbon emissions from energy

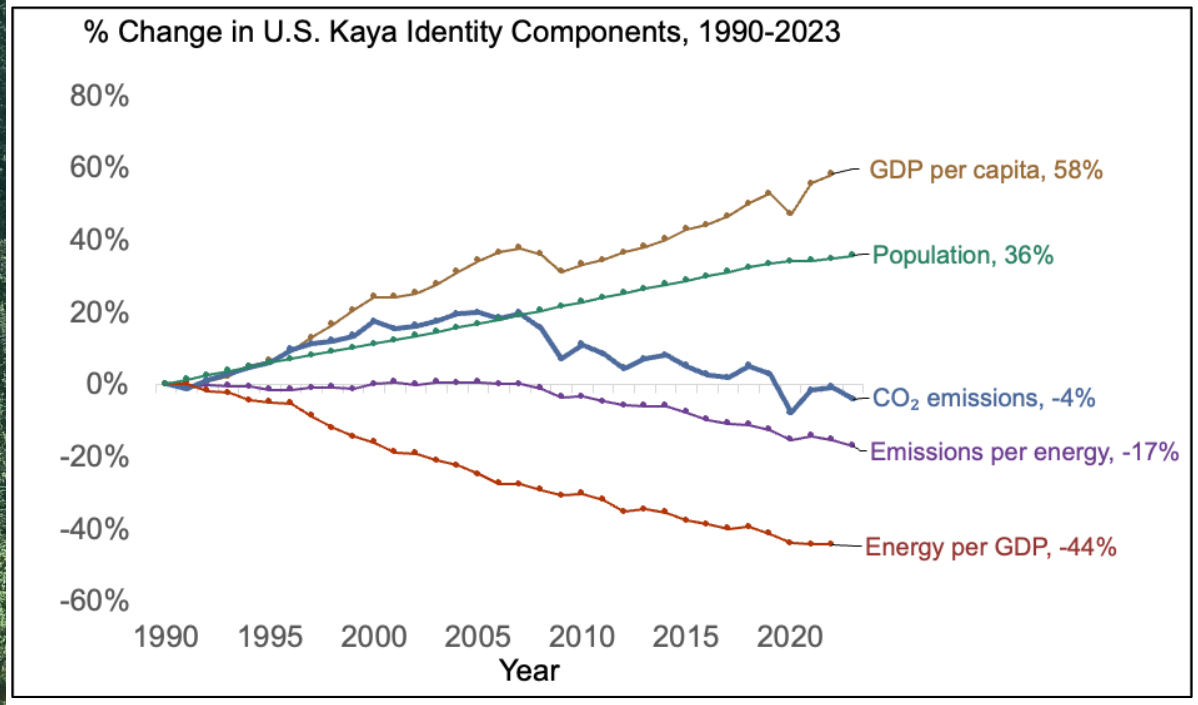
$$\underset{\text{from energy}}{CO_2 \text{ emissions}} = Population \times \frac{GDP}{Population} \times \frac{Energy}{GDP} \times \frac{CO_2 \text{ emissions}}{Energy}$$

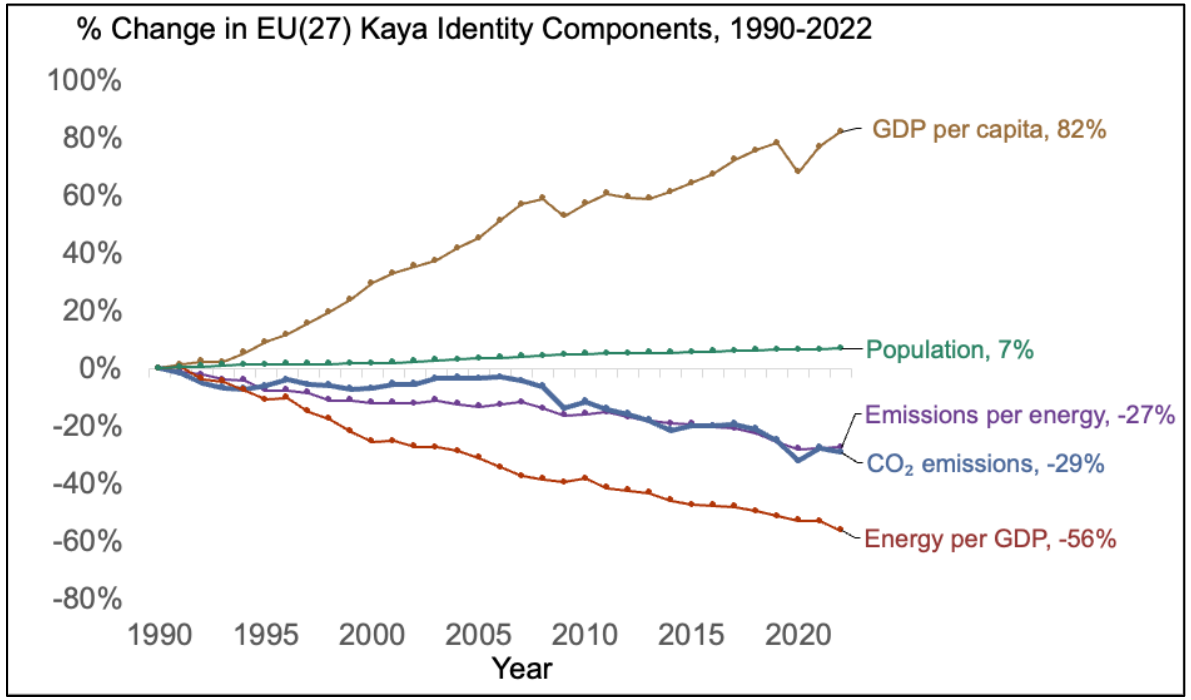
Energy Intensity of Economy

Carbon Emissions Intensity of Energy

- **Used by IPCC, IEA, and policymakers globally**
- **Useful framework for identifying the social, economic, and technological drivers of emissions**
- **Drivers have varying degrees of actionability over time**

US emissions have declined since 1990 – despite growth in GDP per capita and population – due to lower energy and carbon intensity

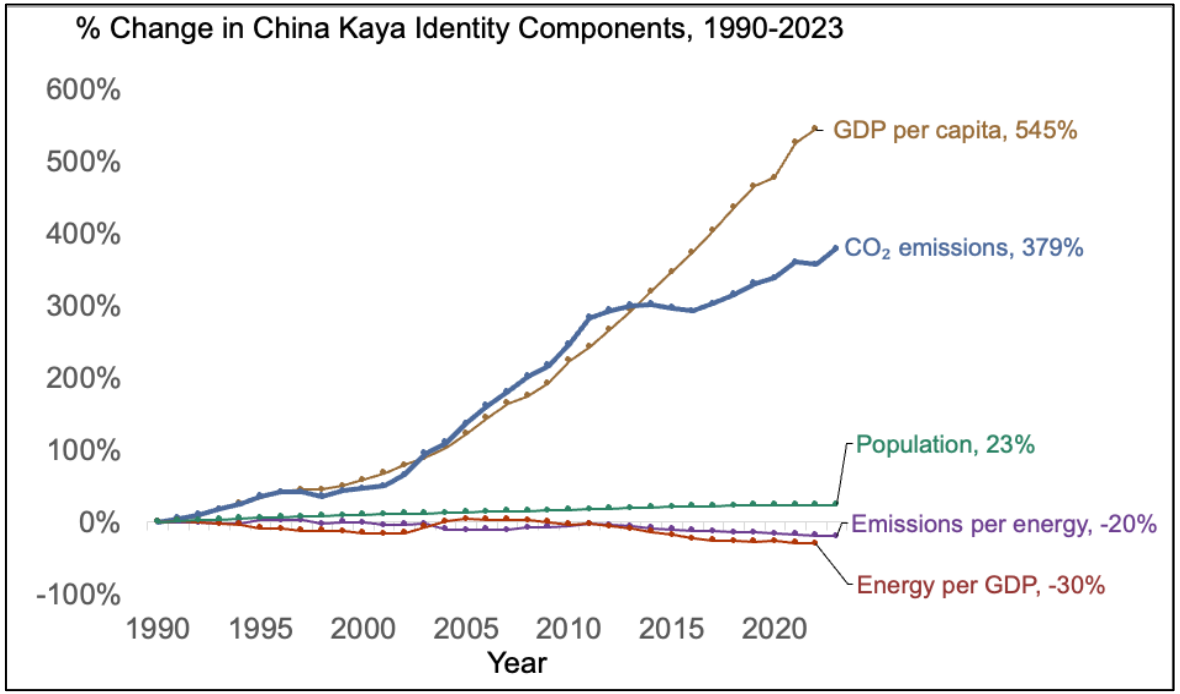


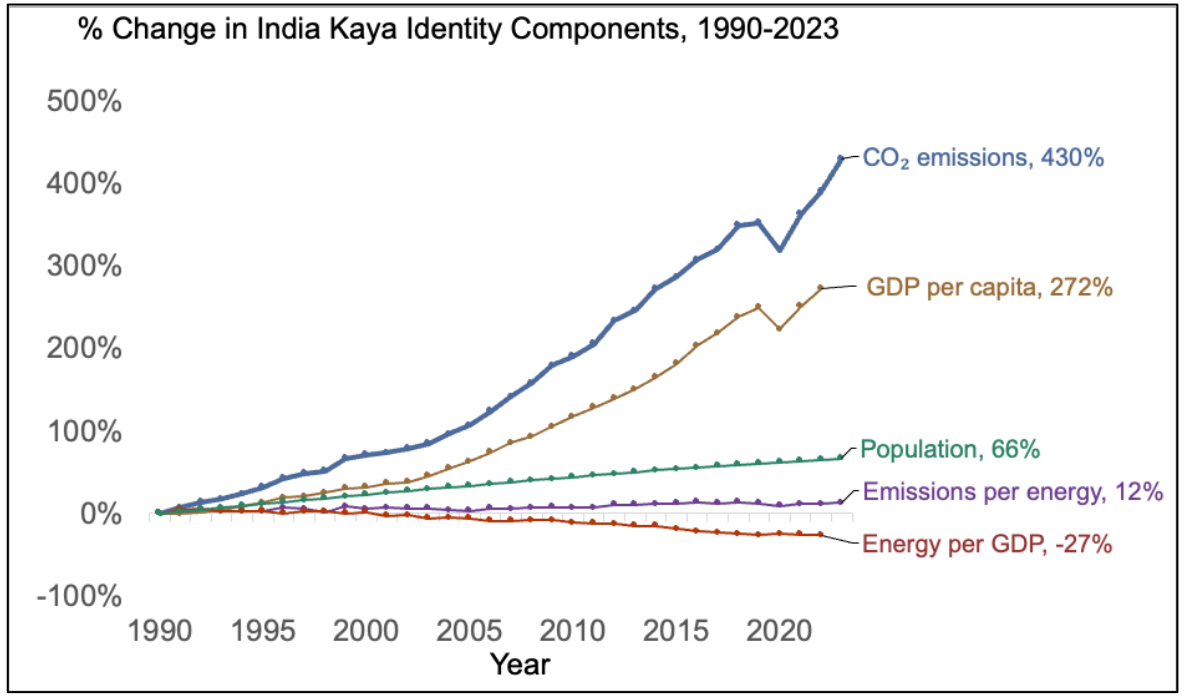


However, U.S. emissions have fallen much less than the EU (4% vs. 29%), driven by a slower drop in energy and carbon intensity (-44% and -17%) compared to the EU (-56% and -27%), respectively

Data Source: Our World in Data

China's emissions have grown 379% since 1990, driven primarily by a 545% increase in GDP per capita

