Natural Gas and the U.S. Energy Transition

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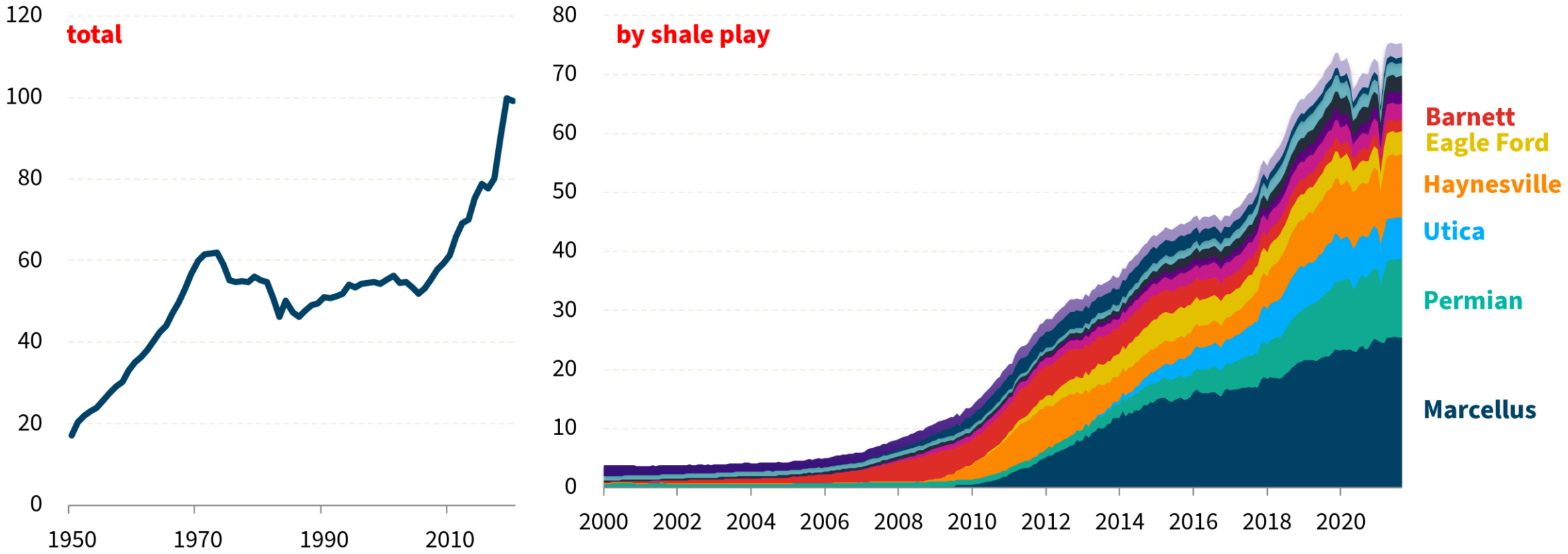
The United States has a lot of natural gas that is cheap to produce. To reach net zero emissions, the United States must eliminate gas use altogether or, at least, the emissions from gas. Either task will be very hard.

Background

U.S. gas production up 91 percent from 2005 to 2020

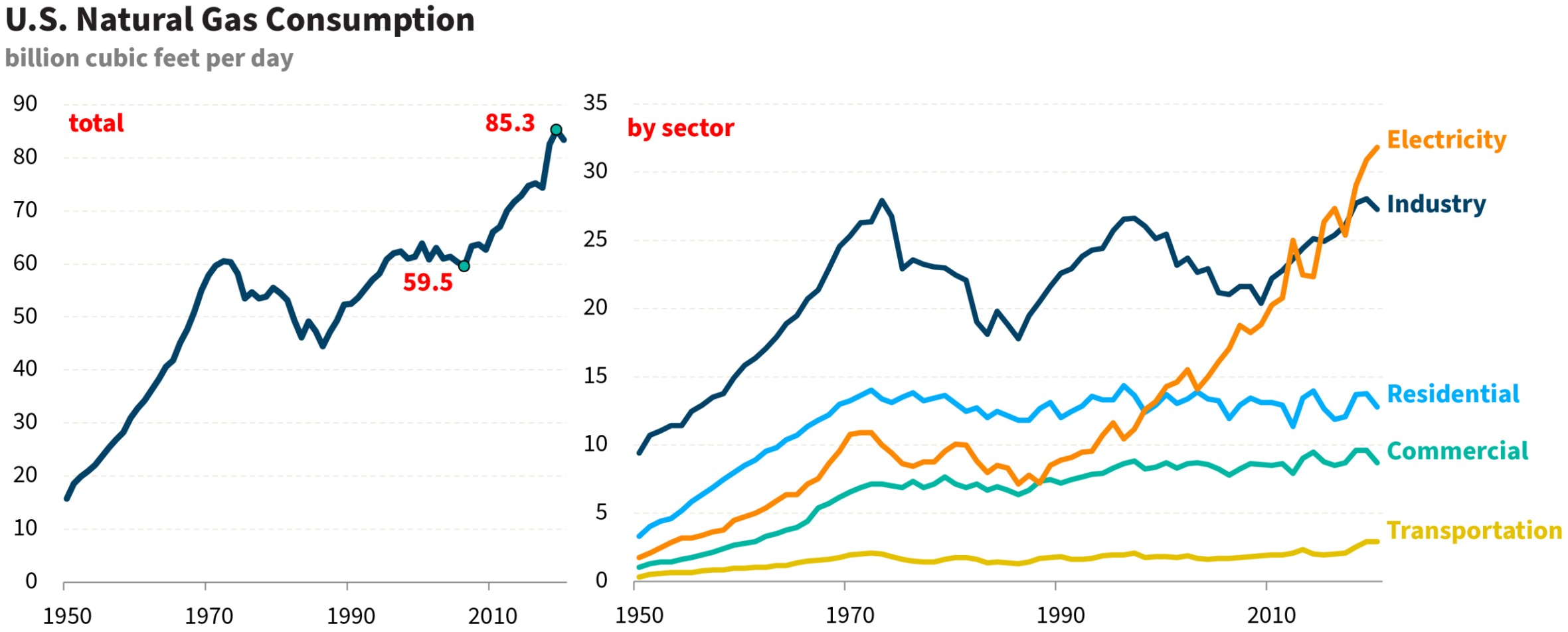
U.S. Natural Gas Production—Total and By Main Play

billion cubic feet per day



Source: U.S. Energy Information Administration, Natural Gas Gross Withdrawals and Production; Dry shale gas production estimates by play.

U.S. gas consumption up 44 percent—driven by power and industry

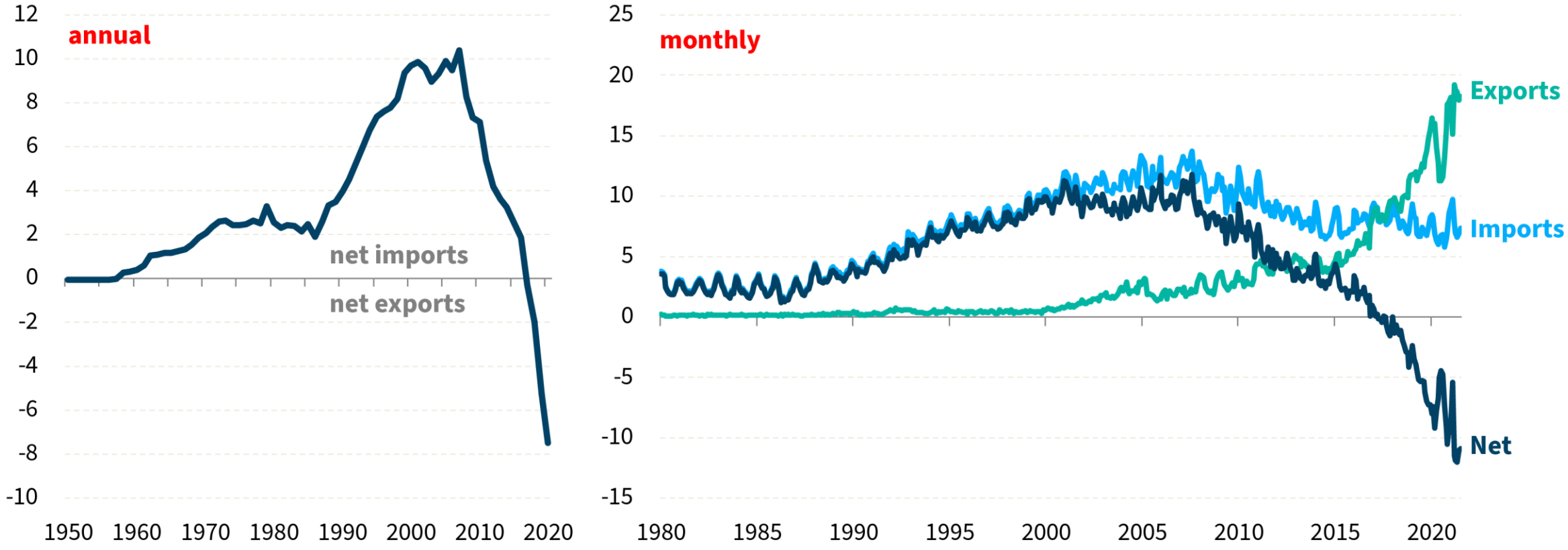


Source: U.S. Energy Information Administration, Table 4.3 Natural Gas Consumption by Sector, Monthly Energy Review, October 26, 2021.

