SEPTEMBER 2024

Strategic Equilibrium

The United States' Manufacturing Resurgence and the Role of Natural Gas in a Carbon-Competitive World

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Introduction

A variety of forces are promoting reindustrialization of the United States. Concerned about the fragility of long supply chains, some firms are reinvesting in U.S. production. They are enabled by government support ranging from tax subsidies for capital investment to active support for *strategic industries* that will keep the United States at the technological frontier or that relate closely to national security.

Expanding manufacturing in the United States inevitably raises questions for energy policy. Energy security, resilience, and affordability are important factors for business competitiveness, and each influences how and where companies locate manufacturing facilities. Companies are also focusing on their emissions footprints, as carbon intensity affects corporate emissions accounting and will impact the global trade of manufactured goods due to the implementation of border adjustments in Europe and elsewhere.

The role of natural gas in reshoring manufacturing is an important consideration for policymakers. Gas supplied **43 percent** of U.S. power in 2023, and the expansion of gas in the power sector over the last 20 years has helped to **reduce emissions**, **expand renewables**, and **lower prices**. As policymakers consider how to address emissions while increasing power supply for strategic industries, they must decide on frameworks for natural gas.

To probe these issues, this paper examines the energy requirements of some key manufacturing sectors and their emissions implications, assesses the role of natural gas in supporting strategic manufacturing, and analyzes the competitiveness of U.S. manufacturing from a carbon-intensity perspective. This paper presents the key findings from CSIS's research—including from a literature survey, data analysis, workshops, and stakeholder interviews—and policy recommendations on how the United States can maintain competitiveness while furthering decarbonization.

RESHORING MANUFACTURING

Since 2020, investments in new manufacturing facilities have accelerated in the United States, driven by two key sectors: semiconductors and electric vehicles (EVs). Remarkably, real spending on construction of computer and electrical manufacturing facilities, including semiconductor and EV battery manufacturing, has nearly **quadrupled** since the beginning of 2022. By April 2024, project announcements reached **$367.9 billion** for semiconductor manufacturing and **$84.4 billion** for EV manufacturing.[1] These industries now account for **nearly 60 percent** of all manufacturing investment in the United States.

Both market and strategic imperatives are driving these investments. Chipmakers aim to diversify supply chains beyond East Asia and move closer to the U.S. market, while automakers and their suppliers are investing to meet growing demand. Federal government support, driven by the Creating Helpful Incentives to Produce Semiconductors (CHIPS) and Science Act and the Inflation Reduction Act, is **accelerating** these trends. **Supply chain vulnerabilities** for semiconductors increase **national security** and **economic risks**, while reshoring and rerouting the EV battery supply chain helps advance the nation's decarbonization efforts and supports the tactical and operational demands of the **U.S. military**.

The Biden administration aims for the United States to produce **20 percent** of global leading-edge logic chips and for EVs to comprise **50 percent** of new vehicle sales by 2030. Taking into account uncertainties in future sales and value chains, forecasts of battery manufacturing capacity vary widely. The Rhodium Group estimates that if all investments announced since 2018 are realized, they would create **1,062–1,288 gigawatt hours** (GWh) of domestic cell and module production capacity in 2030. Benchmark Mineral Intelligence forecasts a more modest **588 GWh** of domestic battery production capacity in 2030.

Energy and Manufacturing

Historically, energy consumption by the semiconductor and EV sectors in the United States is a small fraction of the total energy consumption by U.S. manufacturing. According to 2018 U.S. Energy Information Administration (EIA) data, energy consumption in the semiconductor and EV sectors is far lower than in sectors such as chemicals and petroleum refining (Table 1). However, such comparisons predate the active U.S. policy for reshoring and could change as these sectors grow in significance.

Public data on energy consumption by the semiconductor and EV sectors is scarce because new facilities are only being announced and built now and anticipated energy use is commercially sensitive. The data average derived from multiple papers surveyed by CSIS suggests the need for 44 kilowatt-hours (kWh) of average energy consumption to produce 1 kWh of EV battery capacity.[2] At that

1 The figure for EV manufacturing is a sum of announced monetary values, where available, since September 2022. The figure for semiconductor manufacturing is a sum of announced monetary values, where available, since May 2020. This CSIS report defines EV manufacturing to be the production of EVs and EV components, including batteries and battery materials processing and recycling, while semiconductor manufacturing to be materials production, chips fabrication, and packaging.

2 Frank Degen et al., "Energy Consumption of Current and Future Production of Lithium-Ion and Post Lithium-Ion Battery Cells," *Nature Energy* 8 (2023): 1284–1295.; Florian Degen and Marius Schutte, "Life cycle assessment of the energy consumption and GHG emissions of state-of-the-art automotive battery cell production," *Journal of Cleaner Production* 330 (January 1, 2022): 129798; Dai et al., "Life Cycle Analysis of Lithium-Ion Batteries for Automotive Applications," *Batteries* 5(2) (June 1, 2019): 48; and Simon Kurland, "Energy use for GWh-scale lithium ion battery production," *Environmental Research Communications* 2(1) (December 20, 2019). This excludes studies that analyzed energy consumption beginning with raw materials extraction ("cradle-to-gate").