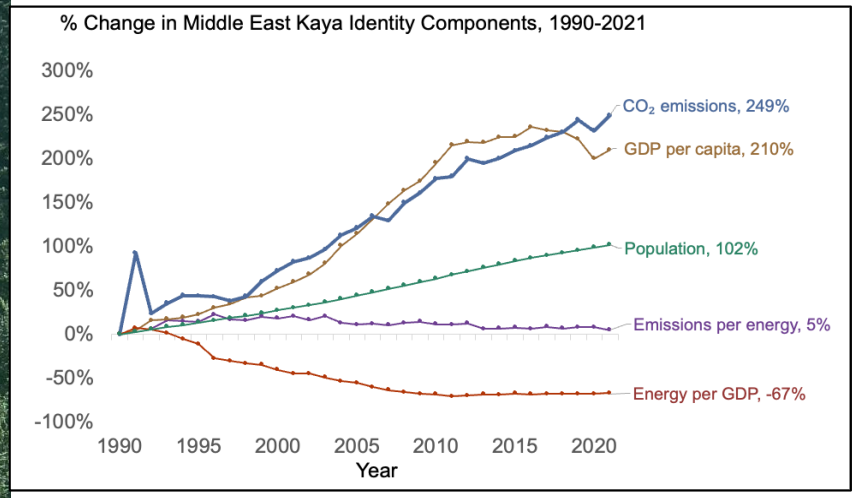


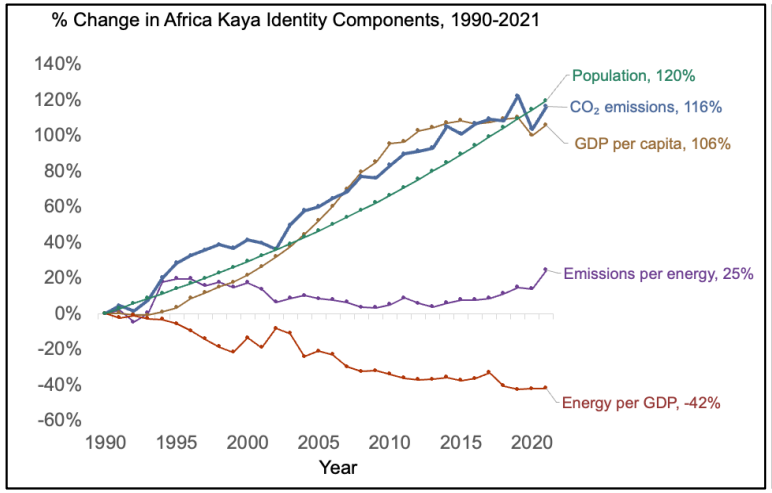


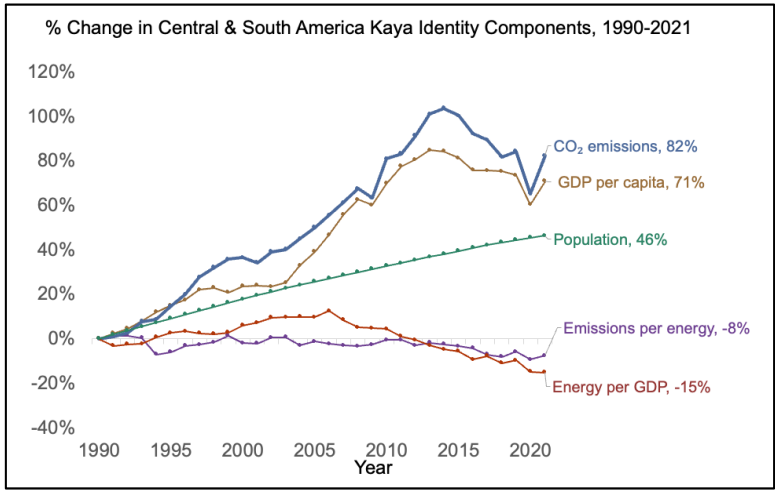
India's emissions have grown more than China's (+430% vs. 379%), driven by higher population growth (+66% vs. +23%) and a 12% increase in carbon intensity of energy while China's has *declined* by 20%

Data Source: Our World in Data

Middle East, Africa, and Central and South America have each experienced increases in emissions, driven by increases in population and GDP per capita







In all three regions, the economy has become less energy-intense; however, the carbon intensity of energy varies, with Africa having highest and growing carbon intensity

Data Source: Our World in Data

Electrification as a pathway to decarbonizing energy use

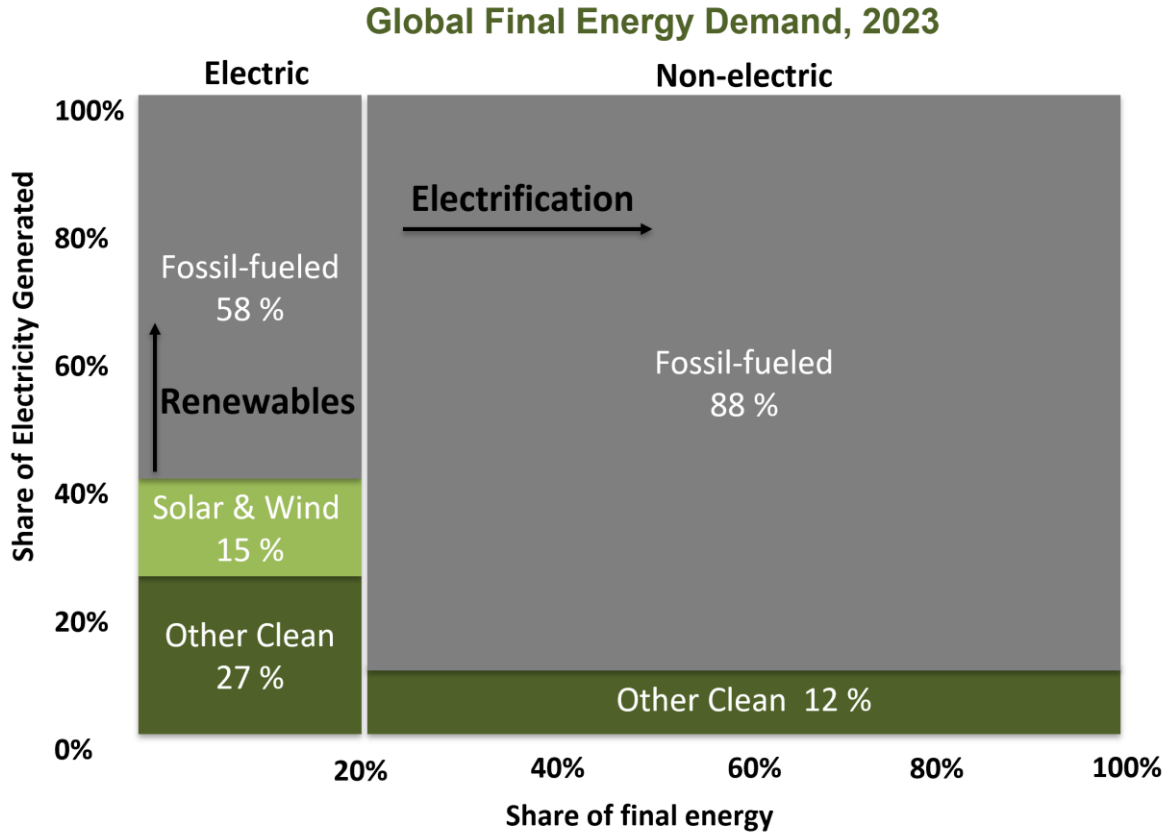
An indicator of how much final energy demand is served by electricity

a key step toward net-zero once the grid is clean

$$\% \text{ Electrification} = \frac{\text{Electricity Consumption}}{\text{Total Final Energy Consumption}} \times 100$$

- **Indicates progress in shifting energy end-use sectors (transportation, residential, commercial, industrial) to electricity from other fuels like coal, oil, and natural gas**
- **Useful metric for assessing an economy's readiness for decarbonizing its electric grids increasing generation from low-carbon resources**

There are two key dimensions of the energy transition:
Electrification of final energy consumption and increasing the share of low carbon resources in electricity generation