The United States has become a net natural gas exporter

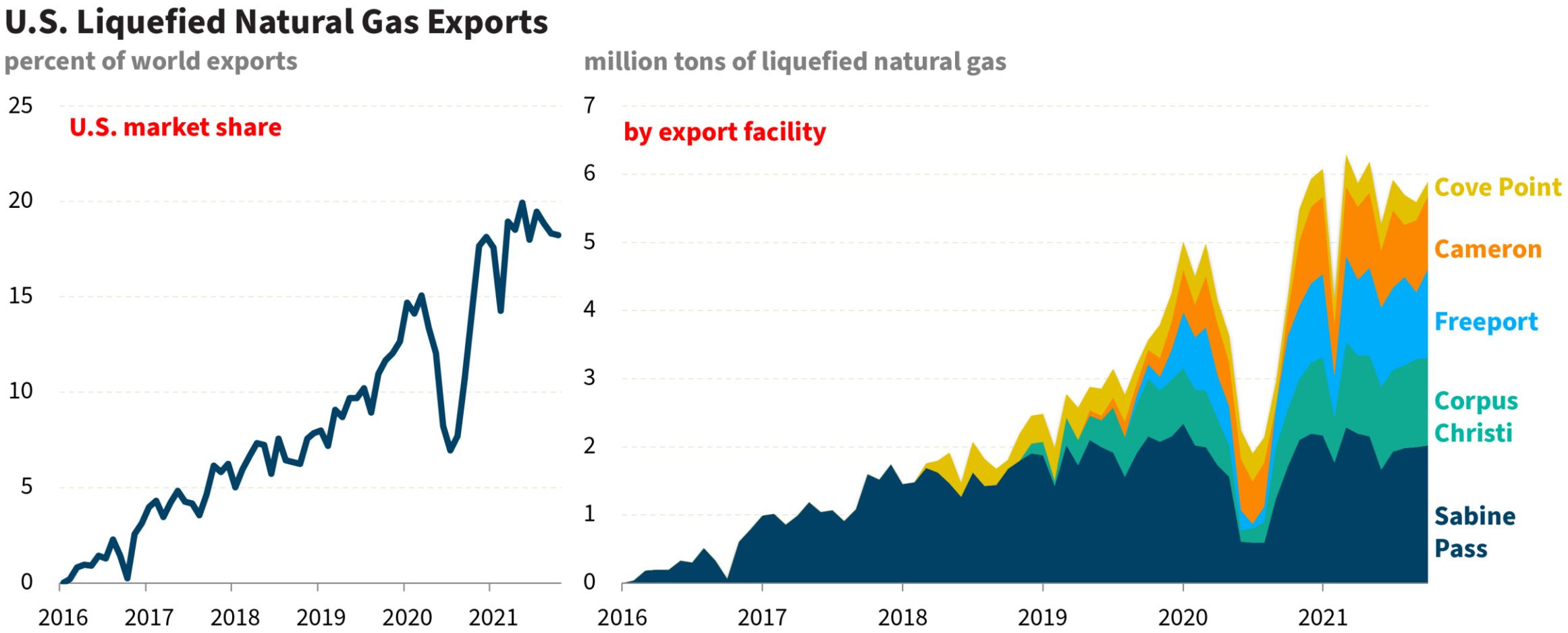
U.S. Natural Gas Imports and Exports

billion cubic feet per day



Source: U.S. Energy Information Administration, Table 4.1 Natural Gas Overview, October 26, 2021.

The United States is now a major LNG supplier—20 percent of global market

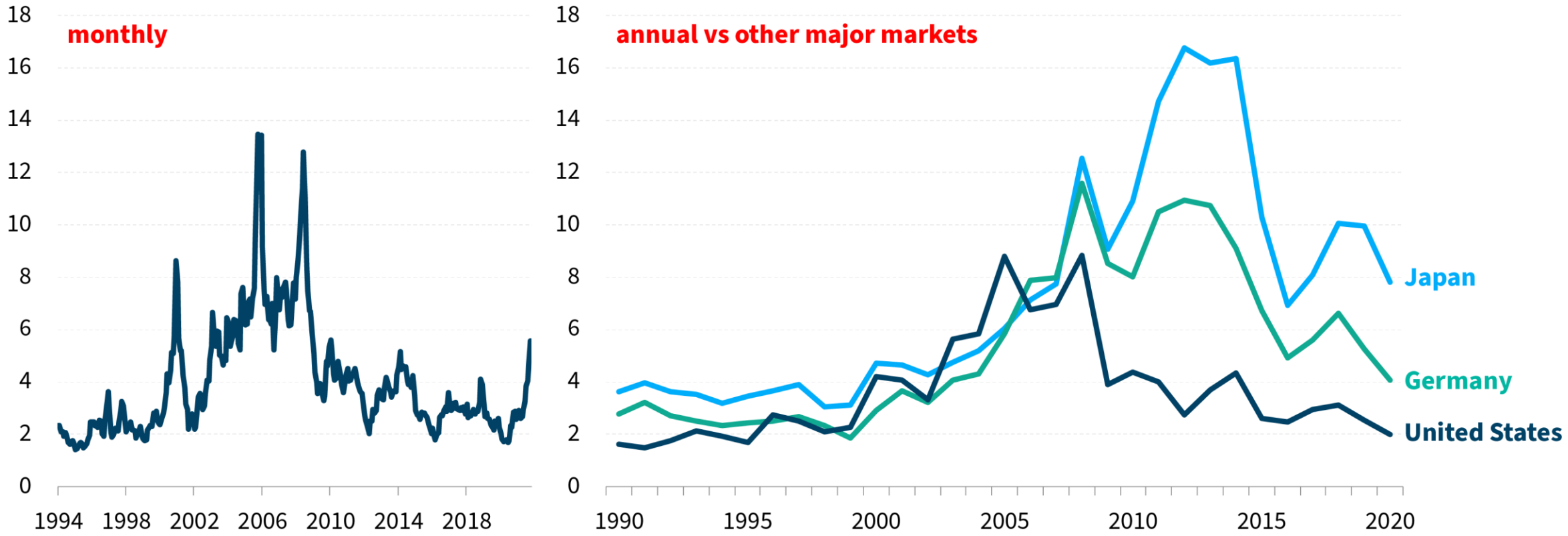


Source: Kpler LNG Service, data as of November 15, 2021.