Table 1: U.S. Manufacturing Energy Consumption by Sector, 2018

Sector	Primary Energy Use (TBtu)	Offsite Electricity Generation (TBtu)	On-site Electricity Generation (TBtu)	Total GHG Emissions (MMT CO_2)	NAICS Code
Total U.S.	19,662	2,591	4,143	1,165	31-33
Top Sectors by Energy Use					
Chemicals	4,852	501	1,256	332	325
Petroleum Refining	3,728	165	702	244	324110
Forest Products	2,883	245	1,394	80	321322
Food and Beverage	1,935	363	442	96	311312
Iron and Steel	1,469	214	134	100	331110, 3312
Selected Additional Industries					
Transportation Equipment	659	172	27	32	336
Other Computers, Electronics, and Electrical Equipment	266	114	15	24	334, 335
Semiconductors	127	40	6	6	334413
Alumina and Aluminium	372	90	12	21	3313
Automobile and Light Duty	125	28	7	6	33611
Aerospace Products and Parts	124	33	13	6	3364

Source: "2018 Manufacturing Energy Consumption Survey (MECS)," U.S. Energy Information Administration (EIA), 2018, https://www.eia.gov/consumption/manufacturing/.

intensity, the 1,000 GWh of potential battery manufacturing capacity forecasted for 2030 would require 44,000 GWh of energy consumption, or approximately 150 trillion British thermal units (Btu). However, energy usage estimates vary across studies due to different methods and data sources. Many rely on data that is over a decade old and that likely differs from current usage, given industry growth and efficiency improvements.

Meanwhile, according to a 2021 regulatory document, a new Taiwan Semiconductor Manufacturing Company (TSMC) fabrication site in Arizona is estimated to use **1,200 megawatts** (MW), which at 99 percent capacity would be equivalent to about 30 trillion Btu. That is roughly equivalent to the peak power output of a Westinghouse AP1000 nuclear reactor or **one-tenth** of the installed capacity of natural gas combined-cycle plants in Arizona.

Notwithstanding the dearth of authoritative energy use estimates, both the administration's goals and the $452.3 billion (actual and planned) invested in the semiconductor and EV manufacturing sectors combined through April 2024 suggest significant energy demand growth. Moreover, the expansion of strategic manufacturing will expectedly induce additional energy demand in other sectors, such as steel and aluminum production. Even with efficiency advancement in manufacturing processes, increased demand from reshoring will be happening at the same time as pronounced load growth nationally, creating supply risks for energy.

Additionally, projections over the next 10 years are already pointing to a higher electricity growth forecast than at any point in the past decade, including summer peak demand growth of **79 gigawatts** (GW) and winter peak demand growth of **91 GW**, according to the North American Electric Reliability Corporation (NERC).

NATURAL GAS AND MANUFACTURING

In the last few decades, the role of natural gas in the U.S. economy has risen dramatically. Enabled by shale production, U.S. dry gas production has grown from **18 trillion cubic feet** (Tcf) in 2005 to **38 Tcf** in 2023, with consumption increasing from **22 Tcf** to **33 Tcf** over the same period. For most of that period, the Henry Hub natural gas price has been below **$5 per million Btu** (MMBtu), easing the cost of higher consumption throughout the economy.