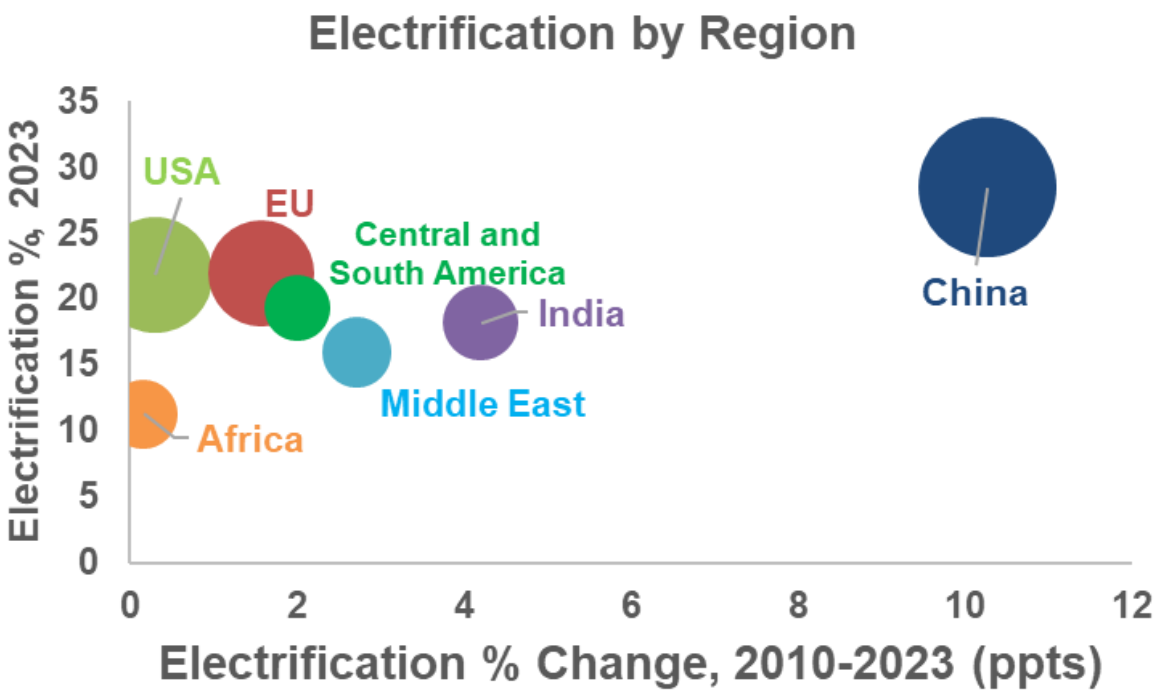


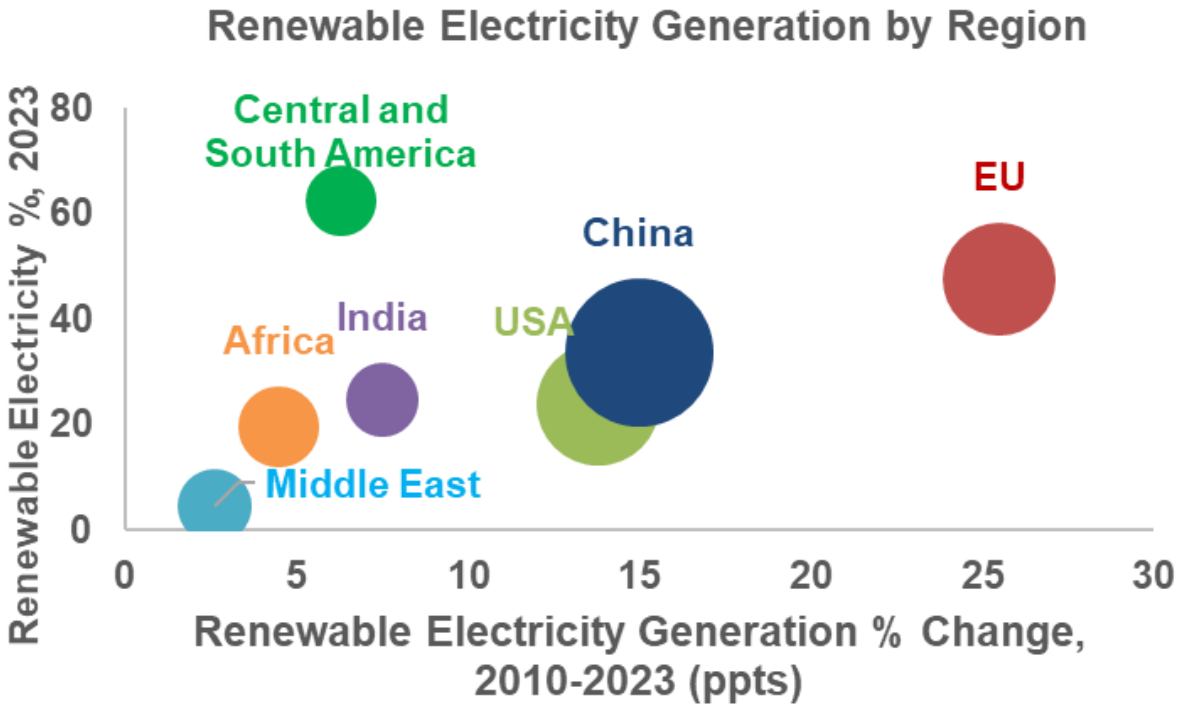
Globally, only 20% of final energy consumption is electrified (and of this, only 42% is generated with low carbon resources); of the 80% that is not electrified, only 12% uses low carbon resources

Source: IEA WEB, Ember Electricity Data Explorer

There are big regional differences in electrification and the rate of electrification as well as renewable electricity share and growth

Bubble size : Total energy consumption TJ

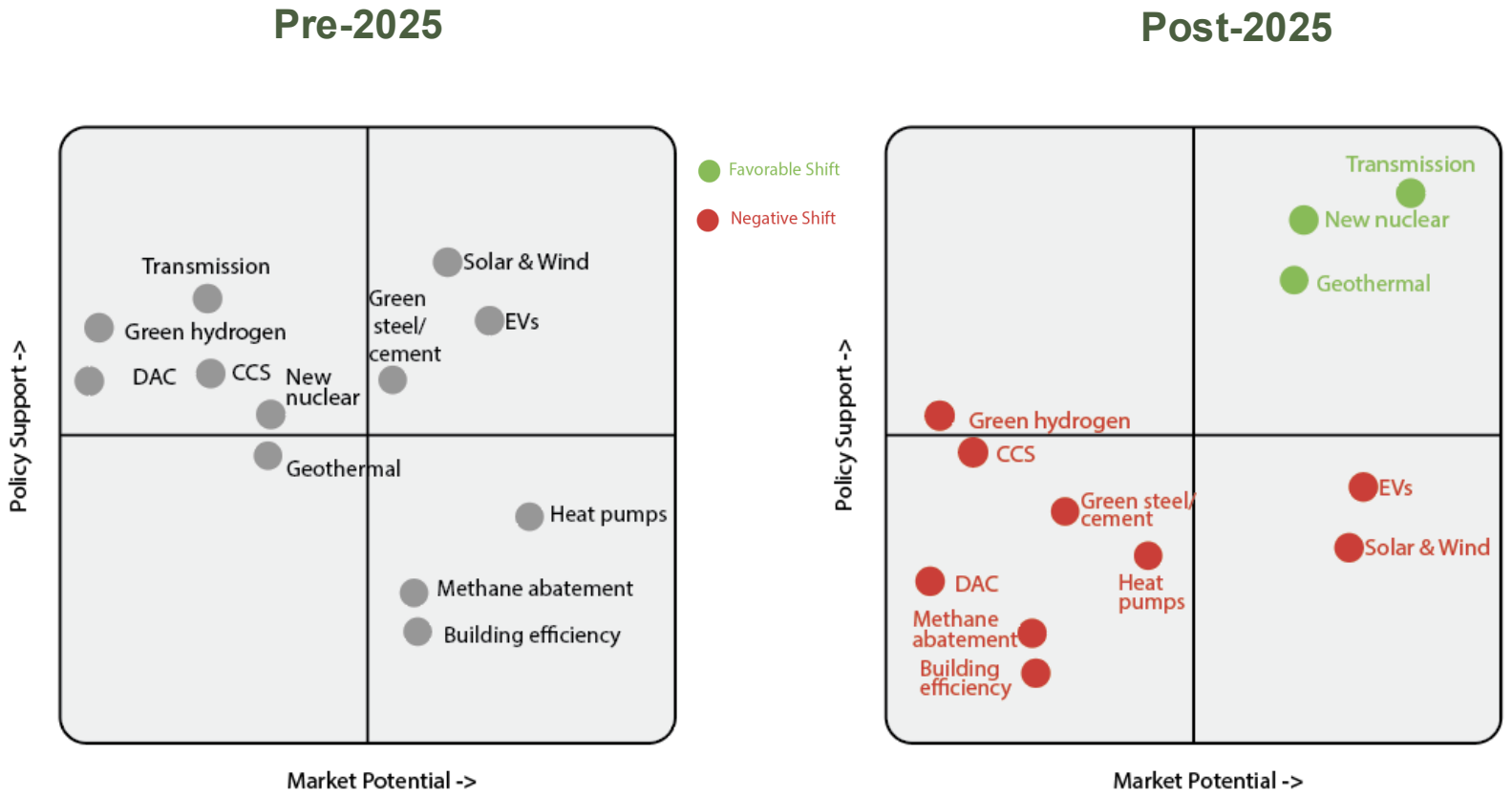




China, the EU, and the U.S. have similar renewable shares (~17–20%), but China has a higher electrification rate (30%) and has electrified more rapidly over the past decade. However, with ~65% of its electricity still from non-clean sources, its emissions remain substantial.

Source: IEA WEB, Ember Electricity Data Explorer

Changes in U.S. Policy Support and Market Potential for Selected Decarbonization Technologies 2024-2025



Federal policy is reshaping, not stopping, decarbonization; shifting support toward nuclear, transmission, and geothermal, while leaving other technologies more dependent on markets.

***Policy Support** encompasses financing, permitting timelines, regulatory frameworks, litigation risk, community benefit requirements, and compliance mandates. Even well-capitalized sectors face non-financial policy barriers

***Market Potential** reflects: (1) economic competitiveness without subsidies, (2) demand drivers (load growth, compliance, cost savings), (3) technology maturity, and (4) scalability within current infrastructure.

Kaya Identity Dashboard

Kaya Identity

$$\underset{\text{from energy}}{CO_2 \text{ emissions}} = Population \times \frac{GDP}{Population} \times \frac{Energy}{GDP} \times \frac{CO_2 \text{ emissions}}{Energy}$$

$$\%\ \text{Electrification} = \frac{\text{Electricity Consumption}}{\text{Total Final Energy Consumption}} \times 100$$

Entity	Year	CO_2 emissions (Gt) from energy[2]		Population (billions)		GDP per capita ($ thousands)		Energy Intensity (kWh/$)		Carbon Intensity (kg/kWh)		Electrification (%)		Renewable Electricity (%)	
		Amount	% Change since 1990	Amount	% Change since 1990	Amount	% Change since 1990	Amount	% Change since 1990	Amount	% Change since 1990	Amount	% Change since 2010	Amount	% Change since 2010
World	2022	38	66	8	52	17	103	1	-42	0	-8	21	3	16	13
USA	2022	5	-4	0	36	58	58	1	-44	0	-17	22	0	17	15
EU	2022	1	-29	0	7	38	82	1	-56	0	-28	22	2	20	17
China	2022	12	379	1	23	19	545	2	-30	0	-20	28	10	19	18
India	2022	3	430	1	66	8	272	1	-27	0	13	18	4	11	9
Middle East	2021	2	249	0	102	20	210	2	-67	0	5	16	3	3	3
Africa	2021	1	117	1	130	5	106	1	-42	0	25	11	0	25	8
Central + South America	2021	1	82	1	48	13	71	1	-15	0	-8	19	2	62	6

[1] Cell color coding notes: for Kaya Identity components, green shades indicate reductions in the drivers of CO_2 emissions relative to the World; conversely, red shades indicate increases in these drivers. For electrification and renewable electricity, darker shades of green represent higher percentage point changes

[2] Only CO_2 emissions, which account for **76%** of total global CO_2 equivalent emissions

Global Policy Impact Dashboard

Moderately negative policy ↓ | Neutral or mixed policy → | Moderately supportive policy ↑ | Favorable policy environment ↑↑

Technology	United States	European Union	China	India	Middle East (GCC)	World (Aggregate)
Solar & Wind	↓	↑↑	↑	↑	↑	↑ Global build-out accelerating; policies diverge but net-positive
EVs	↓	↑↑	↑↑	↑	→	↑ Strong global sales, mixed policies cancel out
Heat Pumps	↓	↑	↑	→	→	→ Growth steady but policy momentum mixed
Geothermal	↑↑	→	→	→	→	↑ Slow but rising global policy interest
Hydrogen (Green)	↑	↑↑	↑	↑	↑↑	↑↑ The strongest global policy push of 2024–25
CCS	→	↑	↑	→	↑	↑ Emerging global momentum via industry clusters
DAC	↓	→	→	→	→	→ Limited global policy; still niche
Nuclear (New/SMR)	↑↑	→	↑↑	↑	↑	↑ Major growth in China + U.S. push raises global trend
Transmission / Grid	↑↑	↑	↑↑	↑	↑	↑↑ Universal global policy focus due to electrification + AI load
Building Efficiency	→	↑	↑↑	↑	→	↑ Most countries tightening efficiency codes
Methane Abatement	↓	↑↑	→	→	→	→ Global split: U.S. rollback offsets EU action

Viable Solutions Worldwide Under Policy Headwinds

Policy volatility but strong market-driven opportunity in efficiency, methane, nuclear, transmission.

Strong policy alignment and carbon pricing make most clean solutions viable, investable, and increasingly required under EU law.

Global hydrogen leadership; record-low-cost renewables built for export competitiveness.

Strong alignment of market scale and state policy; renewables and electrification continue expanding even as subsidies decline.

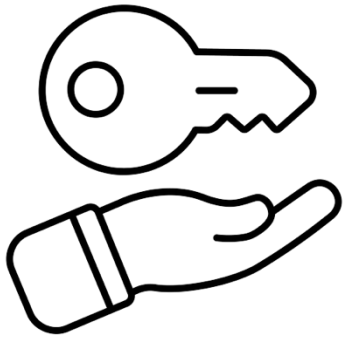
Rapid renewable expansion and early-stage hydrogen growth driven by energy security and export-oriented industrial strategy.

Across regions, policy headwinds have shifted the geography of opportunity. In the U.S., economics now drive efficiency and methane abatement; in the EU and China, policy and markets still reinforce each other; and in the Middle East and India, export-oriented hydrogen and large-scale renewables are creating new centers of investment.