Gas prices have fallen significantly—and diverged from global levels

U.S. Natural Gas Prices in Comparative Perspective

$ per million British thermal units

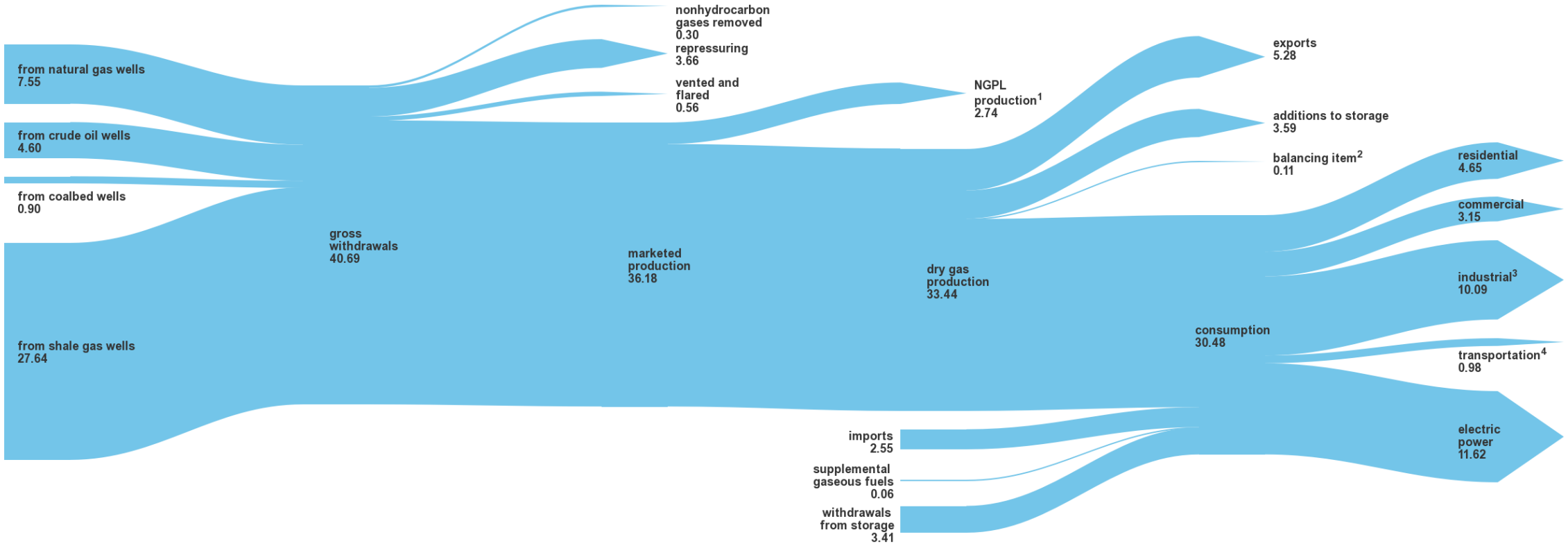


Source: U.S. Energy Information Administration, Natural Gas Spot and Futures Prices (NYMEX); BP Statistical Review of World Energy 2021.

The future of gas is not just the future of gas in power generation

U.S. natural gas flow, 2020

trillion cubic feet

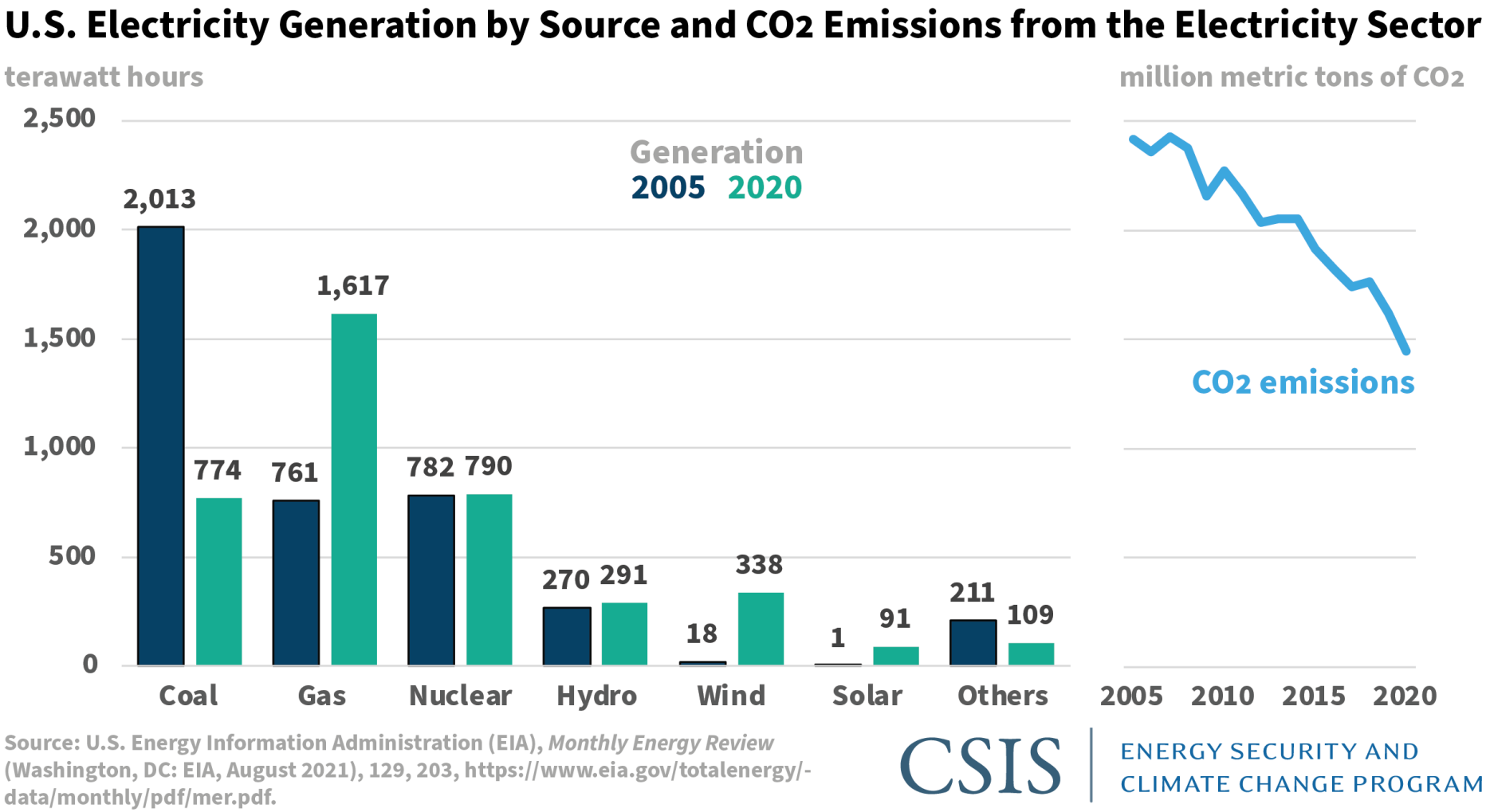


[1] Natural gas plant liquids production (NGPL), gaseous equivalent. | [2] Quantities lost and imbalances in data due to differences among data sources. Excludes transit shipments that cross the U.S.-Canada border (i.e., natural gas delivered to its destination via the other country). | [3] Lease and plant fuel, and other industrial. | [4] Natural gas consumed in the operation of pipelines (primarily in compressors) and as fuel in the delivery of natural gas to consumers, plus a small quantity used as vehicle fuel. | Notes: • Data are preliminary. • Values are derived from source data prior to rounding for publication. • Totals may not equal sum of components due to independent rounding.

eia Sources: U.S. Energy Information Administration (EIA), *Monthly Energy Review* (April 2021), Tables 4.1, 4.3, and 4.4; and EIA estimates based on previous year's data.

Electricity

Coal-to-gas switching main driver of lower CO_2 emissions from power



Source: U.S. Energy Information Administration (EIA), *Monthly Energy Review* (Washington, DC: EIA, August 2021), 129, 203, https://www.eia.gov/totalenergy/-data/monthly/pdf/mer.pdf.