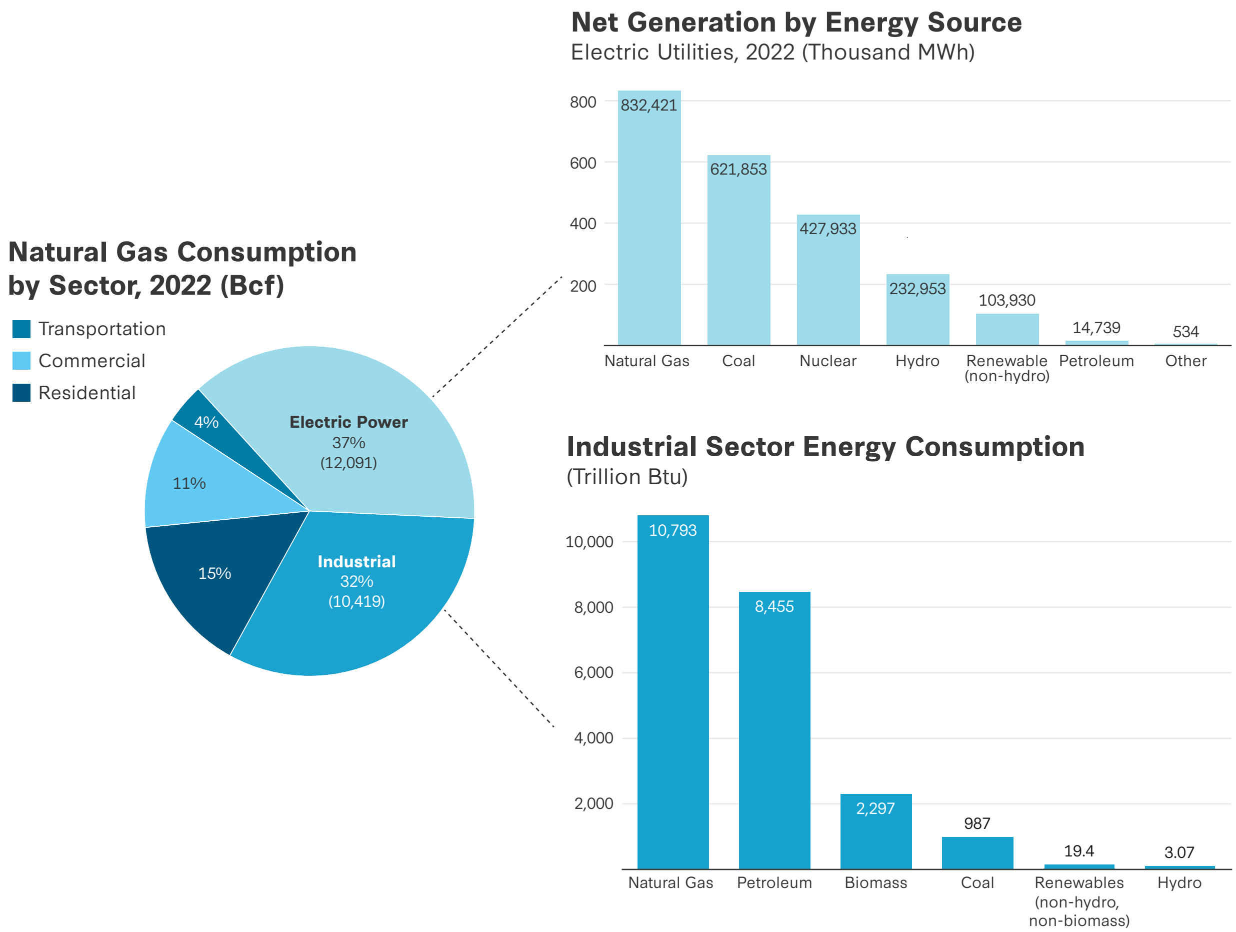
Low energy prices are associated with manufacturing competitiveness. In general, economic studies find a small positive effect on manufacturing output and employment from lower gas prices enabled by U.S. production. A working paper for the Federal Reserve first released in 2014 found that the decrease in natural gas prices between 2006 and 2013 contributed to an increase in manufacturing output by **2 to 3 percent** across the whole manufacturing sector. The increase appears to be **higher** in more energy-intensive sectors, such as fertilizer production. A similar **study** published in 2021 found roughly similar effects, verifying a larger body of literature produced in the meantime.

Industry players expect that natural gas will continue to play a **key role** in meeting growing energy demands. In the most recent long-term reliability assessment, published in 2023, NERC sees natural gas remaining a "**critical resource**" for the U.S. electric power supply in many areas. Particularly in winter, natural gas power plants **will provide** "necessary reliability attributes . . . as traditional generators retire and inverter-based renewable resources take their place in the resource mix." Goldman Sachs expects natural gas to meet about **60 percent** of additional load growth from expanding data centers and artificial intelligence.

Utilities in states attracting manufacturing investment are re-elevating natural gas in resource planning. Arizona is one of the major destination states for actual and planned investments in both EV batteries (**$3.7 billion**) and semiconductor manufacturing (**$100.7 billion**).[3] One of the leading utilities in the state, Arizona Public Service (APS), **projects** the energy needs through 2038 in its service territory to increase at 3.7 percent annually to 23,700 GWh—about 55 percent from data center expansions and 24 percent from large industrial activities (inclusive of demand-side management and efficiency gains). This projected growth translates into about **3,400 MW** of capacity needs in the next 15 years. Particularly in light of its planned exit from coal-fired generation in 2031, APS views natural gas—including hydrogen-capable natural gas combustion turbines—as a means to **ensure reliability** while expanding renewables and energy storage resources.

3 The figure for EV manufacturing is a sum of announced monetary values, where available, from September 2022 to April 2024. The figure for semiconductor manufacturing is a sum of announced monetary values, where available, from May 2020 to April 2024.

Figure 1: The Major Role of Natural Gas in Electricity Generation and the Industrial Sector, 2022