Dashboard Operation and Maintenance

Recommended Owners

- **Data lead (2 hrs/quarter):** Pulls data; updates core metrics
- **Policy and markets lead (5 hrs/quarter):** Tracks global policy shifts; updates policy dashboard; validates interpretation
- **Technical integration lead (3 hrs/quarter):** Maintains the file, ensures formulas work, updates charts, publishes outputs



Sources (all open and free)

- IEA Web
- Ember Electricity Data Explorer
- Our World in Data

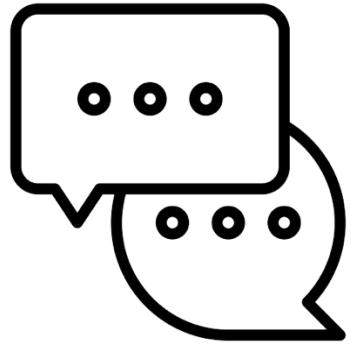
Note: No licenses required. All data sources are publicly accessible.

Update Frequency

- **Annual (July-August):** All core metrics
- **Spring update (Feb-March):** Methane tracker; Carbon emissions update
- **Quarterly:** Policy changes; US Regulatory shifts

Format and Publication

- **Recommended:** A **dynamic online dashboard** hosted on OpenMinds203x.org
- **Secondary option:** Static PDF/PPT archived annually if web hosting is not feasible.

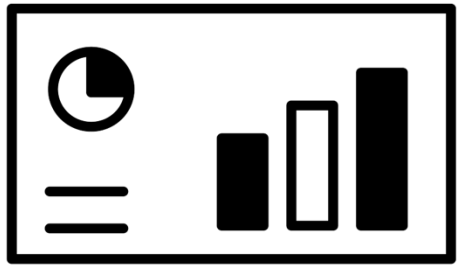


Practical Considerations:

Continuity: Each NextGen cohort receives a short handover memo + the live dashboard file
Version control: One shared Google Sheet + one “published snapshot” PDF per year
Documentation: Clear tab-by-tab method notes inside the file

Solutions Assessment Framework

To support the ongoing assessment of climate solutions, our team also continued the work for the **Top 20 Solutions Assessment Framework** originally developed jointly by **OpenMinds and Bain & Company**.



1. **Document the existing framework structure and methodology**
   - Review the nine-dimension assessment approach spanning readiness and viability factors
2. **Establish comprehensive source documentation**
   - Identify and validate authoritative data sources for each assessment dimension
3. **Assess data availability and identify gaps**
   - Document areas where authoritative sources are limited or unavailable
4. **Build infrastructure for ongoing framework maintenance**
   - Establish protocols for integrating new research and updated benchmarks

Our work provides future teams with a documented, repeatable process for assessing climate solutions as new data becomes available.

Recap and Future Work

The Dual Challenge Dashboard provides a foundation to measure progress on energy and emissions.

Main Findings

- **Policy shifts redistribute investment, not halt it**: Regulatory friction blocks deployment more than capital availability.
- **Electrification requires grid decarbonization, and vice versa**: Both must advance simultaneously to reduce emissions effectively.
- **Updated Previous Bain Work:** Solution Assessment Framework for Bubble Chart

Future Work

- Expand dashboard metrics to include new resilience indicators
- Develop sector-specific pathways for steel, cement, and heavy transport, or other industries.
- Connect evidence from the dashboard to policy levers (ex: Subsidies, standards, carbon pricing).
- Engage stakeholders to further refine matrices and prioritize solutions with maximum impact.

Key Takeaway: The work seeks to identify where progress is happening fastest and where immediate interventions can drive outsized impact, while likewise laying the groundwork for more profound sectoral analyses and future policy application.

OpenMinds

Thank you all for your attention.
We would be happy to answer any questions!

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Solving for the
Dual Challenge.

Appendix

2025 U.S. Policy Landscape

U.S. Policy Reversals

Trump administration dismantling Biden-era clean energy rules:

- Rolling back fuel economy & emissions standards
- Restricting California's authority for stricter rules

DOE Loan Program uncertainty: major projects still closing, yet numerous grants cut.

Significant clean energy grants and awards cancelled: U.S. Department of Energy terminated 321 awards supporting 223 projects (≈$7.6 billion) in Oct 2025.

Global contrast: While the U.S. signals regulatory retrenchment, the European Union rolls out Carbon Border Adjustment Mechanism (CBAM) and China advances domestic manufacturing of clean technologies.

Framing: U.S. regulatory headwinds create uncertainty for investors, while other regions double down

Executive Orders

Jan 2025 - National Energy Emergency

Jan 2025 - LNG Export Acceleration

Apr 2025 - Emergency Powers for Fossil Infrastructure

May 2025 - Nuclear Acceleration EO Package

Changes to IRA

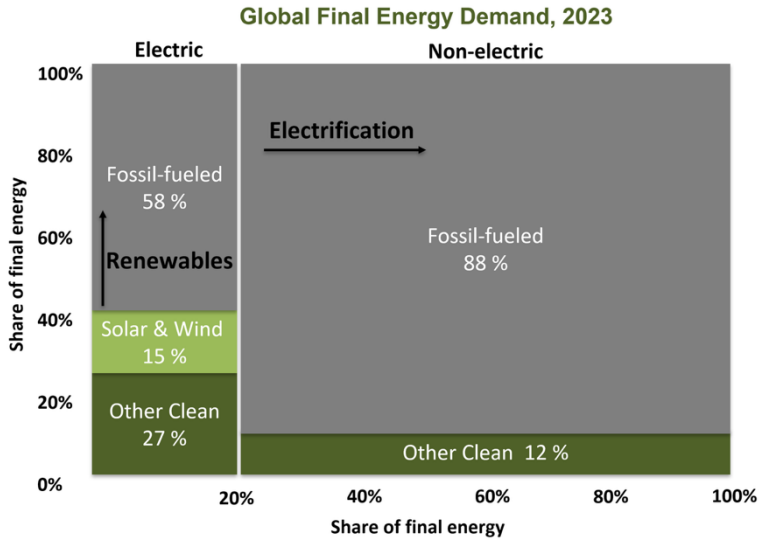
EVs: 30D tax credit modifications/eliminations, manufacturing requirements weakened

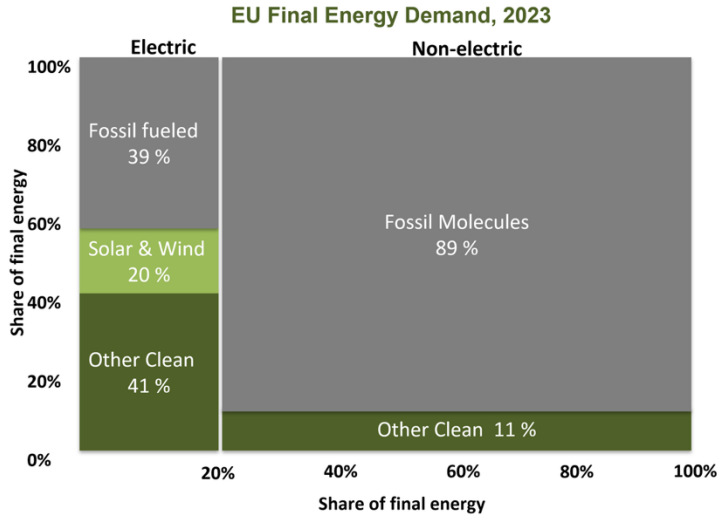
Offshore wind: Permitting freezes, lease sale delays, regulatory rollbacks

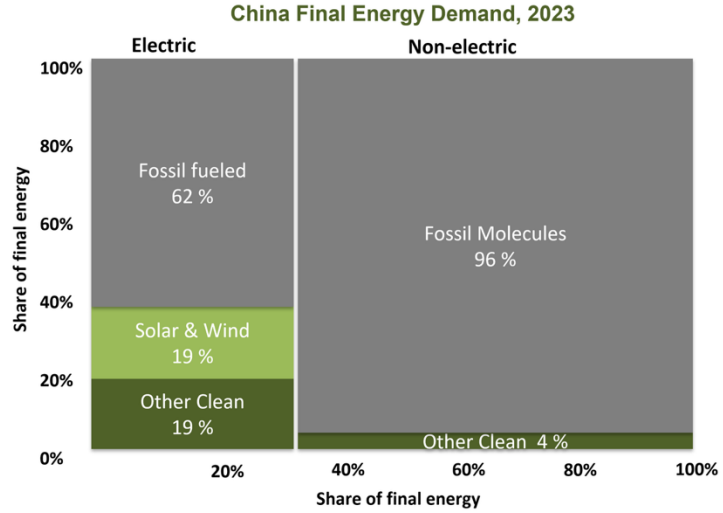
Clean hydrogen: 45V guidance uncertainty

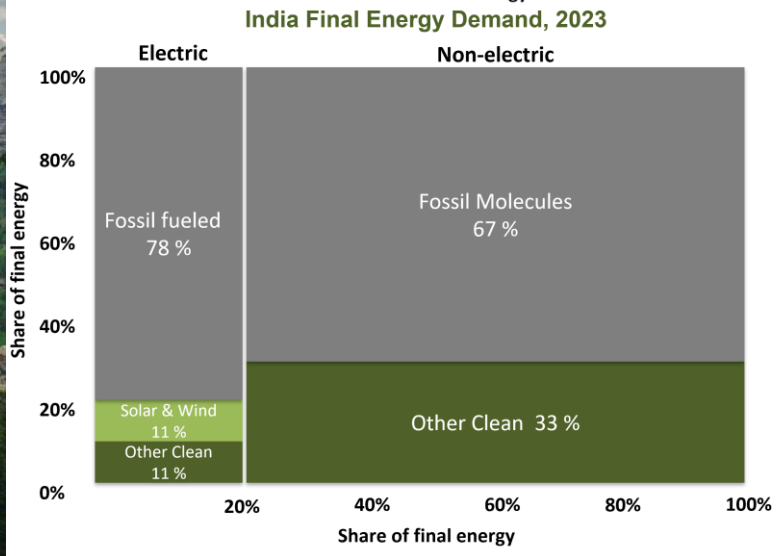
Transmission: DOE loan program cuts

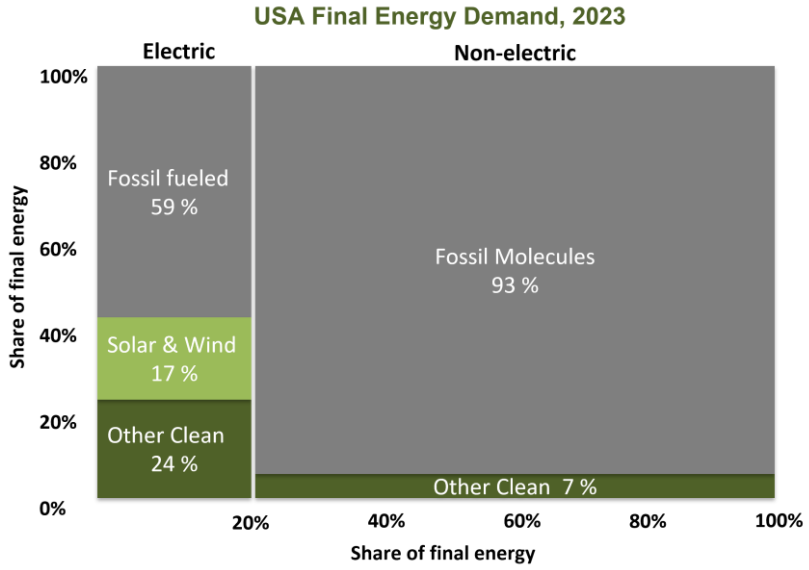
Electrification and Share of Electricity by Region, 2023

