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Competition First? Anchoring U.S. Climate & Energy Strategy Amidst Geostrategic Competition With China

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Note: These are working research findings and are subject to change. In the event of material developments, the author will post an updated version.

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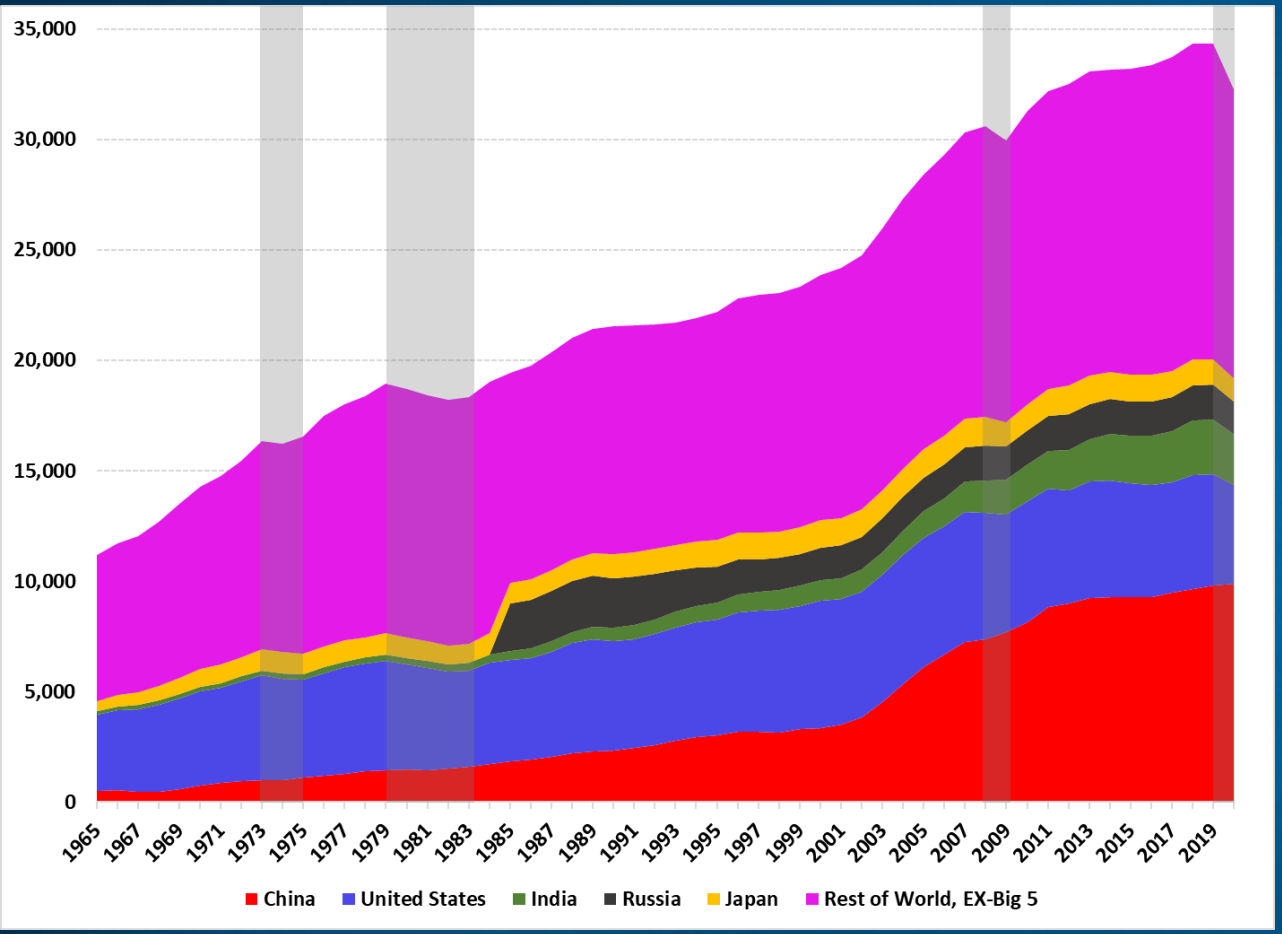
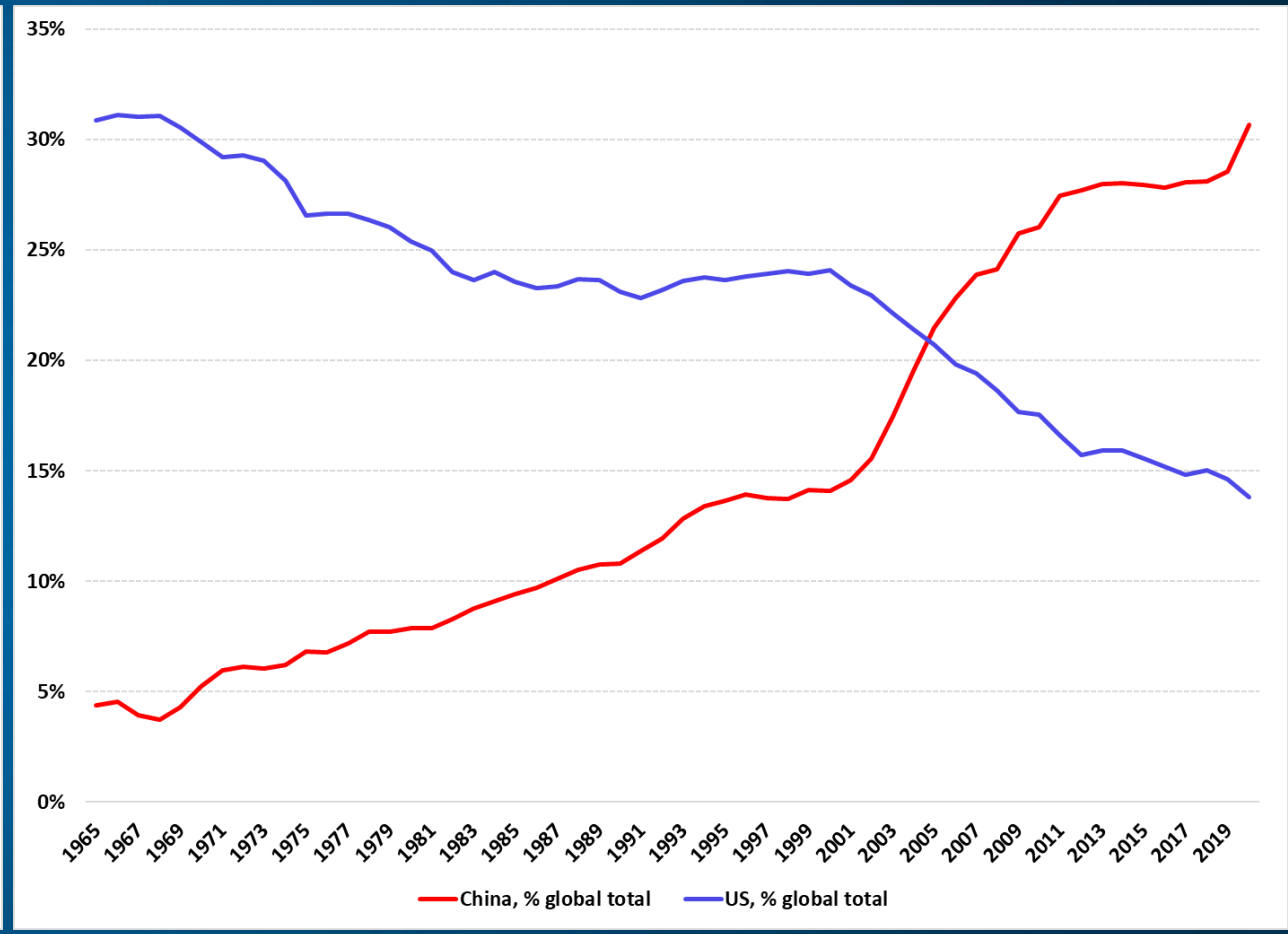
China Drives Global Emissions Growth