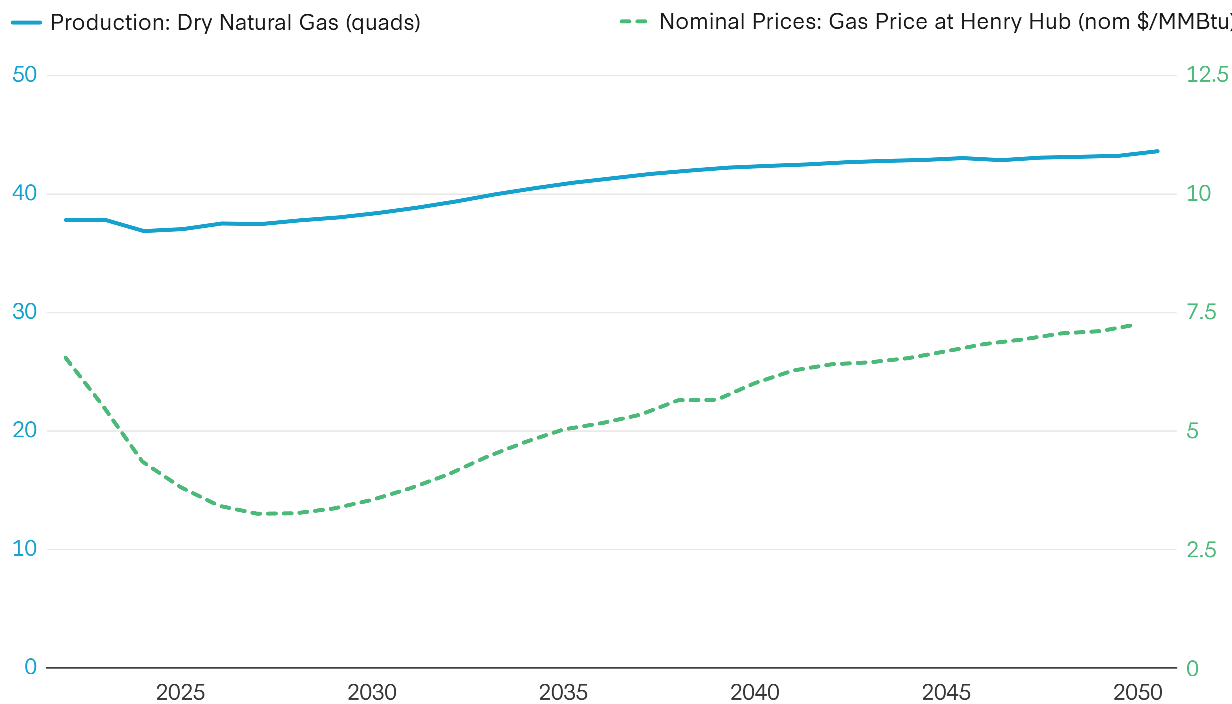
Source: "Table 4.3 Natural Gas Consumption by Sector," EIA, https://www.eia.gov/totalenergy/data/browser/index.php?tbl=T04.03; "Table 3.2.A. Net Generation by Energy Source: Electric Utilities, 2012 – 2022," EIA, Electric Annual, October 19, 2023, https://www.eia.gov/electricity/annual; and "Table 2.4 Industrial Sector Energy Consumption," EIA, https://www.eia.gov/totalenergy/data/browser/index.php?tbl=T02.04.

The story in Georgia is similar. A massive economic expansion since January 2022 led Georgia Power to file an update to its 2022 integrated resource plan (IRP) in October 2023. The utility projects electricity load growth of **6,600 MW** through 2030-31, which is about 17 times larger than what it anticipated in its 2022 IRP. During the first half of 2023, the manufacturing sector—including solar, EVs, and aerospace—was leading the state's economic growth, representing **67 percent** of job creation and **81 percent** of the capital investment. Georgia Power **views** natural gas as crucial for a cost-effective and reliable low-carbon transition, complementing energy storage resources that have limited time duration.

PRICES

Present forecasts for U.S. gas production show that rising consumption will be accompanied by rising prices. The EIA's *Annual Energy Outlook 2023* forecasts a **0.5 percent** growth in the domestic supply of dry gas and a price level increase of **0.4 percent** through 2050. While the trajectory for production growth is relatively linear, the forecasted price increase of 0.4 percent, from $6.52 per MMBtu in 2022 to $7.23 in 2050, is accompanied by a notable dip to below $3.50 in the late 2020s (Figure 2).