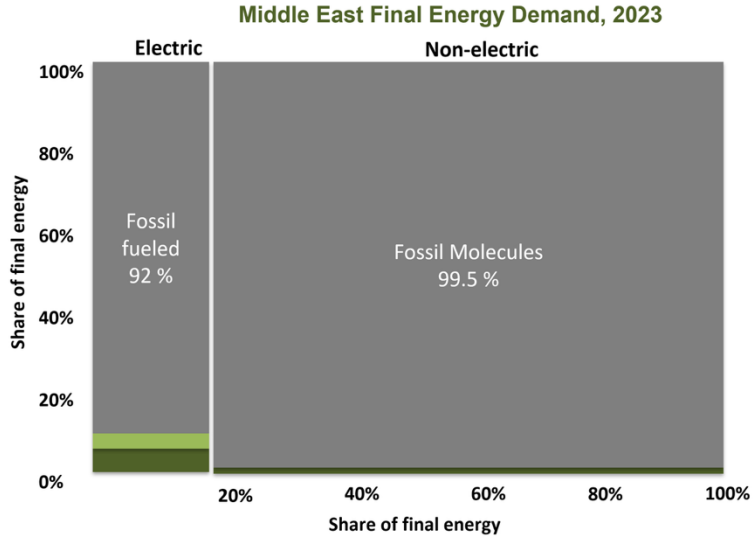












Marginal Cost Best Bets - Global

• Best Bets	• Less Financially Viable
Methane abatement in oil and gas: Most measures are low or negative cost. Even with the IRA methane fee rolled back, core fixes remain cheap. Under Biden, fee was \$900/t CH_4 in 2024 rising to \$1,500/t in 2026. Removing it raises costs but many fixes still pencil out. *Global: Companies must still meet state regulations (e.g., New York) and EU import requirements for LNG. Economics favor action worldwide.*	• **Direct air capture (DAC)** Today, costs around \$250-\$600+/t, with long-run uncertainty. Grant and contract pullbacks push the near-term effective cost higher. *Global: Requires sustained policy support everywhere. Iceland, UAE exploring due to cheap renewable energy, but still uneconomic without contracts/credits.*
• **Building efficiency and LED's:** Short paybacks, net-negative marginal abatement cost. Standards help but aren't required for positive ROI. The IEA calls efficiency the "first fuel." LEDs cut building electricity by 15-20%. *Global: Universal opportunity. EU's building performance standards accelerate adoption; China's efficiency mandates drive scale; India sees strong ROI in commercial buildings.*	• **Green hydrogen** Effective marginal abatement cost rises significantly without sustained subsidies. *Regional opportunities: Middle East (cheap renewables for export), Australia (iron ore decarbonization), EU (industrial demand + subsidies). U.S. 45V uncertainty raises risk.*
• **Industrial efficiency** Motor systems and waste-heat recovery typically \$0-\$30/t CO_2e, which is robust even if federal grants slow down. IPCC industry synthesis shows strong, low-cost potential. *Global: EU CBAM creates additional incentive; China's industrial upgrade policies drive adoption; strong economics in energy-intensive sectors globally.*	• **Carbon capture** Typical capture costs are \$40-\$120/t, but if DOE support tightens, net abatement costs rise to \$85-\$160/t and project financing slows. *Global: Viable in specific sectors (cement, steel, blue hydrogen) where alternatives expensive. Norway's CO_2 tax makes it economic; U.S. 45Q uncertainty problematic; China piloting in coal power.*
• **Heat pumps** Often offer net-savings versus oil/propane heating. Loss of rebates raises effective marginal abatement cost, but remains cost-effective in many cases, especially in cold climates. *Regional variation: Strong economics in EU (high gas prices), Japan, Korea. Mixed in U.S. (varies by climate/fuel). China scaling rapidly for both heating and hot water.*	• **Green steel and cement** High premiums today (20-40% cost increase). EU demand via CBAM helps, but U.S. pullbacks on clean procurement slow domestic uptake. *Regional divergence: EU CBAM creates market pull; Sweden's H2 steel projects advancing. China piloting but slow. India exploring but cost-sensitive. U.S. losing ground without procurement mandates.*
• **Renewables including solar and wind** In many regions, these remain the cheapest form of power even without credits. Lazard/EIA show competitive costs vs. gas. PTC/ITC removal adds roughly \$30-\$70/t CO_2e, but many projects still work on merchant/PPA basis. *Global: Economics strongest in high-resource regions (Middle East solar, offshore EU/Asia wind). U.S. faces permitting restrictions hurting wind; solar less impacted. China/India scaling rapidly on pure economics.*	**EV's – Without Incentives** Total cost of ownership approaching parity in some markets, but upfront cost premium remains barrier without incentives. U.S. CAFE rollbacks and incentive removal increase effective abatement cost. *Global: China approaching cost parity; EVs outselling ICE in 2025. EU mandates drive adoption despite higher costs. U.S. market fragmenting by state. Norway already 90%+ EV sales.*

Policy Strategic Framing – Key Insights

The text below should be updated so it's not the same as that under "Pre 2025 Landscape

Pre 2025 Landscape → **Post 2025 Shifts**

Strong federal support across renewables, EVs, efficiency

IRA incentives **de-risk** capital deployment

Unified policy + market momentum

Strong federal support across renewables, EVs, efficiency

IRA incentives **de-risk** capital deployment

Unified policy + market momentum

Policy ≠ just financing

Policy Resilient Solutions

Market-driven, minimal policy dependence

- **Methane abatement** – negative cost, "no regret"
- **Building efficiency** – economics buffer subsidy loss
- **Industrial efficiency** – strong ROI on efficiency measures
- **New nuclear** (Post-2025) – policy favored + renewed market interest~~demand~~

High Policy Risk

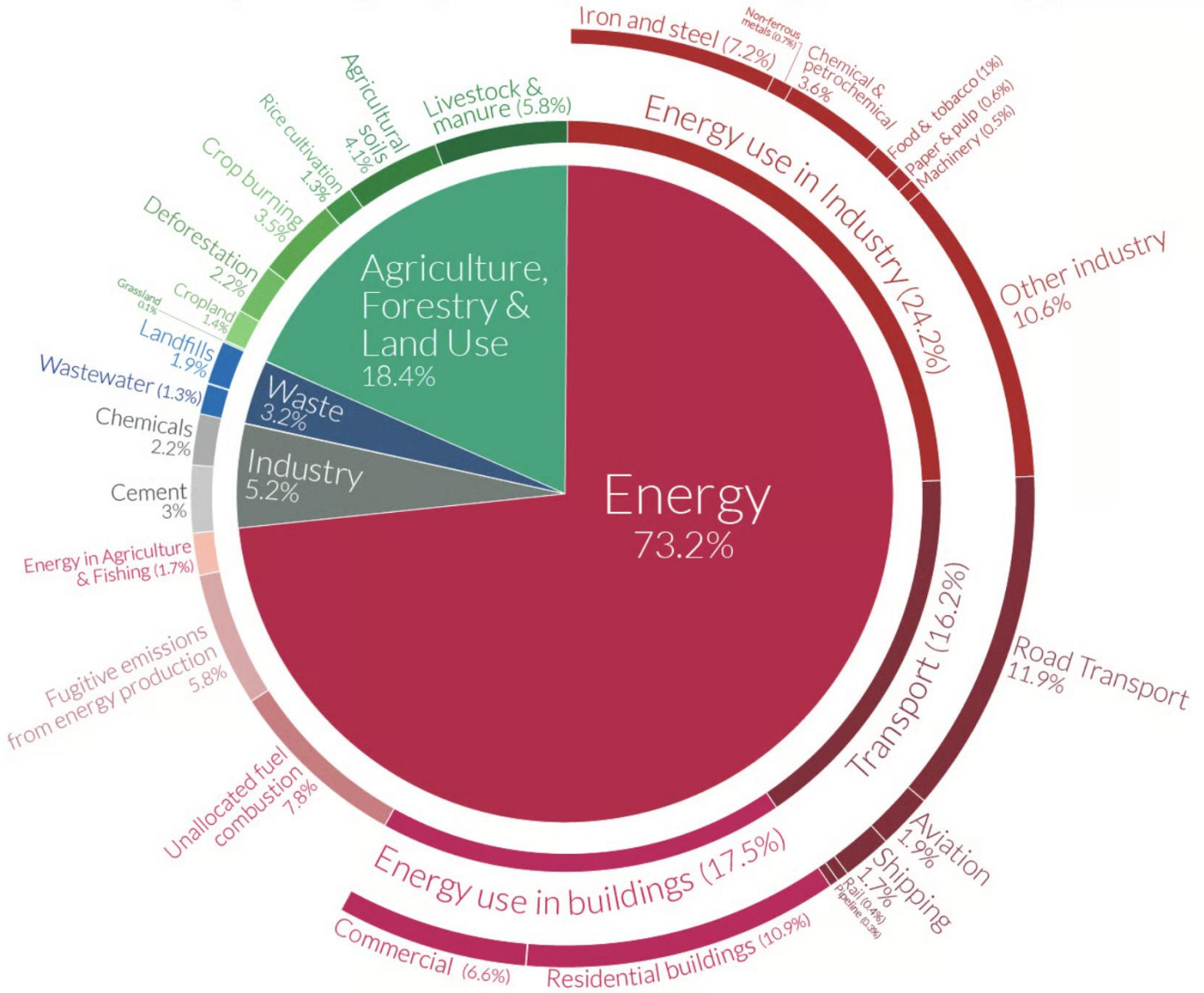
Solutions heavily dependent on subsidies/mandates:

- **EVs** – credits rolled back, CAFE weakened
- **Green hydrogen** – 45V subsidy uncertainty
- **CCS** – 45Q pressure, reduced backing
- **DAC** – requires major procurement support
- **Green steel/cement** – high cost premium

Global greenhouse gas emissions by sector

This is shown for the year 2016 – global greenhouse gas emissions were 49.4 billion tonnes CO_2eq.

Our World in Data



OurWorldinData.org – Research and data to make progress against the world's largest problems.
Source: Climate Watch, the World Resources Institute (2020).

Policy Conclusions

Nuclear, geothermal, and transmission may be the only federally favored solutions in the U.S. today, but globally the most effective solutions combine low marginal cost abatement with economic and global policy tailwinds: methane abatement, efficiency, heat pumps, geothermal, transmission, and renewables in high-resource regions

⚖️ Policy ≠ Financing

Even well-capitalized sectors face barriers in **permitting, regulation, litigation, and community opposition.** Capital availability doesn't guarantee deployment.

📈 Follow the Load

3% annual U.S. electricity demand growth (AI, data centers, electrification) creates opportunities in transmission, reliability, and firm baseload, regardless of federal policy.