Global CO2 Emissions Breakout, Million Tonnes/Year



Trading Places: U.S. and China Share of Global CO2 Emissions



Source: BP Statistical Review of World Energy, Author's Analysis

China and the U.S. now the biggest emitters, combined accounting for almost 45% of global CO2 emissions in 2020

Climate and Energy Actions Exist in a Broad Global Context

Sitting and waiting on the evolution of an increasingly tense relationship not an option, lest we flirt with potential points of no return.

Competition With China Can Save the Planet

Pressure, Not Partnership, Will Spur Progress on Climate Change

Andrew S. Erickson and Gabriel Collins

Late last year, Chinese President Xi Jinping pledged that his country would reach "carbon neutrality" by 2060, meaning that by that time, it would remove every year from the atmosphere as much carbon dioxide as it emitted. China is currently the world's largest greenhouse gas emitter, responsible for nearly 30 percent of global carbon dioxide emissions. Targeting net-zero emissions by 2060 is an ambitious goal, meant to signal Beijing's commitment both to turning its enormous economy away from fossil fuels and to backing broader international efforts to combat climate change.

But this rhetorical posturing masks a very different reality: China remains addicted to coal, the dirtiest fossil fuel. It burns over four billion metric tons per year and accounts for half of the world's total consumption. Roughly 65 percent of China's electricity supply comes from coal, a proportion far greater than that of the United States (24 percent) or Europe (18 percent). Finnish and U.S. researchers revealed in February that China dramatically expanded its use of coal-fired power plants in 2020. China's net coal-fired power generation capacity grew by about 30 gigawatts over the course of the year, as opposed to a net decline of 17 gigawatts elsewhere in the world. China also has nearly 200 gigawatts' worth of coal power projects under con-

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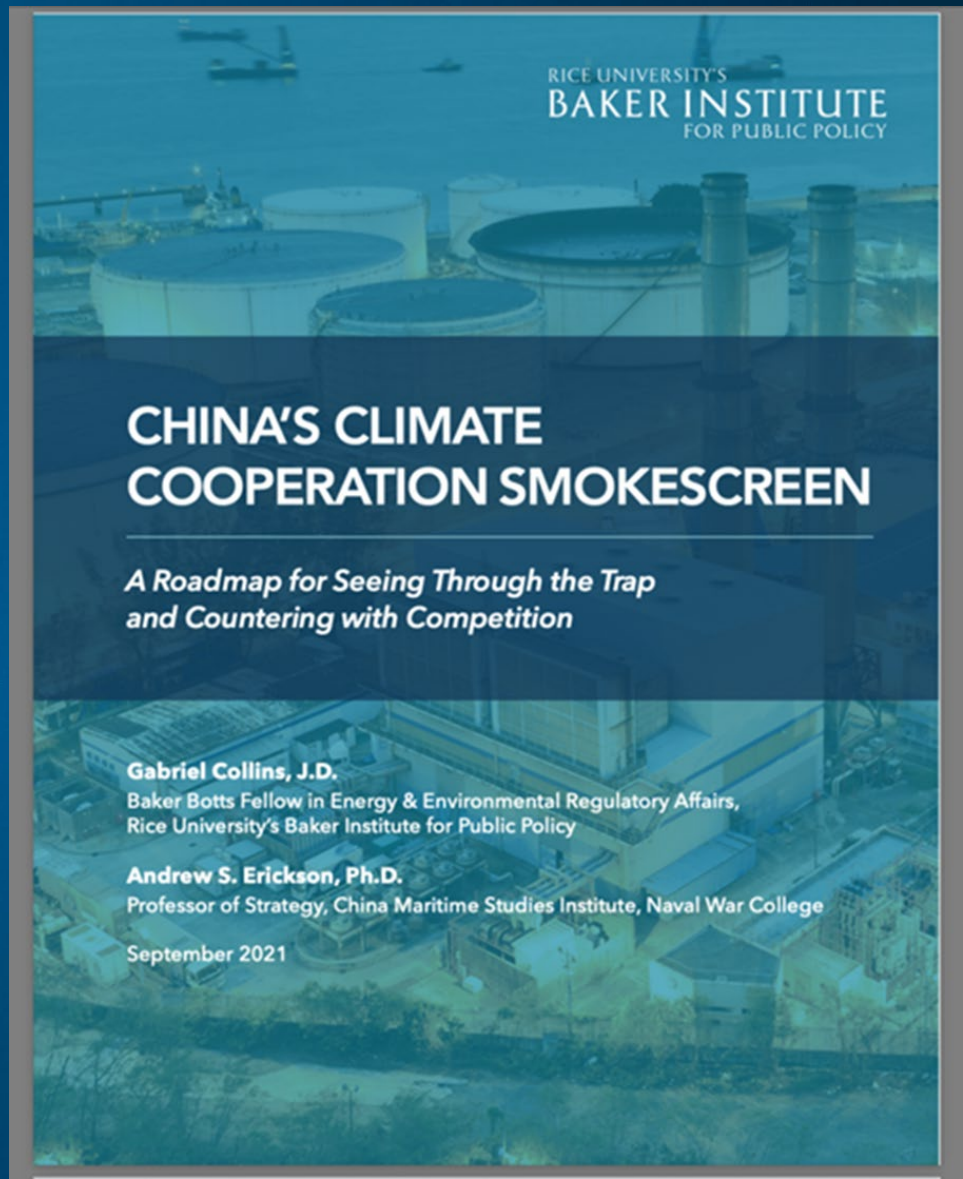
Multi-decade, multi-dimensional competition is already well underway