Figure 2: Outlooks for U.S. Natural Gas Supply and Henry Hub Prices through 2050



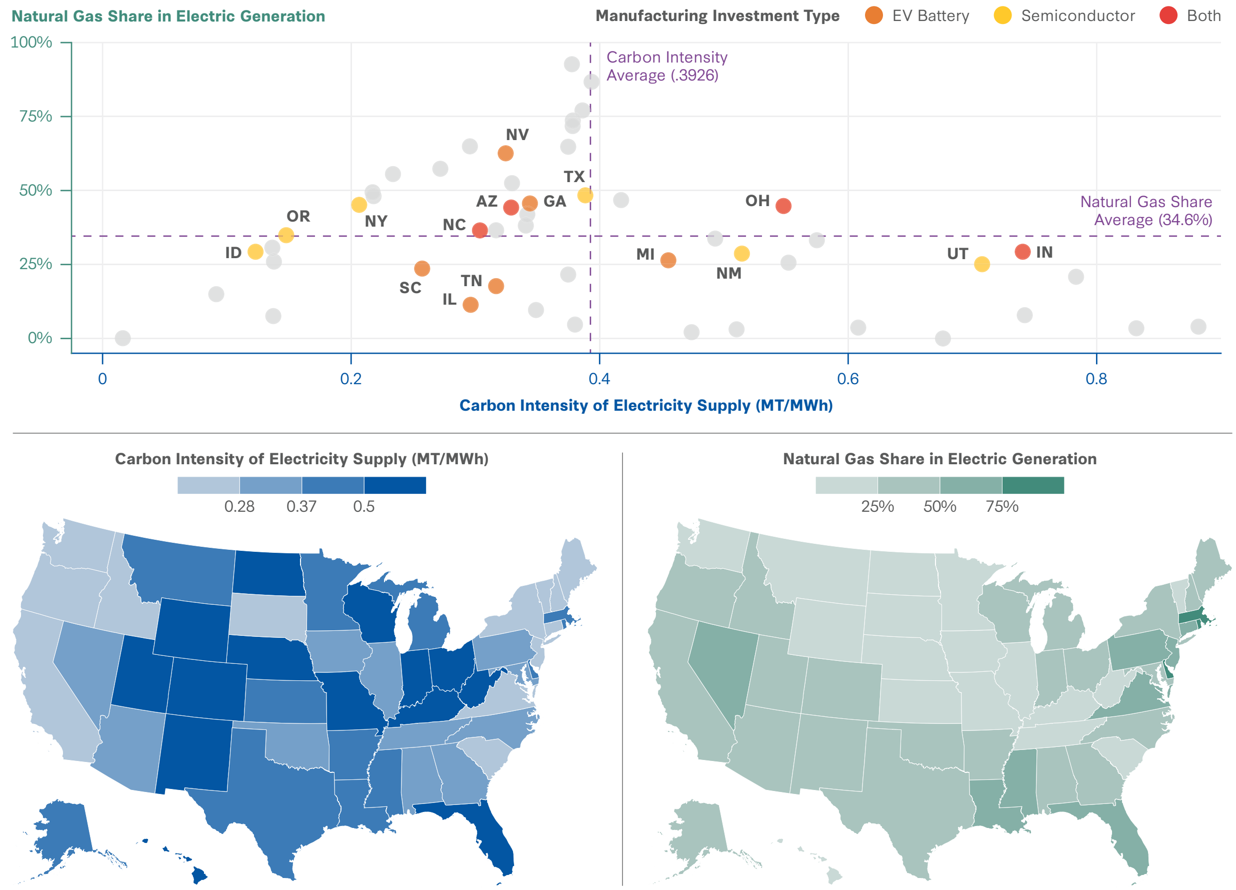
Source: "Table 1. Total Energy Supply, Disposition, and Price Summary," EIA, Annual Energy Outlook 2023, 2023, https://www.eia.gov/outlooks/aeo/data/browser/#/?id=1-AEO2023&region=0-0&cases=ref2023&start=2021&end=2050&f=A&linechart=~~ref2023-d020623a.5-1-AEO2023~~~~~ref2023-d020623a.54-1-AEO2023~~&map=&ctype=linechart&sourcekey=0.

Meanwhile, natural gas consultancy Wood Mackenzie's forecasts show that large increases in gas consumption–from data center operation, chip manufacturing, and liquefied natural gas exports–will not lead to a significant price increase. Corresponding to its upward revision in the U.S. gas demand projection for the early 2040s from 13 billion cubic feet per day (Bcf/d) under the 2022 version to 30 Bcf/d, Wood Mackenzie's latest **forecasts** are for Henry Hub to reach $4 per MMcf by the mid-to-late 2030s, and closer to $6 per MMcf through the 2040s.

EMISSIONS

Natural gas plays a significant role in the energy system, and expanding gas consumption raises potential challenges for meeting ambitious zero-carbon targets for the power sector. The continued use of coal-fired generation and changes in the dispatch order for generations make evaluating the emissions impact of additional capacity challenging to estimate outside of a modeling framework. In the meantime, about two-thirds of the states where strategic manufacturing is on rise are below the national average in terms of the carbon intensity of their electric power supply. The map below shows the top 10 recipient states of actual and planned investments in semiconductors and EV manufacturing, as well as the carbon intensity of associated power generation and the percentage contribution from natural gas in each state (Figure 3).

Figure 3: Natural Gas Reliance and Electric Power Supply Carbon Intensity in the Top 10 U.S. States for Semiconductor and EV Manufacturing Investments



Source: "The CHIPS Act Has Already Sparked $450 Billion in Private Investments for U.S. Semiconductor Production," Semiconductor Industry Association, December 14, 2022, https://www.semiconductors.org/the-chips-act-has-already-sparked-200-billion-in-private-investments-for-u-s-semiconductor-production/; "Update: US Electric Vehicle Supply Chain IRA + 749 Days," Charged, last updated August 16, 2024, https://www.charged-the-book.com/na-ev-supply-chain-map; "Net generation, United States, all sectors, monthly," EIA, Electricity Data Browser, https://www.eia.gov/electricity/data/browser/; and "Energy-Related CO2 Emission Data Tables," EIA, Environment, released July 12, 2023, https://www.eia.gov/environment/emissions/state/.

Carbon Competitiveness

As the world moves toward net-zero emissions, how much CO_2 emissions companies and industries produce will affect their competitiveness. More firms must now report direct and indirect emissions as part of their Scope 1 and 2 emissions accounting. As carbon pricing or similar regulations spread, lower-emissions production will be more profitable, as prices will reflect emissions intensity. Even if the United States delays implementing national climate regulations, markets will value lower-emissions production.

The European Union's Carbon Border Adjustment Mechanism (CBAM) now exposes U.S. exporters to **climate-related trade rules** for certain goods. While these measures will not immediately affect semiconductors or EV batteries, they will apply to commodities such as steel, aluminum, and chemicals. In these areas, U.S. producers have some **carbon advantage** over **international competitors** such as China but may **trail producers in Europe**. For products crucial for decarbonization, such as EV batteries, the carbon output of manufacturing will remain important in life-cycle analysis and could soon affect commercial decisions.