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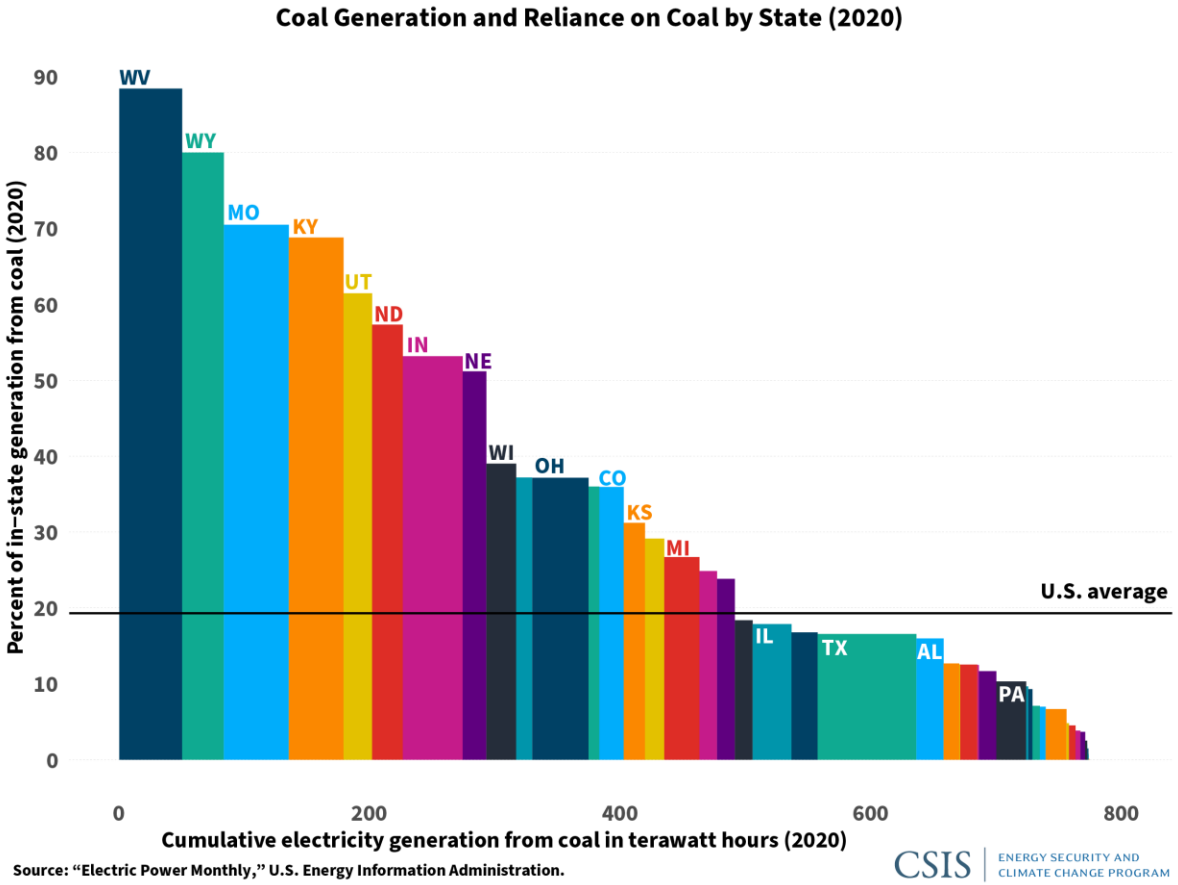
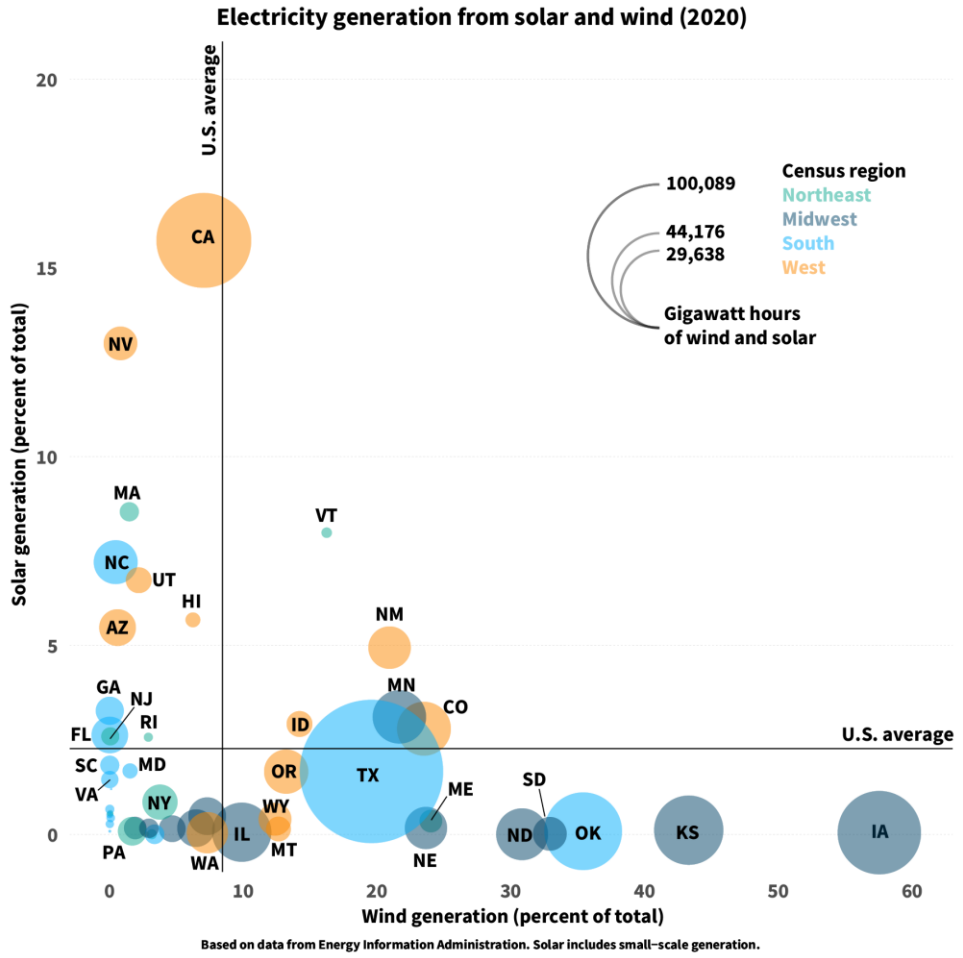
Large variation in state-level changes in electricity profile





Source: Solar and wind from ntsafos, Twitter, March 17, 2021; Tsafos, Phasing Out Coal from U.S. Electricity Increasingly a Regional Challenge, CSIS commentary, May 24, 2021

Gas-based generation must be cut roughly in half by 2030 for net zero goals

Electricity Net Generation

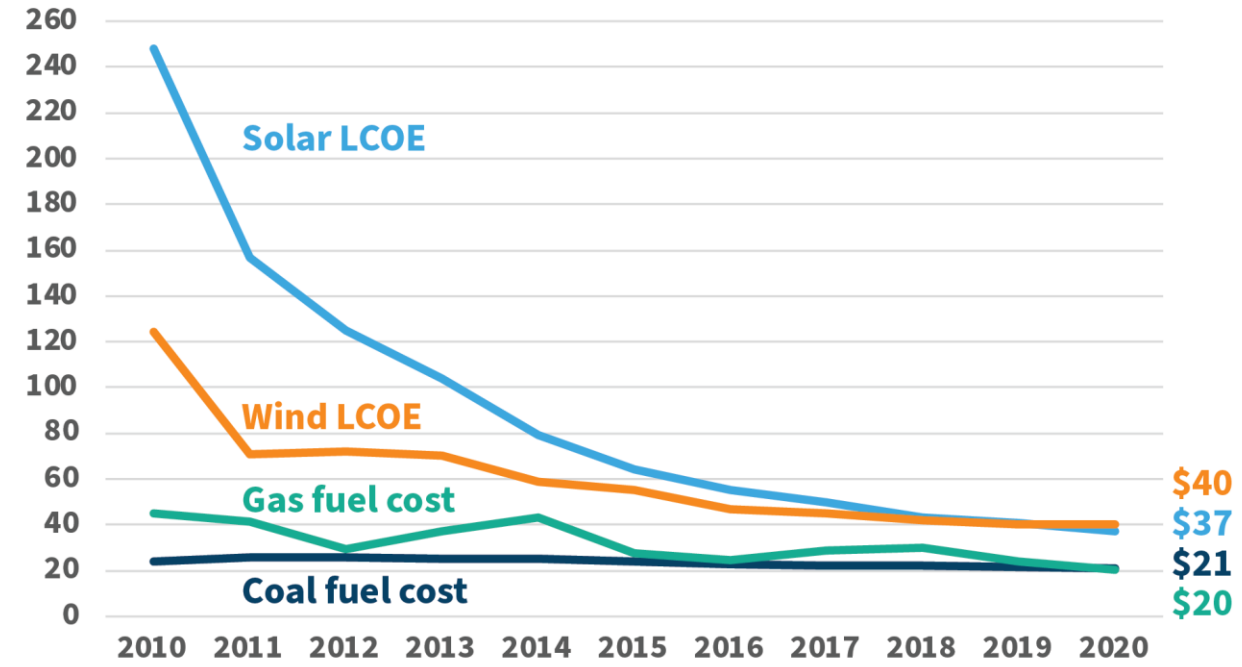
billion kilowatthours	1990	2005	2015	2016	2017	2018	2019	2020	Target for 2030 2030	%	v. '20
Coal	1,594	2,013	1,352	1,239	1,206	1,149	965	774	0	0%	-100%
Petroleum	126	122	28	24	21	25	18	17	0	0%	-100%
Natural Gas	373	761	1,333	1,378	1,296	1,469	1,586	1,617	895	20%	-45%
Other Gases	10	13	13	13	12	13	13	11	0	0%	-100%
Nuclear Electric Power	577	782	797	806	805	807	809	790	790	18%	0%
Hydroelectric Pumped Storage	-4	-7	-5	-7	-6	-6	-5	-5	-5	0%	0%
Conventional Hydroelectric Power	293	270	249	268	300	293	288	291	291	7%	0%
Wood	33	39	42	41	41	41	39	37	37	1%	0%
Waste	13	15	22	22	22	21	19	19	19	0%	0%
Geothermal	15	15	16	16	16	16	15	17	17	0%	0%
Solar	0	1	25	36	53	64	72	91	516	12%	468%
Wind	3	18	191	227	254	273	296	338	1,915	43%	468%
Total	**3,038**	**4,055**	**4,078**	**4,077**	**4,034**	**4,178**	**4,128**	**4,009**	**4,475**	**100%**	**12%**

Data from Energy Information Administratio, Table 7.2a Electricity Net Generation: Total (All Sectors), April 2021 Monthly Energy Review. The total electricity forecast for 2030 is based on the reference case in the EIA's Annual Energy Outlook 2021 (February 2021). Gas is assumed to provide 20 percent of the country's electricity, while other fossil fuels go to zero. The entirety of the balance is met by wind and solar, in the proportion they had in 2020 (wind being 3.7x the volume of solar).