PRC Senior Leaders Are Securitizing Climate Issues

Blunt Form Translations

"Climate diplomacy is inextricably linked with broader PRC diplomacy and protection of revisionist gains"

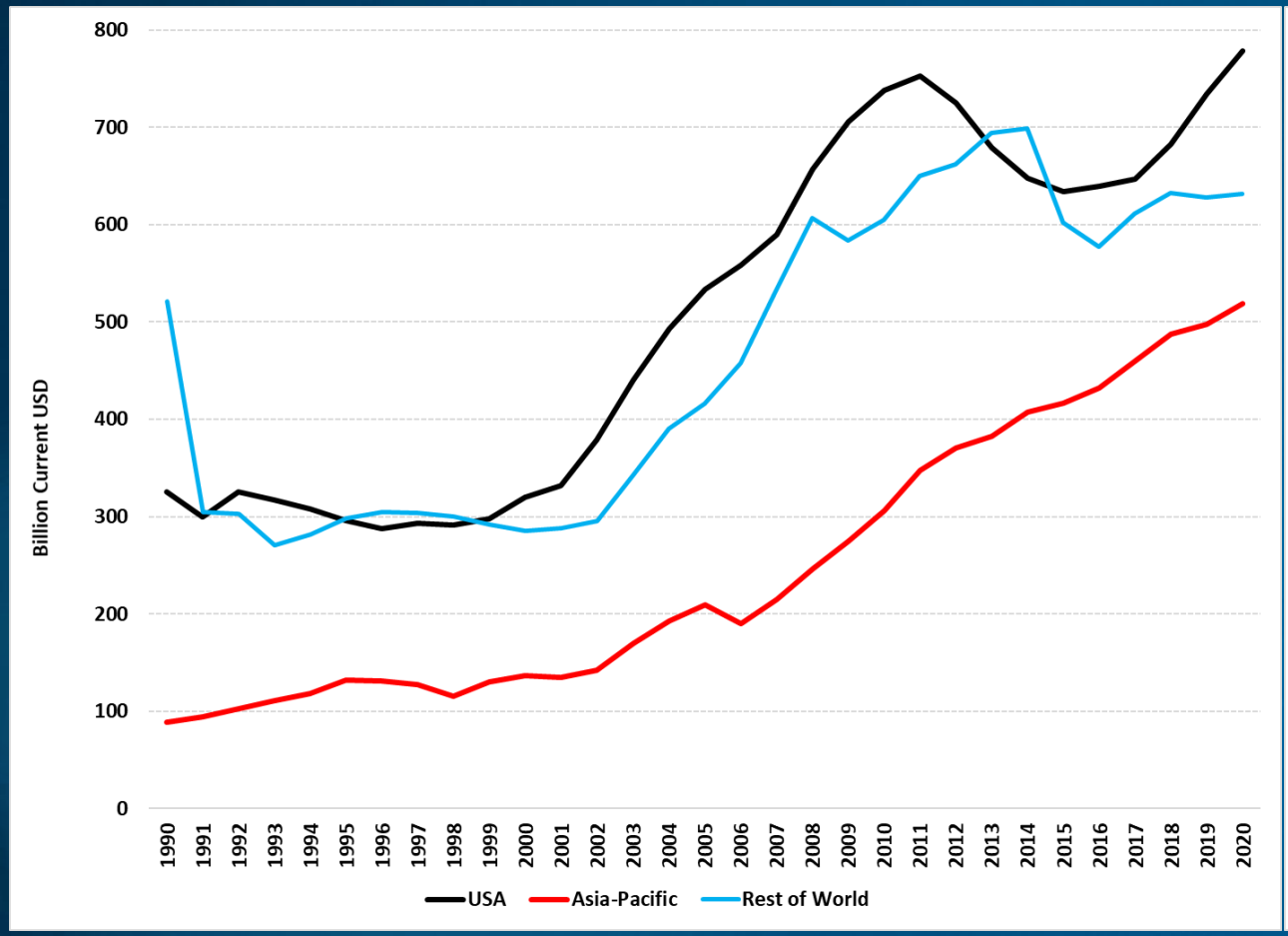
"We're concretely naming some of our 'core interests.' We have some others too, like the South and East China Seas."