In the United States, both Democratic and Republican leaders see benefits in highlighting how efficient the U.S. economy and manufacturing specifically are with respect to emissions. In April 2024, the Biden administration **formed** a climate and trade task force to address the neglect of emissions from imported goods in current trade policies. Announcing the task force, U.S. climate envoy John Podesta cautioned that ignoring these emissions unfairly advantages countries with high-carbon manufacturing, such as China. This echoes a frequent **Republican claim** that lax regulations overseas award foreign manufacturers an unfair advantage. Legislators are drafting proposals to study the relative carbon intensity of production and install carbon border adjustments across different product categories. At their most expansive, these proposals would apply beyond the small set of commodities covered by the European Union's CBAM and include battery materials and other goods.

In a world where carbon emissions matter in competition, U.S. manufacturing has a mixed advantage. U.S. industry produces semiconductors and EV batteries with less carbon than China thanks to cleaner energy generation, but it still trails Europe (Table 2). Although both the U.S. and Chinese power grids rely on fossil fuels, China's higher use of coal power—**63 percent** of its power generation compared to **23 percent** in the United States as of 2021—makes its manufacturing more carbon intensive, particularly as coal is **more than twice** as carbon intensive as natural gas. The European Union uses more emissions-free sources (deriving **37 percent** of its power generation from renewable energy and **25 percent** from nuclear energy) than the United States, reducing its emissions output. The degree of reliance on natural gas within power systems varies notably across the three economies: **38.4 percent** in the United States, **19.9 percent** in the European Union, and **3.3 percent** in China as of 2021.

The expansion of strategic manufacturing demands construction, which requires raw materials such as iron ore and aluminum. In supplying these resources, the United States has a relative advantage over

Table 2: Emission Intensity of U.S. Semiconductor and EV Battery Manufacturing Compared to Europe and China

	European Union		United States	China	
Annual emissions from semiconductor fabrication, 2021	5 mt CO_2e**	-28.5%	7 mt CO_2e	15 mt CO_2e	+114%
NMC111 EV battery* per kilowatt-hour of battery capacity	66.9 g CO_2e/kWh***	-9%	73.7 g CO_2e/kWh	100.6 g CO_2e/kWh	+36%

* Nickel manganese cobalt (NMC) is one of the most common EV battery chemistries. NMC111 typically is composed of one-third nickel, one-third manganese, and one-third cobalt.

** Metric tons of carbon dioxide equivalent

*** Carbon dioxide equivalent per kilowatt-hour

Source: Boston Consulting Group (BCG) and the Semiconductor Climate Consortium (SEMI), *Transparency, Ambition, and Collaboration: Advancing the Climate Agenda of the Semiconductor Value Chain* (Milpitas, CA: 2023), https://discover.semi.org/rs/320-QBB-055/images/Transparency-Ambition-and-Collaboration-BCG-SEMI-SCC-20230919.pdf.

major competitors such as China. A 2019 **report** comparing steel industry emissions across the 15 top steel-producing countries found that U.S. production is one of the least carbon intensive, while China ranked last. Similarly, North American aluminum production emits about **half** the global average rate, according to industry data. An **industry report** found that "the current emission intensity of aluminum products produced in China is 2.5 times [that] of [North American] domestic products, and the global aluminum product carbon intensity is 1.9 times [that] of [North American] domestic products."

ABATEMENT OPPORTUNITIES

Over the past decade, the expansion of gas in the power sector has reduced emissions as it has displaced coal. Using gas in the power and industrial sectors contributes to the relative emissions advantage of U.S. manufacturing. However, a path to net zero will require emissions abatement for all use cases of natural gas, as other emissions abatement opportunities will be exhausted.

There are three general options for reducing emissions from natural gas consumption. The first is reducing the emissions intensity of natural gas by producing renewable natural gas (or biomethane) or synthetic methane via clean hydrogen production. These methods are presently limited in potential scale and cost, respectively. The second option is using carbon capture and storage (CCS) on point sources where gas is combusted for power or heat, which can be costly but is scalable. The last option is reducing gas use to the point where remnant emissions can be offset using carbon removals. Of these three, the deployment of CCS on existing or new facilities is most likely to help square near-term energy demand growth and long-term climate ambitions.

Energy modeling indicates that deploying CCS can achieve rapid emissions reductions and the continued utilization of natural gas. The National Renewable Energy Laboratory's 2023 Standard Scenarios Report found that gas capacity continues to **expand** across different scenarios, adding 200 GW through 2050 under current policy and 130 GW in the case that achieves a 95 percent emissions reduction in 2050. But in scenarios with strong and immediate emissions policies (net-zero electricity by 2035), natural gas with CCS can grow significantly—even after the emissions standards are in place—and provide as much generation in 2050 as it does today.

The cost of capture and a lack of pipeline infrastructure for CO_2 are commonly cited reasons for not deploying CCS today. Even with subsidies, the U.S. Department of Energy (DOE) assesses combined-cycle natural gas generators to be a longer-term opportunity for deployment of CCS, meaning that it will be **commercially viable** after 2030. In the meantime, deployment of capture technologies in other sectors will help reduce costs and support infrastructure. The post-2030 timeline makes CCS a relevant consideration for utilities, power plant operators, and regulators today. The U.S. Environmental Protection Agency has already identified CCS as the best means of emissions reduction for natural gas generators in its **rule** for new emissions sources.