Power sector decarbonization is now existing gas vs new renewables

Cost to Build Solar and Wind versus Fuel Costs for Coal and Gas

dollar per megawatt hour ($/MWh)



Note: LCOE is levelized cost of electricity. Source: Data for wind and solar from Lazard, *Lazard's Levelized Cost of Energy Analysis: Version 14.0* (Lazard, October 2020), https://www.lazard.com/media/451419/lazards-levelized-cost-of-energy-version-140.pdf; fuel costs for coal and gas estimated based on data from the Energy Information Administration (cost of fuel times fuel consumed against total net generation from coal or gas).

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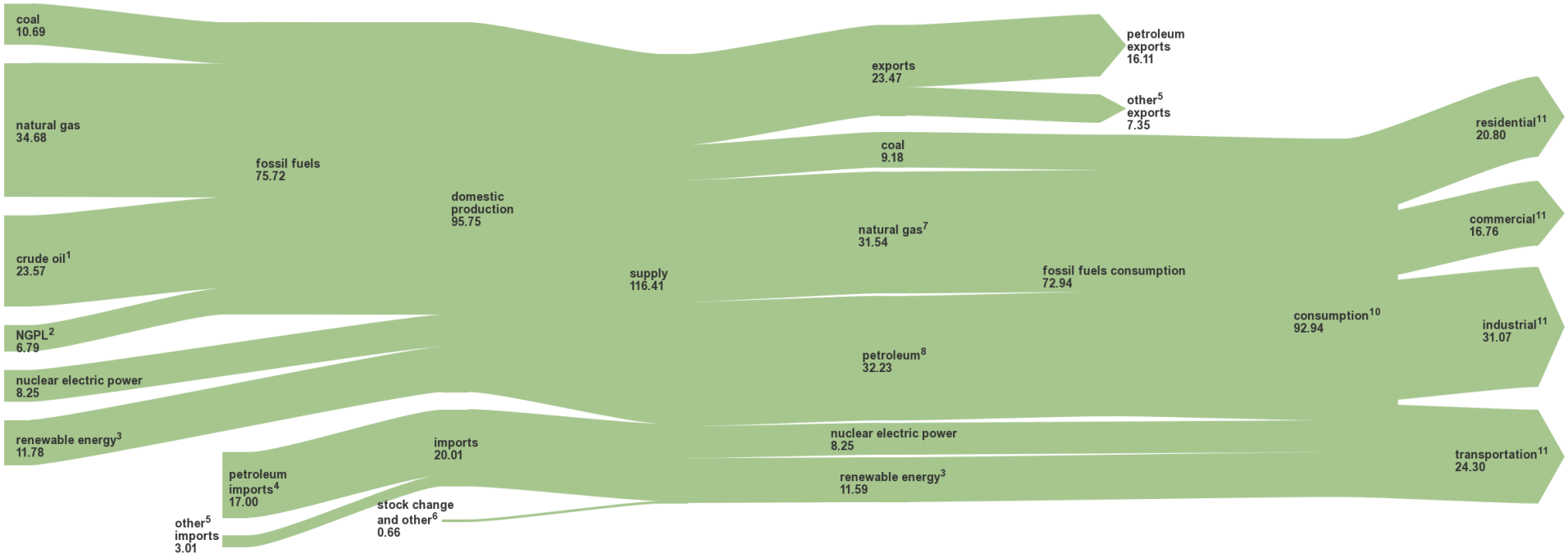
Industry

As end-user, industry is the largest consuming sector

U.S. energy flow, 2020

quadrillion Btu



[1] Includes lease condensate. | [2] Natural gas plant liquids. | [3] Conventional hydroelectric power, biomass, geothermal, solar, and wind. | [4] Crude oil and petroleum products. Includes imports into the Strategic Petroleum Reserve. | [5] Natural gas, coal, coal coke, biomass, and electricity. | [6] Adjustments, losses, and unaccounted for. | [7] Natural gas only; excludes supplemental gaseous fuels. | [8] Petroleum products supplied. | [9] Includes -0.01 quadrillion Btu of coal coke net imports. | [10] Includes 0.16 quadrillion Btu of electricity net imports. | [11] Total energy consumption, which is the sum of primary energy consumption, electricity retail sales, and electrical system energy losses. Losses are allocated to the end-use sectors in proportion to each sector's share of total electricity retail sales. See Note 1, "Electrical System Energy Losses," at the end of U.S. Energy Information Administration (EIA), *Monthly Energy Review* (April 2021), Section 2. See Note 2, "Other Energy Losses," at the end of U.S. Energy Information Administration (EIA), *Monthly Energy Review* (April 2021), Section 2. | Notes: • Data are preliminary. • Values are derived from source data prior to rounding for publication. • Totals may not equal sum of components due to independent rounding.

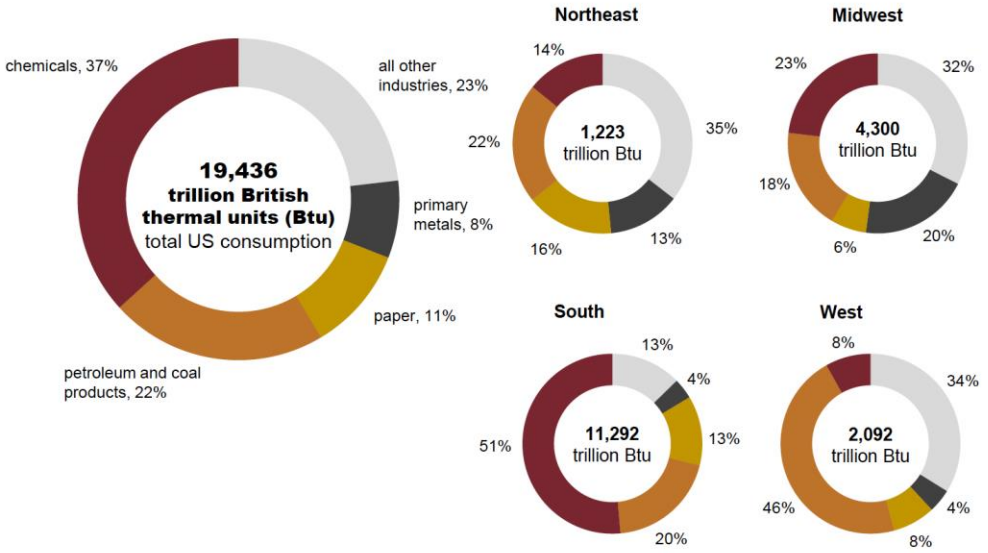
eia Sources: EIA, *Monthly Energy Review* (April 2021), Tables 1.1, 1.2, 1.3, 1.4a, 1.4b, 1.4c, and 2.1.