"Climate discussions might begin *IF* Washington makes a big down payment by accepting our revisionist actions."

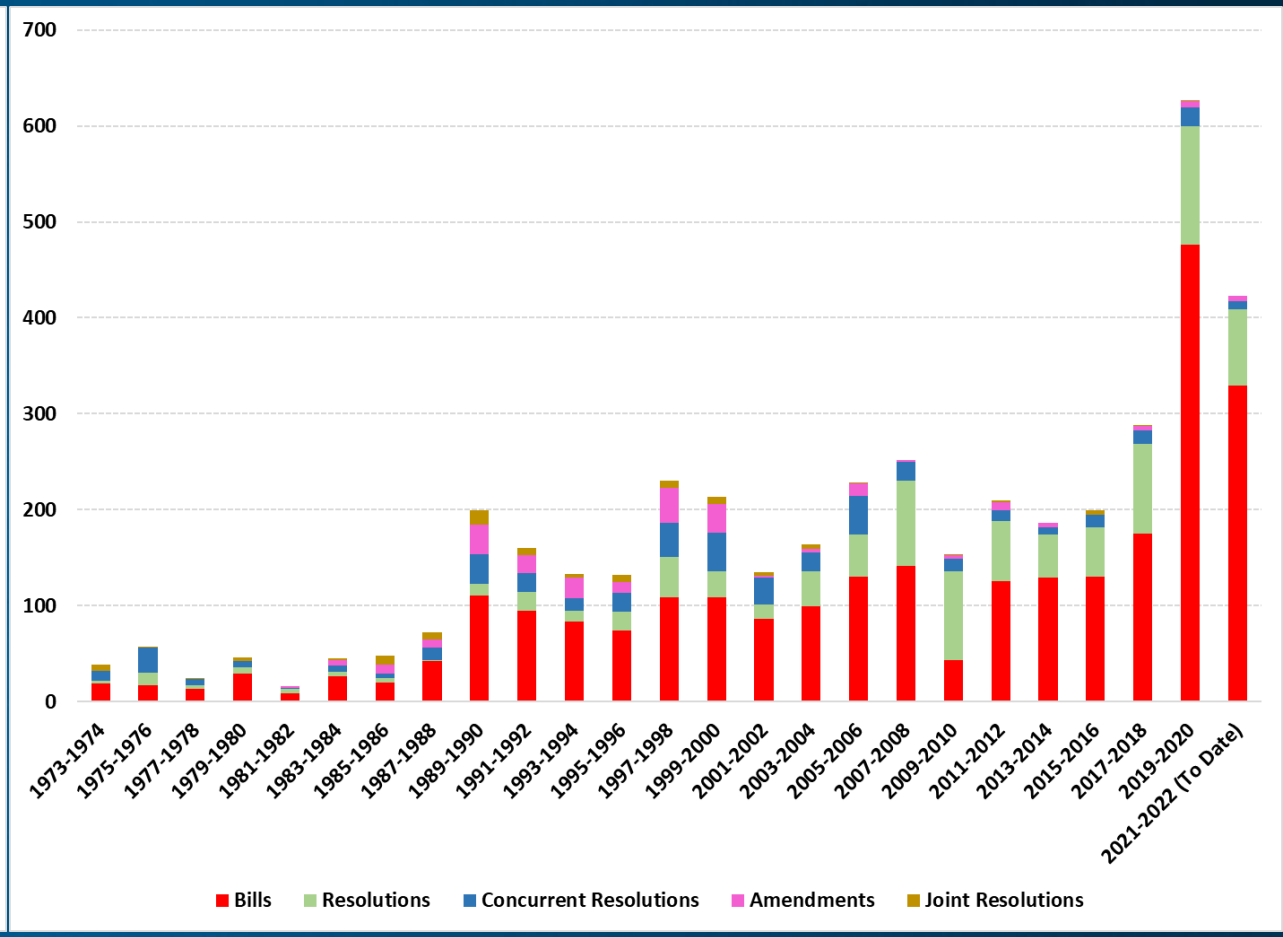
- "…**I'd like to stress that China-U.S. cooperation in specific areas, unlike flowers that can bloom in a greenhouse despite winter chill, is closely linked with bilateral relations as a whole**. China has emphasized time and again that no one should imagine they could ask China to understand and support them in bilateral and global affairs when they blatantly interfere in China's domestic affairs and undermine China's interests."—PRC Foreign Ministry Spokesman Zhao Lijian, 28 January 2021
- "**The United States should not repeatedly challenge China's rights and interests on issues related to Taiwan, Xinjiang and Hong Kong, and at the same time expect China to cooperate with it on issues of its own concern**."—PRC Foreign Minister Wang Yi, 23 April 2021
- "**China-U.S. cooperation on climate change cannot be divorced from the overall situation of China-U.S. relations. The United States should work with China to meet each other halfway and take positive actions to bring China-U.S. relations back on track**."—PRC Foreign Minister Wang Yi, 1 September 2021