To accelerate progress toward commercial deployment, the DOE has **sponsored** front-end engineering and design studies for retrofitting natural-gas-fired power plants with CCS technologies. Capital and finance costs dominate the total cost of retrofitting natural gas generation for carbon capture. In a DOE-sponsored **study** of the retrofit costs for a 750 MW gas plant in Texas, capital costs accounted for 70 percent of the cost of the retrofit, which totaled $477 million, or about $115 per ton of CO_2 captured over 15 years. At present, there are reportedly **eight** planned or in process deployments of CCS on gas plants in the United States.

STAKEHOLDER CONSIDERATIONS

The strong outlook for energy demand growth introduces a range of qualitative considerations and concerns for energy planners and firms. Reliability, affordability, accessibility, and carbon intensity are some of the key considerations that shape stakeholder approaches to energy requirements from the strategic manufacturing sectors. What stakeholders value in addressing energy requirements may not vary significantly, but there is some diversity in how different stakeholders prioritize key attributes of energy supply.[4]

Manufacturers: Along with factors such as the availability of a skilled labor force, logistical infrastructure, and local political support, local energy resources shape manufacturers' siting decisions. Energy considerations extend beyond securing large, low-cost supplies, though this remains crucial for manufacturers' profitability. Energy *reliability* is a key priority for semiconductor manufacturers, as a "stoppage at any of its manufacturing stages can result in **wasted batches**." The cost of a supply disruption can be significant. For example, Samsung reportedly incurred a **$43.3 million** loss in 2018 when a regional transmission cable failed, leaving its chip plant without power for 30 minutes. The need for an uninterrupted supply of electricity could accelerate interest from manufacturers in these sectors to **seek** on-site power generation assets.

Carbon intensity is another major interest of manufacturers. Leading companies in EV battery and semiconductor manufacturing, as well as data center operators, have corporate sustainability commitments that include greenhouse gas (GHG) reduction commitments and energy conservation targets. EV battery manufacturers seem eager to **procure clean power** to produce the goods whose primary objective is to decarbonize the transportation sector. For example, **Panasonic**, **LG Energy Solution**, and **SK hynix** have pledged to achieve net-zero operational emissions by 2030 or 2040. These commitments may amount to a future where half of batteries would be made at factories that source **at least 50 percent** of their power demand from renewable energy sources by 2030. Battery manufacturers' interest in a low-carbon supply chain has also manifested in exploration of the option of leveraging investment interests to facilitate a regional power supply mix, including coal plant closures. Also, leading U.S. semiconductor manufacturer **Intel** has pledged net-zero emissions by 2040 for both direct emissions from chip fabrication and purchased electricity, steam, and heating/cooling equipment, while semiconductor end users such as **Microsoft** and **Amazon** are committed to reaching net-zero emissions by 2030 and 2040, respectively. However, a recent media report highlights the difficulty in accelerating, let alone maintaining, the pace of emissions reduction as **AI business expands**.

Utilities: Electric and gas utilities need to ensure the provision of energy to various customers—ranging from households to large-scale industrial users, including semiconductor and EV battery manufacturers—while sustaining a profitable business. The economics of various energy resources are

4 The CSIS scholars conducted several workshops as well as research interviews with a variety of stakeholder groups, including electric and gas utilities, manufacturers, and public utility commissions. The summary of stakeholder priorities authored in this report represents the authors' interpretation and analysis of stakeholder priorities, with supplemental desk research, as appropriate.

important factors that utilities watch in planning what generation and transmission infrastructure is needed where and at what increments.

The possibility of *stranded assets* is a major concern for utilities. They make plans for resource procurement (including by trade with neighboring states) and new infrastructure based on the best available energy data. Some view energy data *availability* as a primary challenge, whereas others find *data analysis* a bigger challenge. Some factors necessary for sound modeling are dynamic and difficult to analyze. Consumer preference in the case of modeling the growth of EV battery manufacturing capacity may be one such example.

Another complicating factor is the misalignment of the pace of decisionmaking among different stakeholders. For example, investment decisionmaking by manufacturers is generally much faster than the pace of planning by utilities, whether they operate in regulated or unregulated markets. Even when utilities recognize the demand growth, they often face delays in obtaining the permits required to build the necessary infrastructure.

State Utility Regulators: The principal mission of state utility regulators (e.g., public utility commissions, or PUCs) includes ensuring that energy supply is reliable, affordable, and accessible.[5] Another key concern of state regulators is who pays for infrastructure that will be required to meet energy demand from expanding manufacturing. Conveying the net economic benefit for the state could be a challenge, as ratepayer interests can be more geographically segmented even within a state or such benefits may not be immediately apparent.

Clean energy use, including measures such as renewable portfolio standards, can also be part of oversight and regulatory consideration where the state legislature so mandates a state regulatory body. The impact of rapid growth in energy demand on clean energy mandates warrants close regulatory attention.