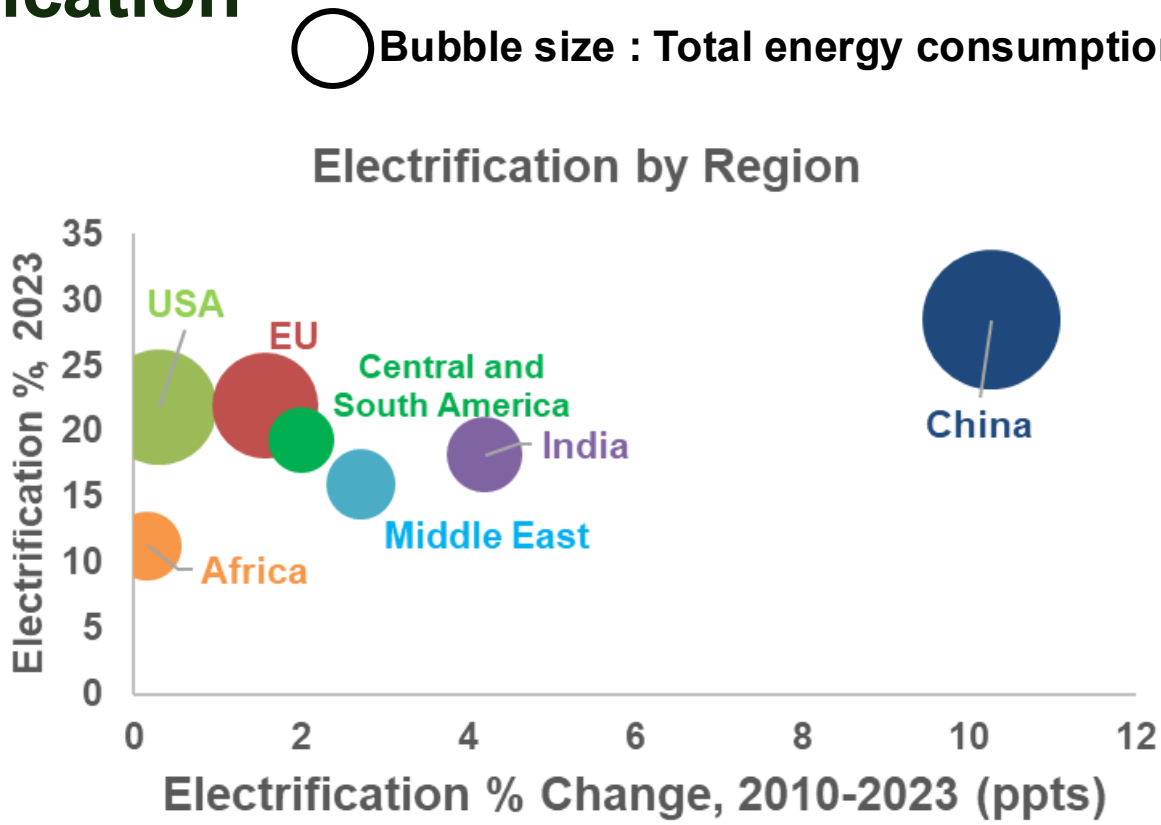
🌍 Geography Matters

While U.S. reverses course, **EU, China, and emerging markets double down.** Policy headwinds shift investment geography, not eliminate climate opportunities.

Investment/Development Priorities

- **Universal bets:** Methane abatement, building/industrial efficiency where economic
- **U.S. opportunities:** Nuclear (policy favored), geothermal, efficiency where economic, transmission (load growth)
- **Global plays:** EU CBAM beneficiaries (green steel/cement), China/India renewables, Middle East hydrogen
- **Avoid high policy risk:** U.S. EVs, offshore wind, clean hydrogen without long-term contracts

There are big regional differences in both electrification and the rate of electrification



China's economy is both more electrified (~30%) and has electrified more rapidly (~10 ppts) over the past decade

Source: IEA WEB, Ember Electricity Data Explorer

Preliminary Dashboard[1]

Kaya Identity

$$CO_2\ emissions\ from\ energy = Population \times \frac{GDP}{Population} \times \frac{Energy}{GDP} \times \frac{CO_2\ emissions}{Energy}$$

2023 data	CO_2 emissions (Gt) from energy[2]		Population (billions)		GDP per Capita ($ thousands)		Energy Intensity (kWh/$)		Carbon Intensity (kg/kWh)	
	Amount	% Change since 1990	Amount	% Change since 1990	Amount	% Change since 1990	Amount	% Change since 1990	Amount	% Change since 1990
World	37.7	+66.3	8.09	+51.9	16.68	+103.1	1.30	-41.7	0.22	-7.7
US	4.91	-4.1	0.34	+35.6	58.49	+58.2	1.36	-44.4	0.19	-17.2
EU	3.87	-29.2	0.45	+6.9	38.05	+82.2	0.96	-56.2	0.16	-27.6
China	11.90	+379.0	1.42	+23.3	19.24	+545.1	1.65	-29.6	0.25	-19.8
India	3.06	+429.8	1.44	+66.3	7.77	+272.1	0.96	-26.9	0.28	+12.5
Middle East	2.02	+249.3	0.25	+101.8	19.64	+209.9	2.03	-67.0	0.21	+4.8
Africa	1.41	+116.5	1.33	+130.1	4.82	+106.1	0.96	-41.9	0.25	+24.5
Central+South America	1.24	+82.4	0.52	+48.1	12.90	+70.9	1.39	-15.2	0.18	-7.6

[1] Cell color coding notes: since CO_2 emissions should be minimized, green shades indicate reductions in the drivers of CO_2 emissions; conversely, red shades indicate increases in these drivers
[2] Only CO_2 emissions, which account for 76% of total global CO_2 equivalent emissions

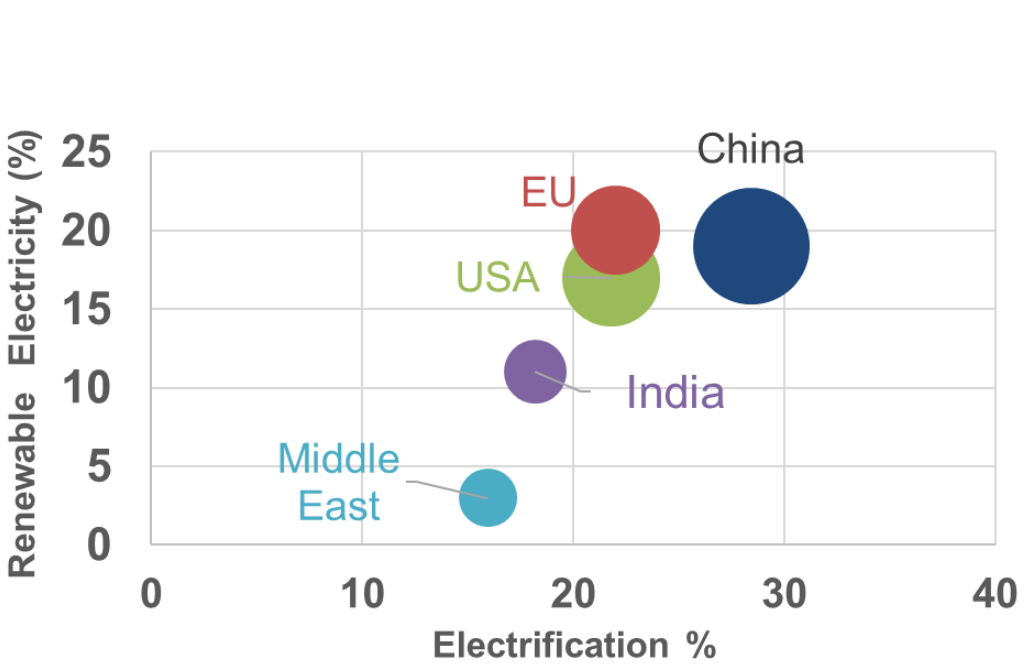
Data Source: Our World in Data

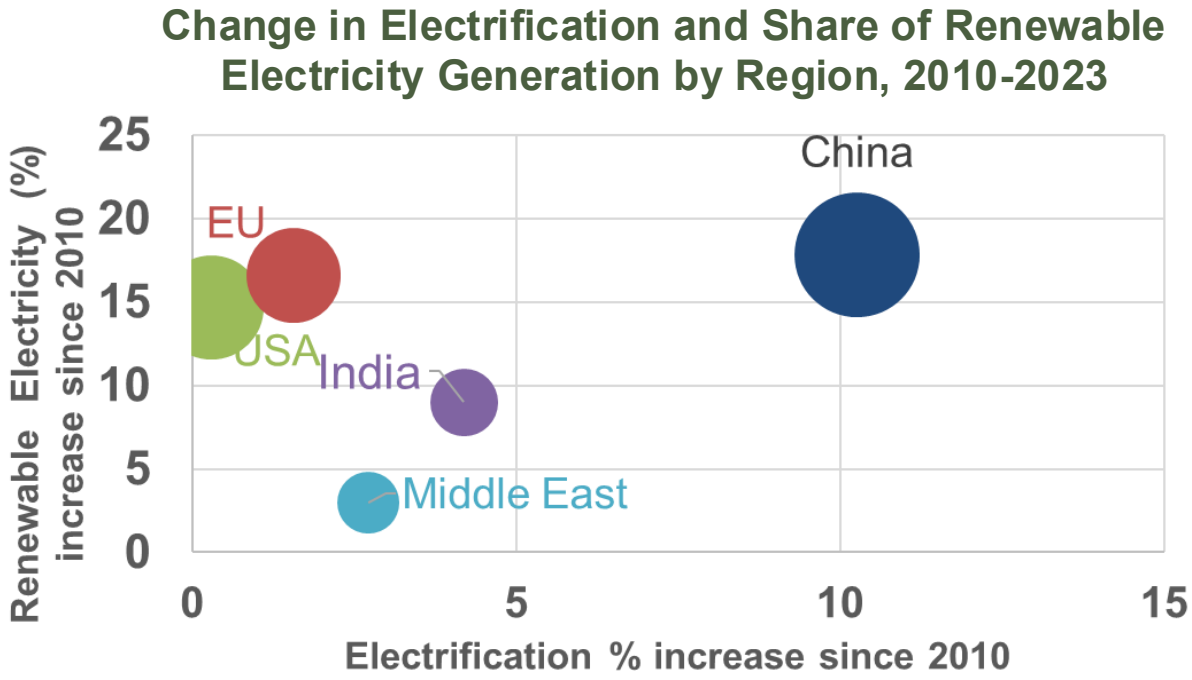
Breakdown of Countries in each region for Kaya Identity

Region	Countries included	Total Countries in Region	Countries with Data	Coverage %	Year Range	Missing Countries List
European Union (27)	['Austria', 'Belgium', 'Bulgaria', 'Croatia', 'Cyprus', 'Czechia', 'Denmark', 'Estonia', 'Finland', 'France', 'Germany', 'Greece', 'Hungary', 'Ireland', 'Italy', 'Latvia', 'Lithuania', 'Luxembourg', 'Malta', 'Netherlands', 'Poland', 'Portugal', 'Romania', 'Slovakia', 'Slovenia', 'Spain', 'Sweden']	27	26	0.963	1990-2022	Malta
Middle East	['Bahrain', 'Iran', 'Iraq', 'Jordan', 'Kuwait', 'Lebanon', 'Oman', 'Qatar', 'Saudi Arabia', 'Syria', 'United Arab Emirates', 'Yemen']	12	11	0.917	1990-2021	United Arab Emirates
Africa	['Algeria', 'Angola', 'Benin', 'Botswana', 'Burkina Faso', 'Burundi', 'Cabo Verde', 'Cameroon', 'Central African Republic', 'Chad', 'Comoros', 'Congo', Cote d\'Ivoire', 'Democratic Republic of Congo', 'Djibouti', 'Egypt', 'Equatorial Guinea', 'Eritrea', 'Eswatini', 'Ethopia', 'Gabon', 'Gambia', 'Ghana', 'Guinea', 'Guinea-Bissau', 'Kenya', 'Lesotho', 'Liberia', 'Libya', 'Madagascar', 'Malawi', 'Mali', 'Mauritania', 'Mauritius', 'Morocco', 'Mozambique', 'Namibia', 'Niger', 'Nigeria', 'Rwanda', 'Sao Tome Principe', 'Senegal', 'Seychelles', 'Sierra Leone', 'Somalia', 'South Africa', 'South Sudan', 'Sudan', 'Tanzania', 'Togo', 'Tunisia', 'Uganda', 'Zambia', 'Zimbabwe']	54	48	0.889	1990-2021	Cabo Verde, Eritrea, Namibia, Somalia, South Sudan, Sudan
Central and South America	['Argentina', 'Bolivia', 'Brazil', 'Chile', 'Colombia', 'Costa Rica', 'Cuba', 'Curacao', 'Dominican Republic', 'Ecuador', 'El Salvador', 'Guatemala', 'Haiti', 'Honduras', 'Jamaica', 'Nicaragua', 'Panama', 'Paraguay', 'Peru', 'Suriname', 'Trinidad and Tobago', 'Uruguay', 'Venezuela']	22	21	0.913	1990-2021	Curacao, Suriname