Industrial energy use concentrated regionally and sectorally

MECS

Four industries account for most manufacturing energy consumption

Proportion of total energy consumption by industry and region
percentage

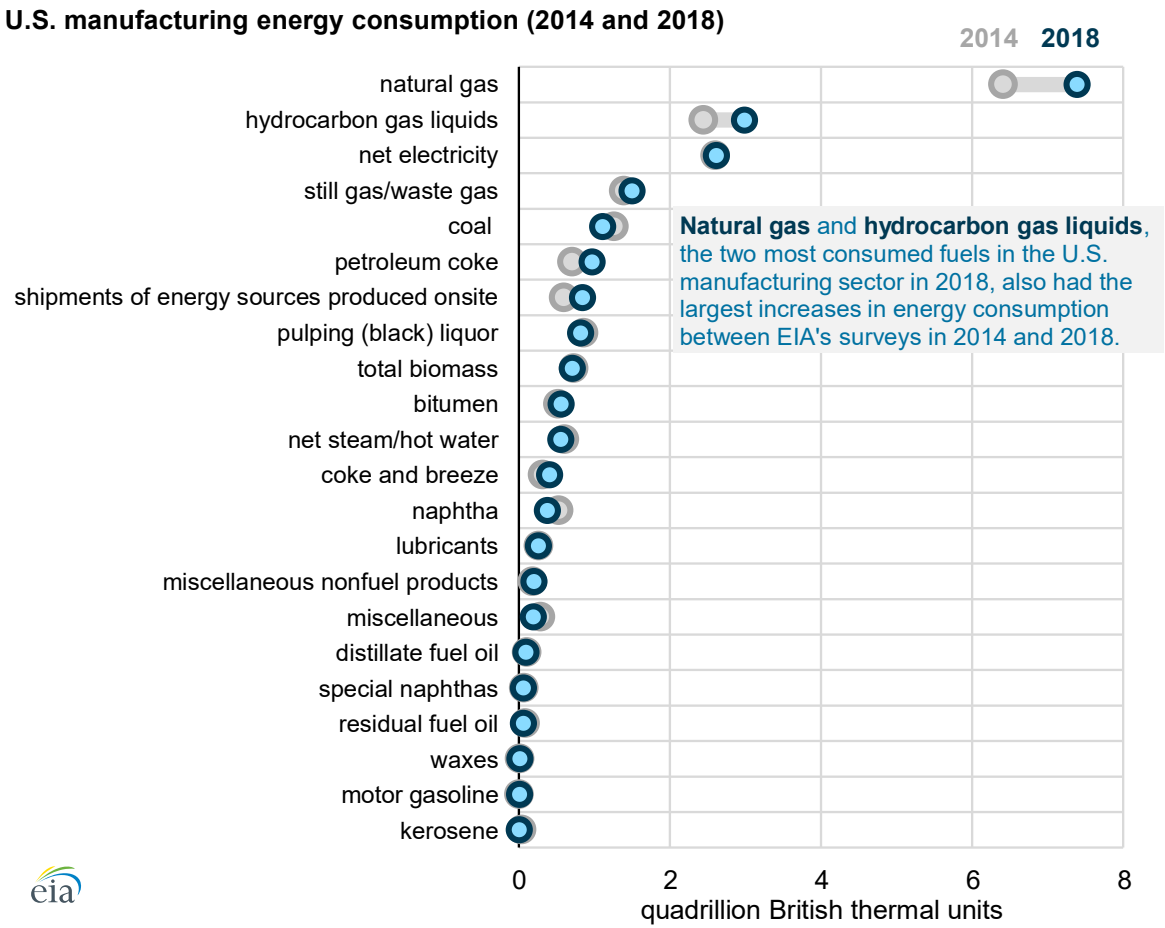


- The chemical, petroleum and coal products, paper, and primary metals industries accounted for 77% of manufacturing energy consumption in 2018.
- Manufacturing consumption was greatest in the South, and chemical manufacturing accounted for more than half (51%) of the South's energy consumption.

U.S. Energy Information Administration #MECS2018 | www.eia.gov/consumption/manufacturing 10

Source: U.S. Energy Information Administration, Manufacturing 2018 Manufacturing Energy Consumption Survey Flipbook, March 2021.

Natural gas is, by far, the most used fuel in U.S. manufacturing



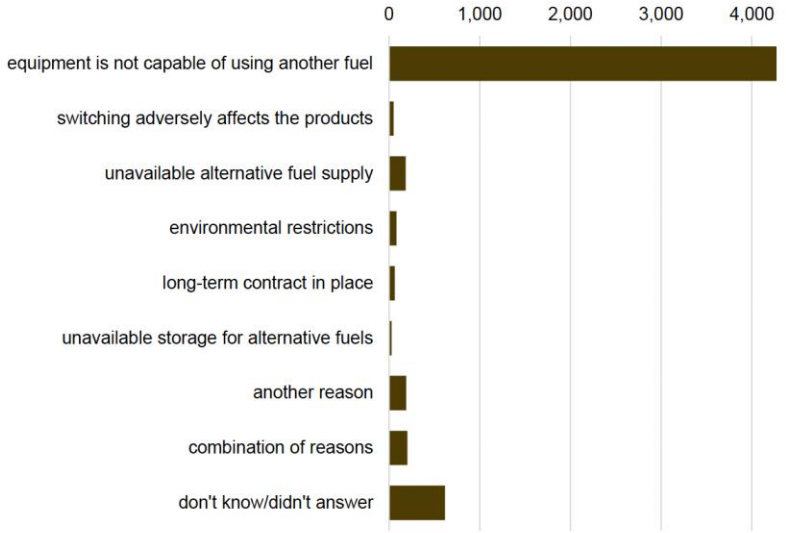
Source: U.S. Energy Information Administration, EIA survey of energy use by U.S. manufacturers shows increased use of natural gas, HGLs, September 17, 2020.

Switch away from gas is limited by current equipment constraints

MECS

Due to equipment limitations, most natural gas fuel cannot be switched with other fuels

Natural gas fuel switching limitations by reason
billion cubic feet

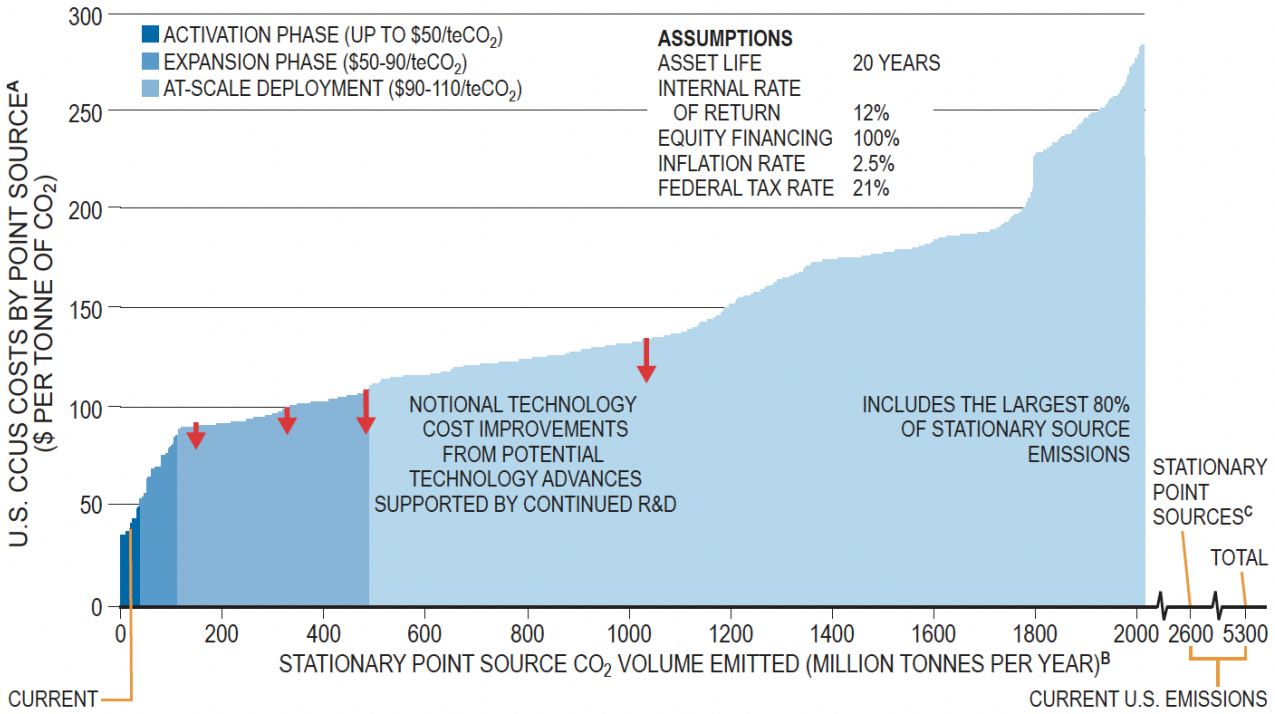


- The most common reason manufacturers could not switch from natural gas was that their equipment was not capable of using another fuel.
- A combination of reasons (204 billion cubic feet) and an unavailable alternative fuel supply (185 billion cubic feet) were also common responses.
- About 10% of the non-switchable amount was unknown.

U.S. Energy Information Administration #MECS2018 | www.eia.gov/consumption/manufacturing 15

Source: U.S. Energy Information Administration, Manufacturing 2018 Manufacturing Energy Consumption Survey Flipbook, March 2021.

Industrial decarbonization likely depends on CCUS (more support needed)



Cost Curve Notes:

A. Includes project capture costs, transportation costs to defined use or storage location, and use/storage costs; does not include direct air capture.

B. This curve is built from bars each of which represents an individual point source with a width corresponding to the total CO_2 emitted from that individual source.