Meanwhile, the level of concern regulators have regarding the risk of stranded assets seems to vary depending on whether utilities in each state operate as vertically integrated monopolies under PUC oversights or in unregulated markets. Regulators in regulated markets are likely more concerned with an overbuild of generation and transmission assets by utilities, as the economic loss from a stranded asset can be passed on to ratepayers. At the same time, a state PUC could be less concerned with a utility's ability to build generation to meet the state's energy demand, as investment decisions are made in close consultation with utilities, including through the IRP process.

Key Observations and Policy Recommendations

Maintaining economic competitiveness over higher-carbon manufacturers such as China and narrowing the intensity gap with Europe will require emissions reduction efforts throughout supply chains. The United States needs policies that help unlock the strategic value of natural gas to reestablish its industrial competitiveness while furthering decarbonization.

Notably, neither the CHIPS Act nor the IRA impose energy use or emissions-intensity requirements for tax credit eligibility on strategic manufacturing sectors, such as the semiconductor and EV battery

5 State utility commissions also provide oversight or regulation of public utilities with respect to telecommunications and water.

sectors. An approach that imposes firm guidance on power procurement similar to the one proposed for hydrogen under the IRA (i.e., hourly matching, incrementality, and deliverability under the **Clean Hydrogen Production Tax Credit**) is likely unfeasible in many strategic manufacturing cases. At the same time, it would incur significant costs and thus undermine project economics in most cases. The policy needs to be designed to foster the commercial feasibility of emerging strategic manufacturing while making material progress in emissions reduction.

Several areas are ripe for action by industry and government stakeholders:

1. **Encourage strategic manufacturing sectors to collect and share energy usage data with a federal agency.**

   Energy usage data for emerging strategic sectors is currently scarce, largely due to the sectors' nascence in the United States. Also, manufacturers may be concerned that energy usage data could reveal certain proprietary manufacturing processes. Such data is essential for a multitude of stakeholders, however. It would help utilities and energy regulators improve their ability to identify future energy requirements and infrastructure needs, especially as the regulators strive to ensure the reliability, affordability, and accessibility of energy against the fast-evolving investment and manufacturing landscape.

   In particular, a greater amount of quality data could help reduce the risk of overbuilding or underbuilding. The risk of stranded assets is a major concern for utilities and regulators, as it could incur significant costs to ratepayers. Yet, the risk of underbuilding energy infrastructure has a consequence, too. Failing to meet the energy demand could stymie industrial redevelopment of a state or the country. Ultimately, collecting and sharing more energy data—qualitatively and quantitatively—is also in the interest of strategic manufacturers as a better understanding of energy usage and estimating future needs can help regulators and utilities plan better, thereby cultivating a policy environment that enables such manufacturing activities. Industry associations in leading strategic manufacturing sectors are well positioned to take the lead in collecting and sharing energy usage data with the public, potentially through a federal agency such as the U.S. Department of Commerce or the EIA, as necessary.

2. **Accelerate the reduction of emissions intensity from manufacturing.**

   Manufacturing is intensive in both energy usage and GHG emissions. Electrifying as much of the manufacturing processes as possible while facilitating low-carbon fuel use could help reduce manufacturing emissions. For example, in EV battery cell manufacturing, the process of drying electrodes is a **leading source** of non-electricity-related emissions. Several **technologies**, including near-infrared drying and laser drying, are under development to help reduce energy consumption and GHG emissions in this process.

   Emissions reductions in manufacturing associated materials, such as steel and aluminum, are also crucial. Areas for proactive consideration include greater use of lower-emitting electric arc furnaces over blast furnaces and complementing natural gas use with hydrogen use.

3. **Encourage CCS readiness at new gas power plants.**

CCS is likely the best path for emissions reductions from new gas plants, but it is not ready to meet growing demand today. Utilities and developers could prepare for the deployment of CCS in the future to create option value for all stakeholders and opportunities for natural gas to continue to provide baseload power at decreasing emissions intensity.

Active planning and forward engineering studies at the project development stage can encourage CCS readiness, even when CCS will not be immediately deployed. By considering future retrofit, developers could assess the costs of facilities and site design for accommodating flue gas treatment, solvent regeneration, CO_2 compression, and additional power and water requirements. Avoiding designs and facility layouts that would make future retrofit prohibitively expensive should become an industry standard.

4. **Encourage infrastructure permitting reform.**

The importance of enabling infrastructure is one of the key considerations that was underscored throughout the stakeholder interviews. Infrastructure under consideration ranges from natural gas pipelines to electric power grids.

The federal processes for infrastructure permitting merit modernization that will enhance efficiency and reduce uncertainty while protecting the environment and local communities. Permitting reform could help alleviate the misalignment of the pace of decisionmaking that confronts manufacturers, utilities, and regulators. Having infrastructure in place where and when needed is crucial if government support and business investments are to catalyze reindustrialization that strengthens U.S. leadership in strategic industries and manufacturing competitiveness in the global market, where carbon-intensity is under increased scrutiny. ■

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The authors would like to thank their CSIS colleagues—past and present—Cy McGeady, Hatley Post, and Claire Zhao for research assistance and feedback. Also, the authors are grateful to the individuals who shared their expertise and perspectives—through workshops and interviews—for research that underlines this report.

This report was made possible by the support of the American Gas Foundation.