There are big regional differences in both electrification and the rate of electrification

Bubble size : Total energy consumption

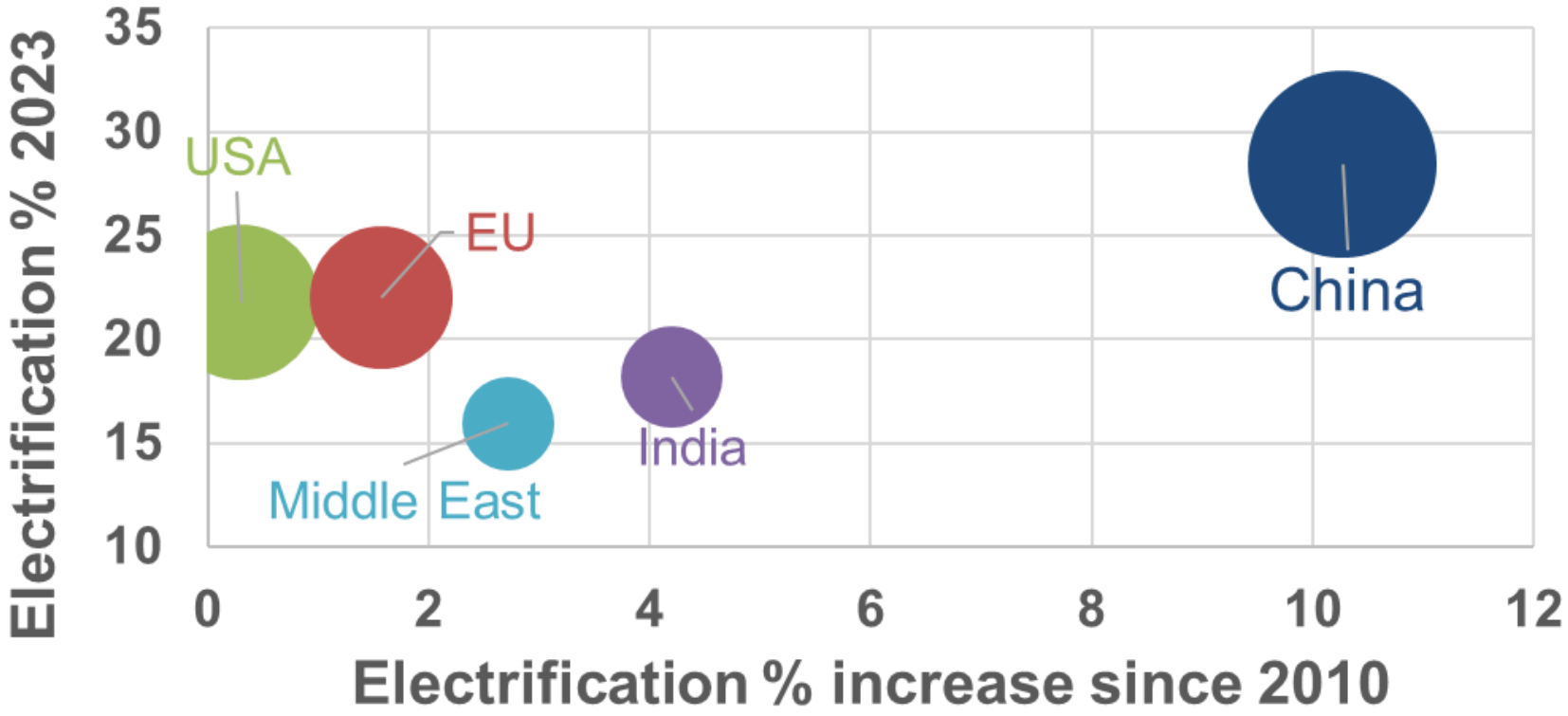




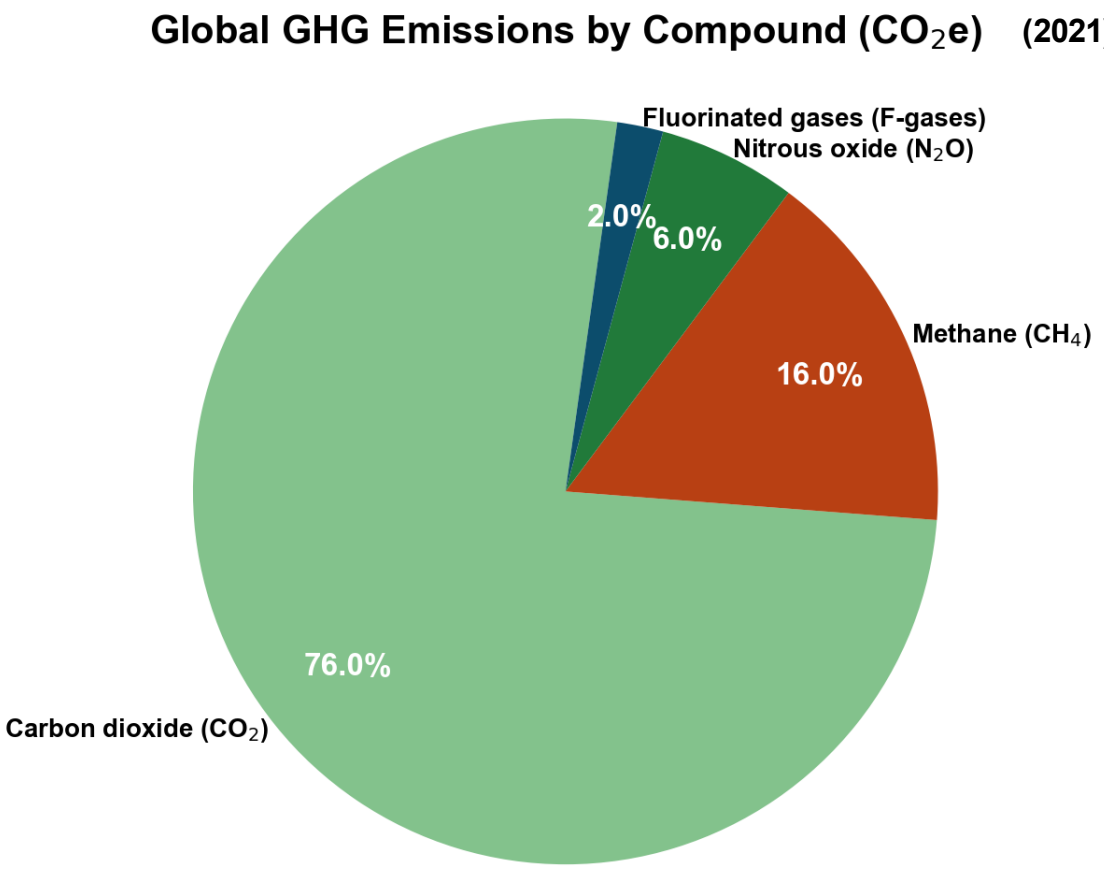
China, the EU, and the U.S. have similar renewable shares (~17–20%), but China has a higher electrification rate (30%) and has electrified more rapidly over the past decade. However, with ~60% of its electricity still from non-clean sources, its emissions remain substantial.

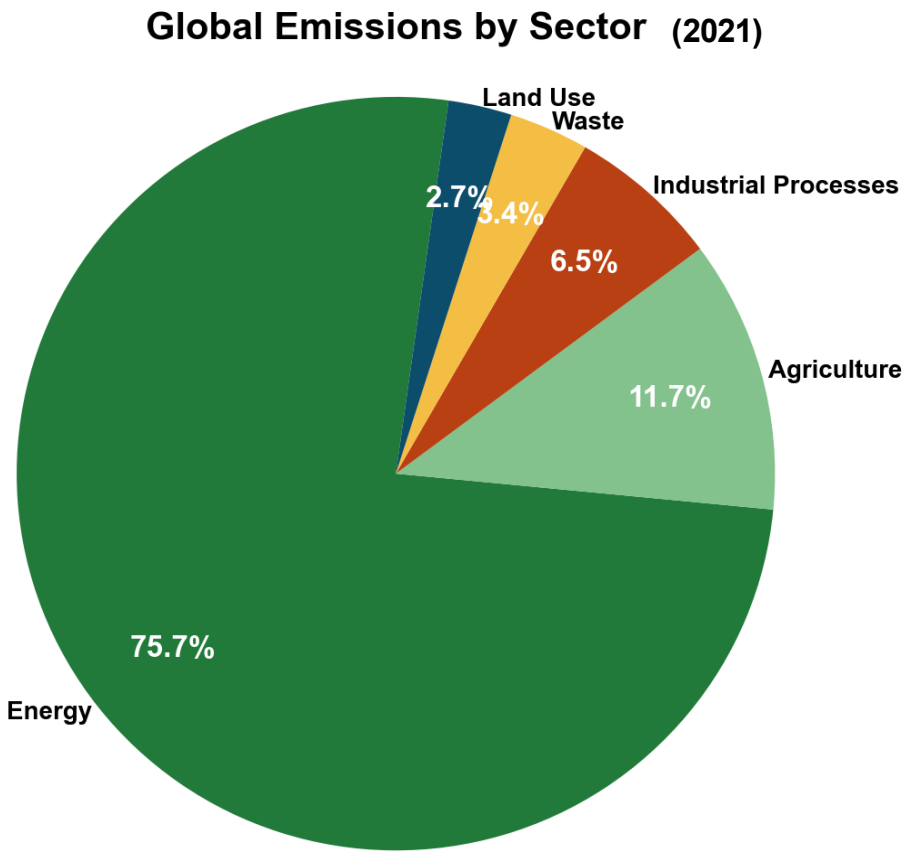
Source: IEA WEB, Ember Electricity Data Explorer

Electrification across regions



The energy sector is by far the largest source of global emissions, which can be reduced by electrification