C. Total point sources include ~600 Mtpa of point sources emissions without characterized CCUS costs.

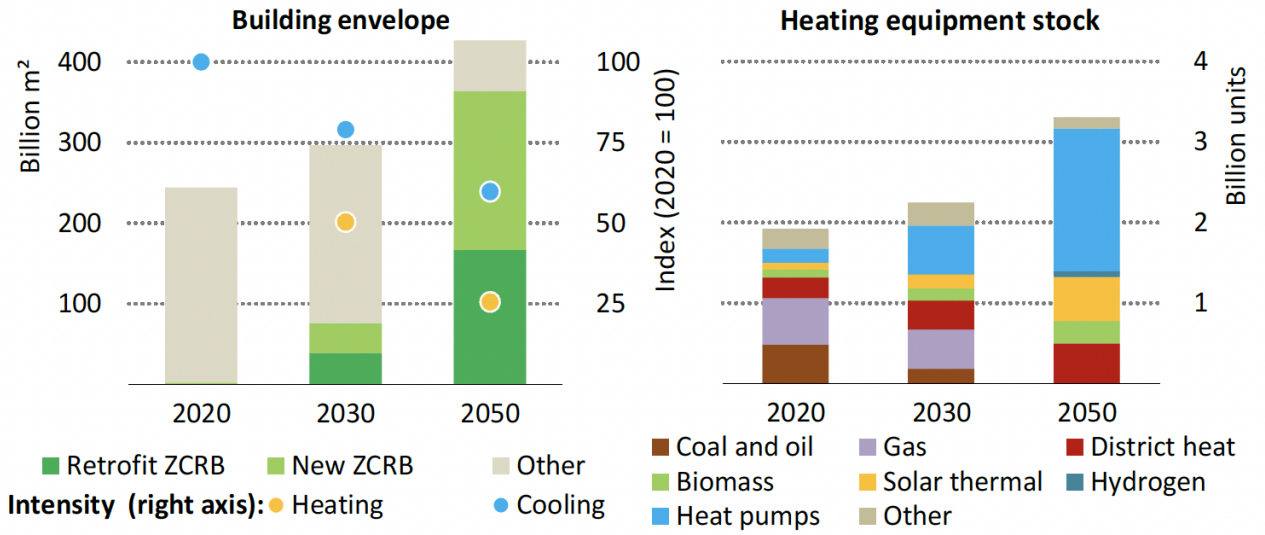
Figure 2-1. *U.S. CCUS Cost Curve with CO_2 Capture Volume by Phase*

Source: National Petroleum Council Report, Meeting the Dual Challenge, A Roadmap to At-Scale Deployment of Carbon Capture, Use, and Storage, 2019.

Buildings

The (global) buildings transition rests on efficiency and electrification

Figure 3.29 ▷ **Global building and heating equipment stock by type and useful space heating and cooling demand intensity changes in the NZE**

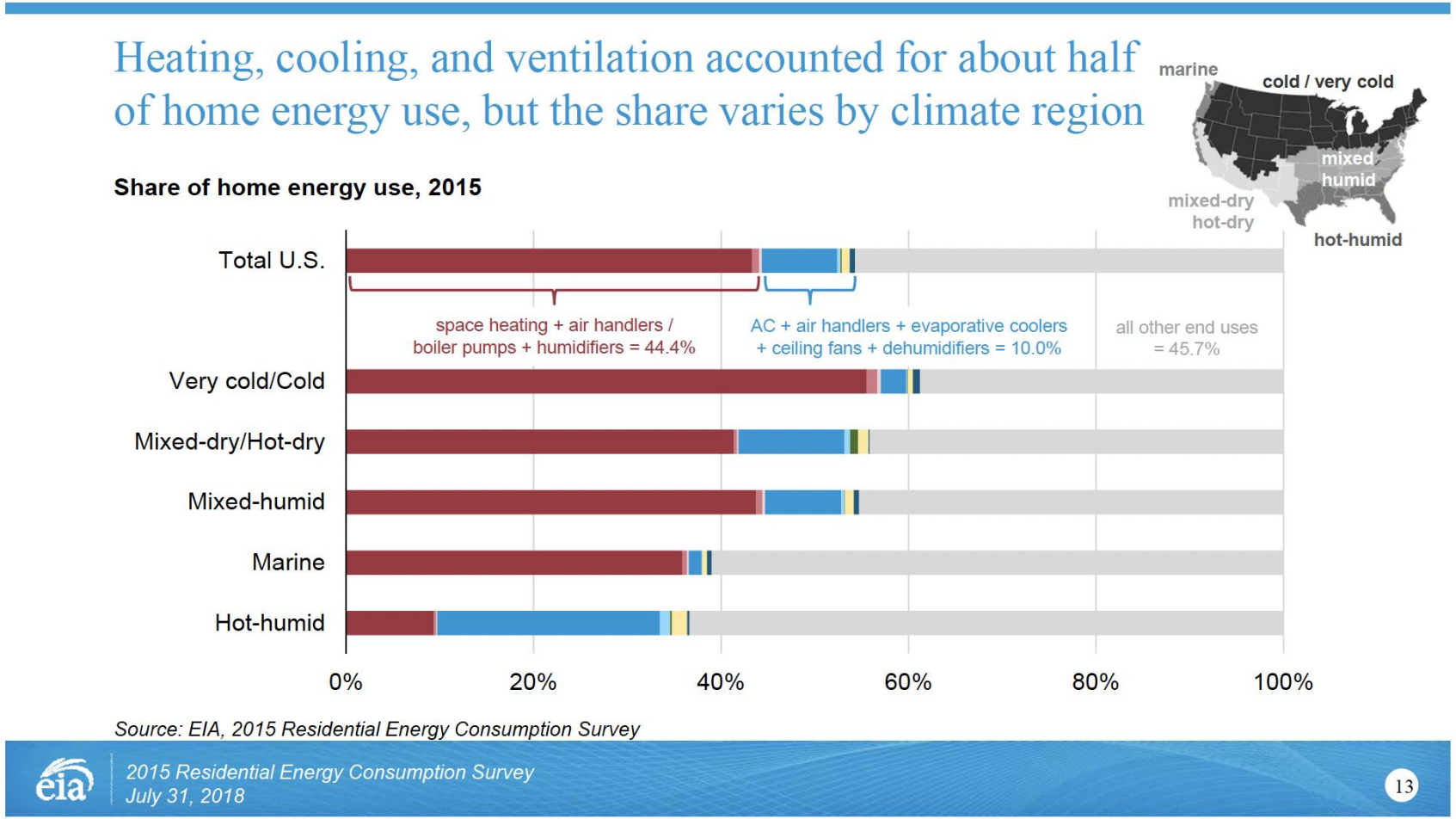


By 2050, over 85% of buildings are zero-carbon-ready, reducing average useful heating intensity by 75%, with heat pumps meeting over half of heating needs

Notes: ZCRB refers to buildings meeting zero-carbon-ready building energy codes. Other for building envelope refers to envelopes that do not meet zero-carbon-ready building energy codes. Other for heating equipment stock includes resistive heaters, and hybrid and gas heat pumps.

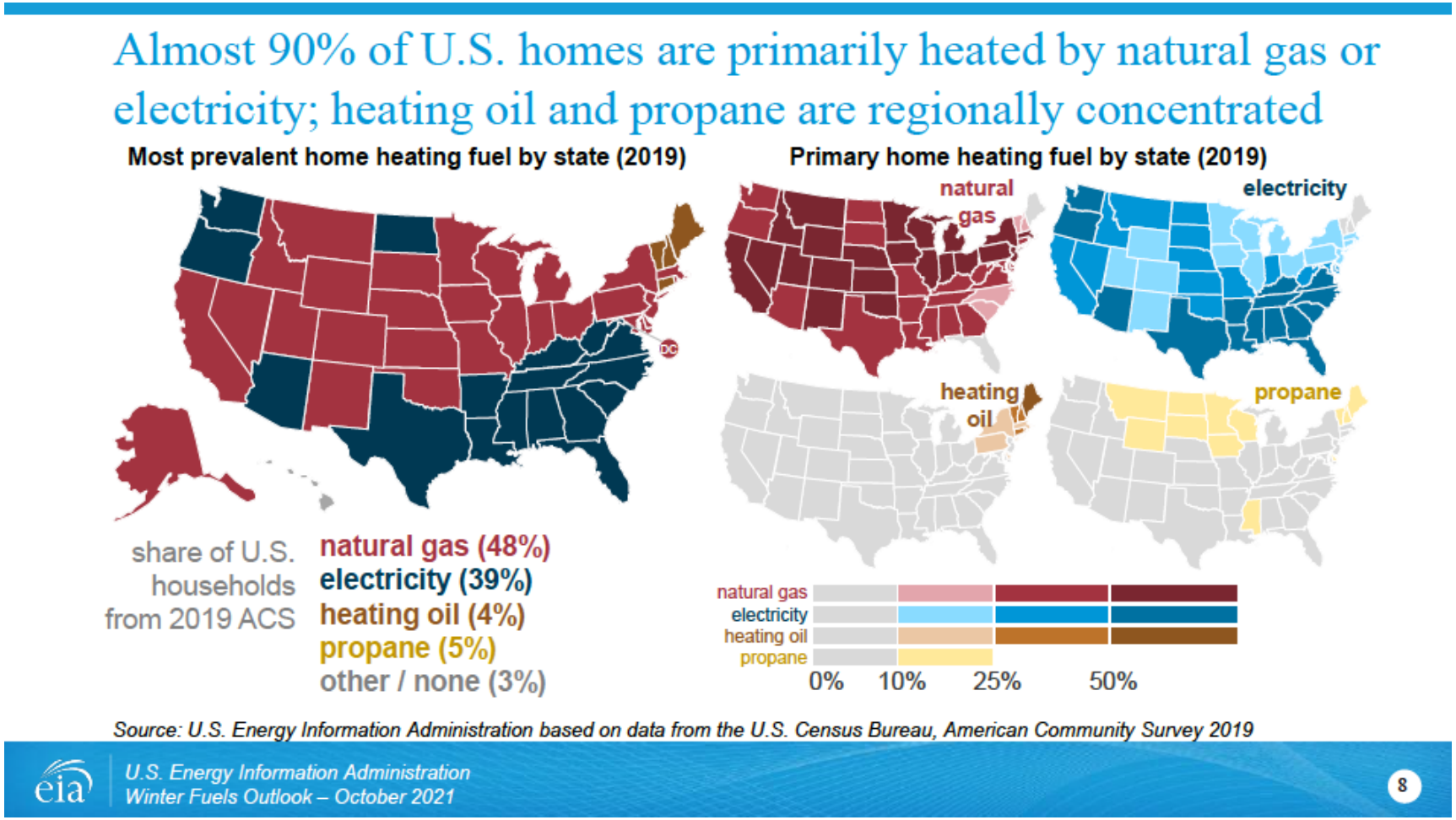
Source: International Energy Agency, Net Zero by 2050 Report, May 2021.

Most energy use at home is for heating, cooling and ventilation



Source: U.S. Energy Information Administration, "Webinar: Highlights from the 2015 RECS: energy consumption, expenditures and end-use modeling," July, 31, 2018.

Natural gas is the prevalent heating fuel for almost half of U.S. households



Source: U.S. Energy Information Administration, Winter Fuels Outlook, October 2021.

At this moment, gas is far cheaper than electricity for space heating

Because of higher prices in the forecast, even in a warmer than forecast scenario, expenditures are up from last winter

	U.S. average household expenditures Base Case (Oct–Mar total)		U.S. average household expenditures 10% Colder (Oct–Mar total)		U.S. average household expenditures 10% Warmer (Oct–Mar total)	
	winter 2021–22	Change from last winter	winter 2021–22	Change from last winter	winter 2021–22	Change from last winter
Natural Gas	$746	+30%	$859	+50%	$700	+22%
Heating Oil	$1734	+43%	$1925	+59%	$1573	+30%
Electricity	$1268	+6%	$1370	+15%	$1237	+4%
Propane	$1789	+54%	$2246	+94%	$1497	+29%

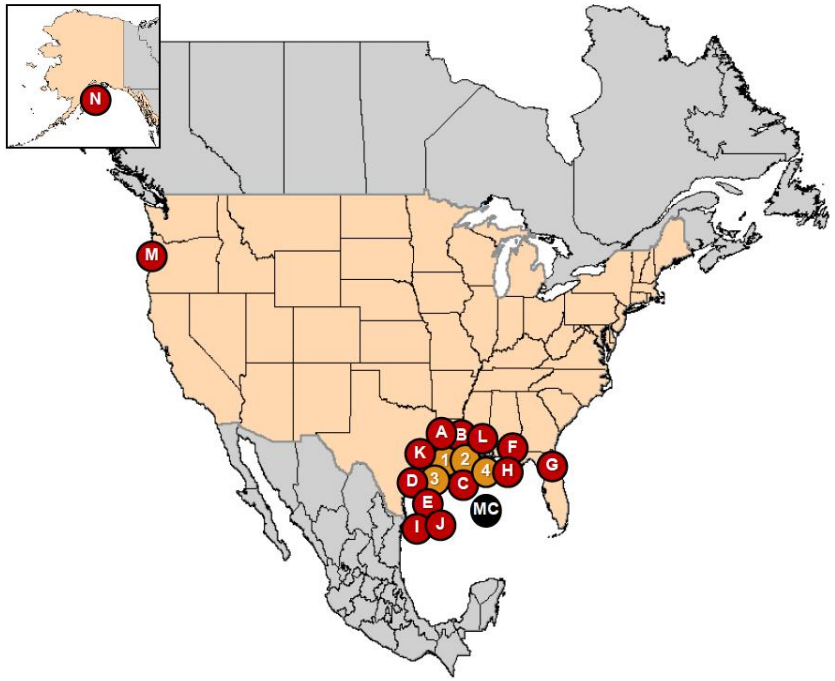
Source: U.S. Energy Information Administration

Source: U.S. Energy Information Administration, Winter Fuels Outlook, October 2021.

Exports

A lot of export projects still in the works

North American LNG Export Terminals
Approved, Not Yet Built



U.S. Jurisdiction & Status

- FERC - Approved, Under Construction
- FERC - Approved, Not Under Construction
- MARAD / U.S. Coast Guard

Export Terminals

UNITED STATES

FERC – APPROVED, UNDER CONSTRUCTION

1. **Sabine Pass, LA:** 0.7 Bcfd (Sabine Pass Liquefaction Train 6) (CP13-552)
2. **Cameron Parish, LA:** 1.41 Bcfd (Venture Global Calcasieu Pass) (CP15-550)
3. **Sabine Pass, TX:** 2.26 Bcfd (ExxonMobil – Golden Pass) (CP14-517, CP20-459)
4. **Calcasieu Parish, LA:** 4.0 Bcfd (Driftwood LNG) (CP17-117)

FERC – APPROVED, NOT UNDER CONSTRUCTION

- **A. Lake Charles, LA:** 2.2 Bcfd (Lake Charles LNG) (CP14-120)
- **B. Lake Charles, LA:** 1. 186 Bcfd (Magnolia LNG) (CP14-347)
- **C. Hackberry, LA:** 1.41 Bcfd (Sempra - Cameron LNG Trains 4 & 5) (CP15-560)
- **D. Port Arthur, TX:** 1.86 Bcfd (Port Arthur LNG Trains 1 & 2) (CP17-20)
- **E. Freeport, TX:** 0.72 Bcfd (Freeport LNG Dev Train 4) (CP17-470)
- **F. Pascagoula, MS:** 1.5 Bcfd (Gulf LNG Liquefaction) (CP15-521)
- **G. Jacksonville, FL:** 0.132 Bcf/d (Eagle LNG Partners) (CP17-41)
- **H. Plaquemines Parish, LA:** 3.40 Bcfd (Venture Global LNG) (CP17-66)
- **I. Brownsville, TX:** 0.55 Bcfd (Texas LNG Brownsville) (CP16-116)
- **J. Brownsville, TX:** 3.6 Bcfd (Rio Grande LNG – NextDecade) (CP16-454)
- **K. Corpus Christi, TX:** 1.86 Bcfd (Cheniere Corpus Christi LNG) (CP18-512)
- **L. Sabine Pass, LA:** NA Bcfd (Sabine Pass Liquefaction) (CP19-11)
- **M. Coos Bay, OR:** 1.08 Bcfd (Jordan Cove) (CP17-494)
- **N. Nikiski, AK:** 2.63 Bcfd (Alaska Gasline) (CP17-178)

MARAD/USCG – APPROVED, NOT UNDER CONSTRUCTION

- **MC. Gulf of Mexico:** 1.8 Bcfd (Delfin LNG)

CANADA - LNG IMPORT AND PROPOSED EXPORT FACILITIES

https://www.nrcan.gc.ca/energy/natural-gas/5683

As of April 16, 2021

Conclusions

Conclusions

Phasing out gas in the United States will be hard.

In power, gas faces competition—but gas is also cheap and will be hard to dislodge.

The industrial sector uses a lot of gas—net zero pathway lies with CCUS and/or hydrogen.

Gas use in buildings requires big appliance turnover—current economic case is mixed.

How to reconcile domestic net zero target with U.S. exports will be a big challenge.