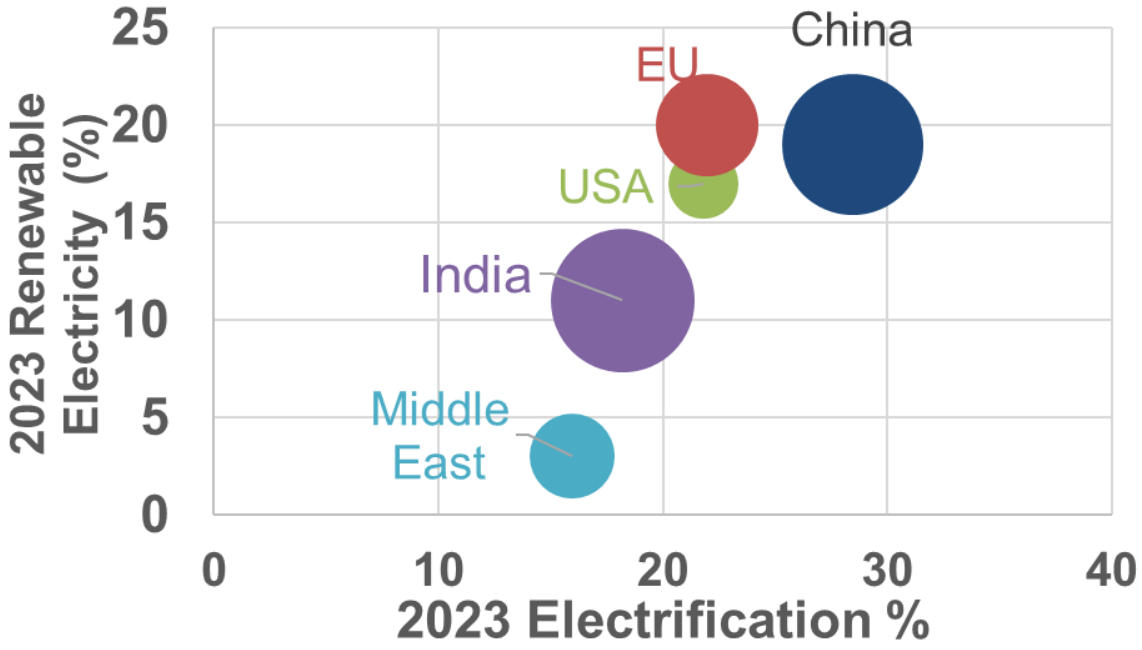


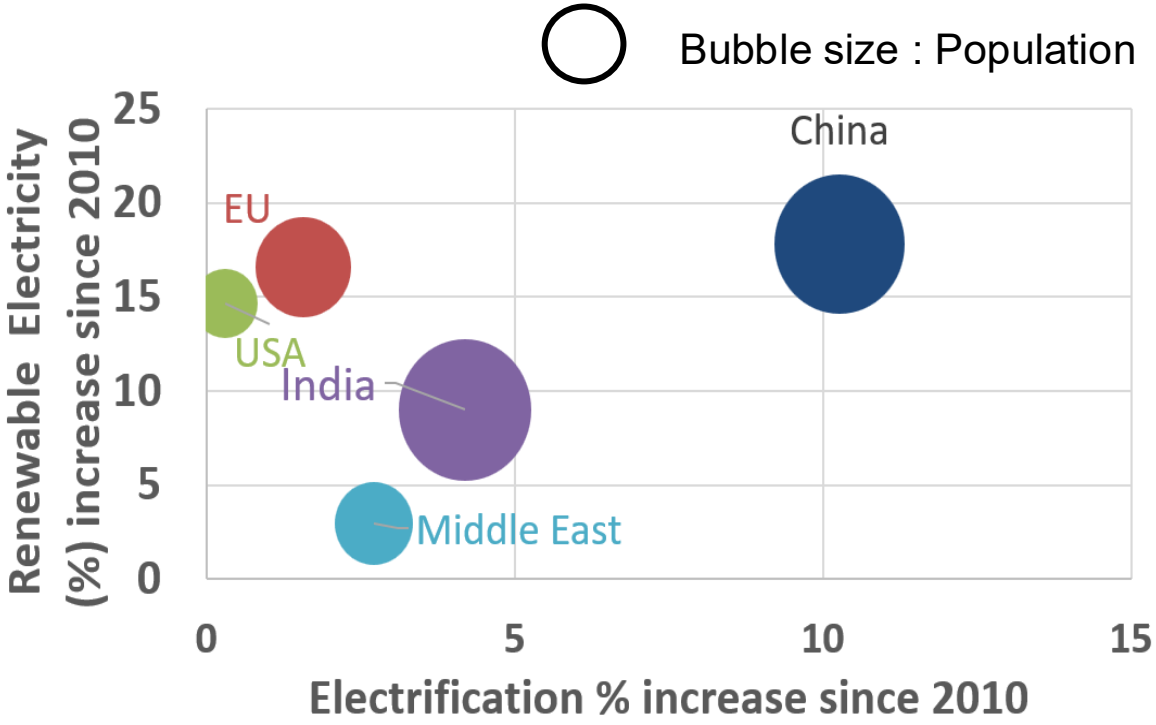


*CO_2e considers global warming potential

Source: EPA; World Resources Institute

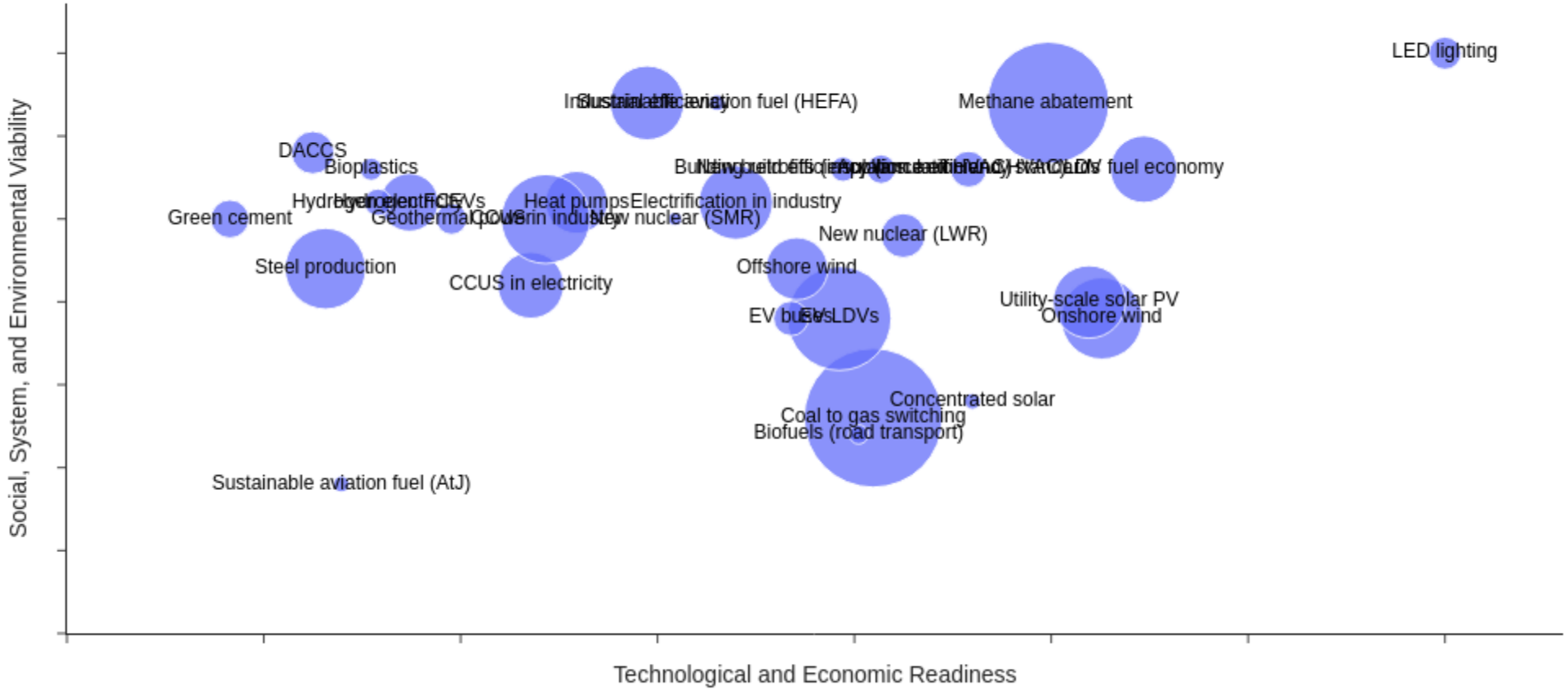
Electrification



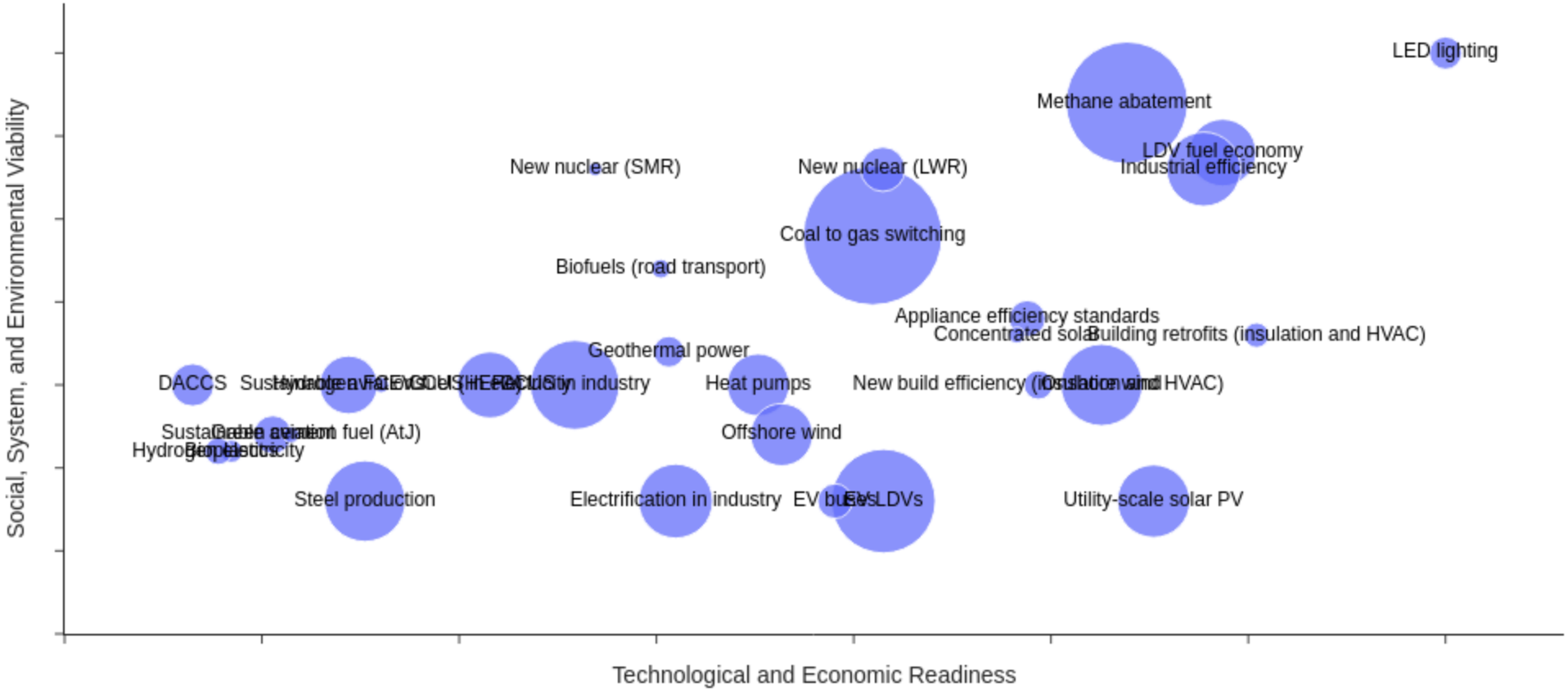


Source: IEA WEB, Ember Electricity Data Explorer

Solutions Assessment Framework: 2023 Result



Solutions Assessment Framework: 2025 Result



- High confidence: Tech readiness, cost data, critical minerals
- Medium confidence: System reliability, consumer preferences
- Data gaps remain: Distributional effects, some environmental lifecycle data

Solutions Assessment Framework

Framework Documentation & Source Mapping

- Documented all 34 solutions across 9 dimensions with primary source URLs
- Identified authoritative sources
- Created comprehensive source reference database for continuity

Data Quality Assessment

- Strong coverage: Tech readiness, marginal costs, cost competitiveness, resource availability
- Critical gaps identified: Consumer preferences (scattered), distributional effects (sector-level only), environmental impacts (water/land incomplete)

Critical Findings Synthesis

- Key insight: Climate transition is materials-constrained, not technology-constrained
- Urgent bottlenecks: Transformers (2-4 yr lead times), copper (supply peak 2035), China concentration (86% critical minerals)
- New supply chains: DACCS, enhanced geothermal, green hydrogen lack established suppliers
- Readiness-viability divergence reveals strategic opportunities (e.g., green steel: high viability, low readiness = R&D priority)

Technical Infrastructure

- Code setup for automated bubble chart updates (readiness-viability visualization)
- Established data integration protocols for maintaining framework currency
- Created maintainable system with documented methodology

Documentation Package

- Methodology guide for dimension scoring (0.5-5.0 scales with evaluation criteria)
- Gap analysis identifying where authoritative data doesn't exist