U.S. Responding to PRC Revanchism, Cooperation Will Be Increasingly Difficult

Defense Spending From 1990-2020, Billion Current USD



China-Related Legislative Activity, 1973-Present



Source: SIPRI, Congress.gov, Author's Analysis

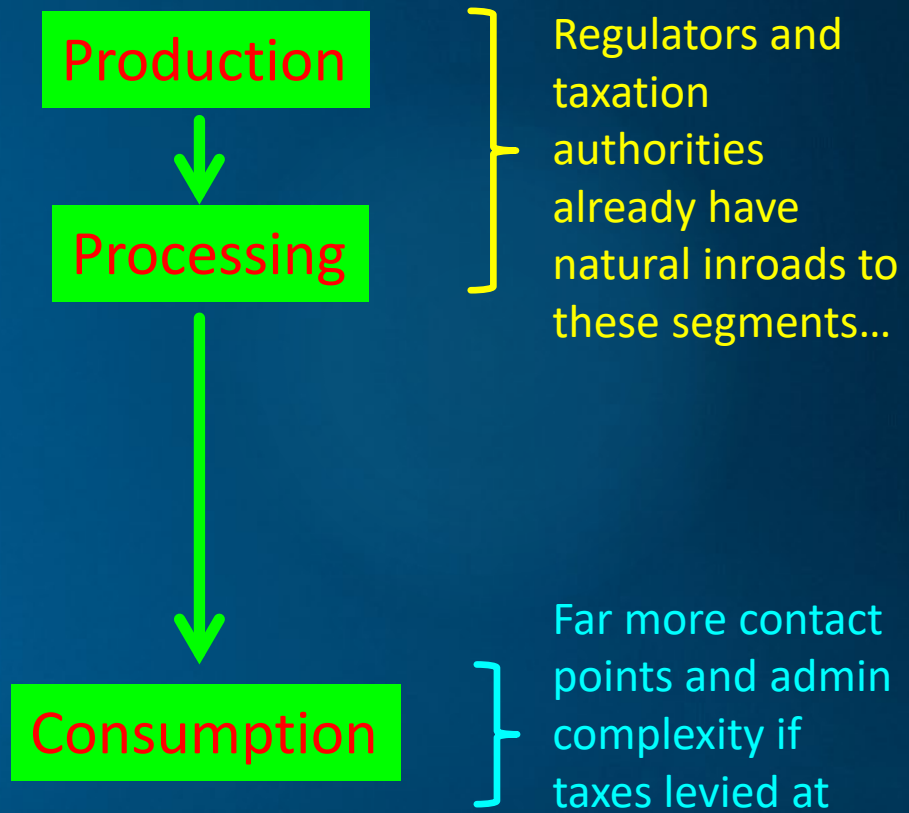
Climate Competition and Energy Evolution Starts at Home, Carbon Taxation Potentially Plays Foundational Role

What Does "Carbon Tax" Potentially Mean Here?

Carbon Tax

- Tax fuels based on carbon content or CO2 emissions upon combustion (0.27 tonnes of carbon per tonne of CO2, so every $1 of CO2 taxation equivalent to $3.70 of actual carbon content taxation).
- Practical Impacts: Every $10/tonne increase in CO2 fee would:
  - raise gasoline prices by about 8.5¢/gallon;
  - increase avg. residential power bills by about 11¢/day, and
  - increase price of hamburger with a quarter-pound patty by about 4¢
- Practical Impacts: Social Security and SNAP payments already pegged to CPI, and food prices, respectively, which builds in protection from carbon fee-driven cost increases
- Practical Impacts: Could also set aside a certain portion of fee income to spin back to lower quartile households as a "carbon dividend." (partial implementation of Baker-Schultz 2017 proposal)

Multiple Potential Taxation Points



“Carbon Fee” And Border Adjustments

Carbon Border Adjustment Mechanism

- Goods importers pay fee based on difference between carbon taxation level in their place of production and United States
- In short, if U.S. assesses a $60/tonne fee on domestic CO2 emissions and China charges $10/tonne, goods imported from China would pay for “embedded” CO2 content at the rate of $50/tonne [U.S. rate – China rate]
- Would include energy embedded in basic materials, including basic materials incorporated into manufactured products and then exported (for instance, an aluminum engine block or EV battery cathodes)
- Emissions can be based on national energy profiles (default) or possibly provincial/state-level, if supported by independently verifiable audit
- EU is already moving to implement a CBAM. Reporting and tracking will begin in 2023, with actual financial payments commencing in 2026. Revenues will be paid into the EU budget.
- Goods initially covered: iron and steel, cement, fertilizer, aluminum and electricity generation.
- Note the precedent set by recent Global Minimum Corporate Tax deal

Domestic Carbon Tax + CBAM = “complimentary goods.”

Key Policy Issues To Consider:

--Offsets/credits, for instance based on nature-based or mechanical CO2 capture and sequestration

--What is ultimate carbon price needed to move from being viewed as “cost of doing business” to a true lever for change?

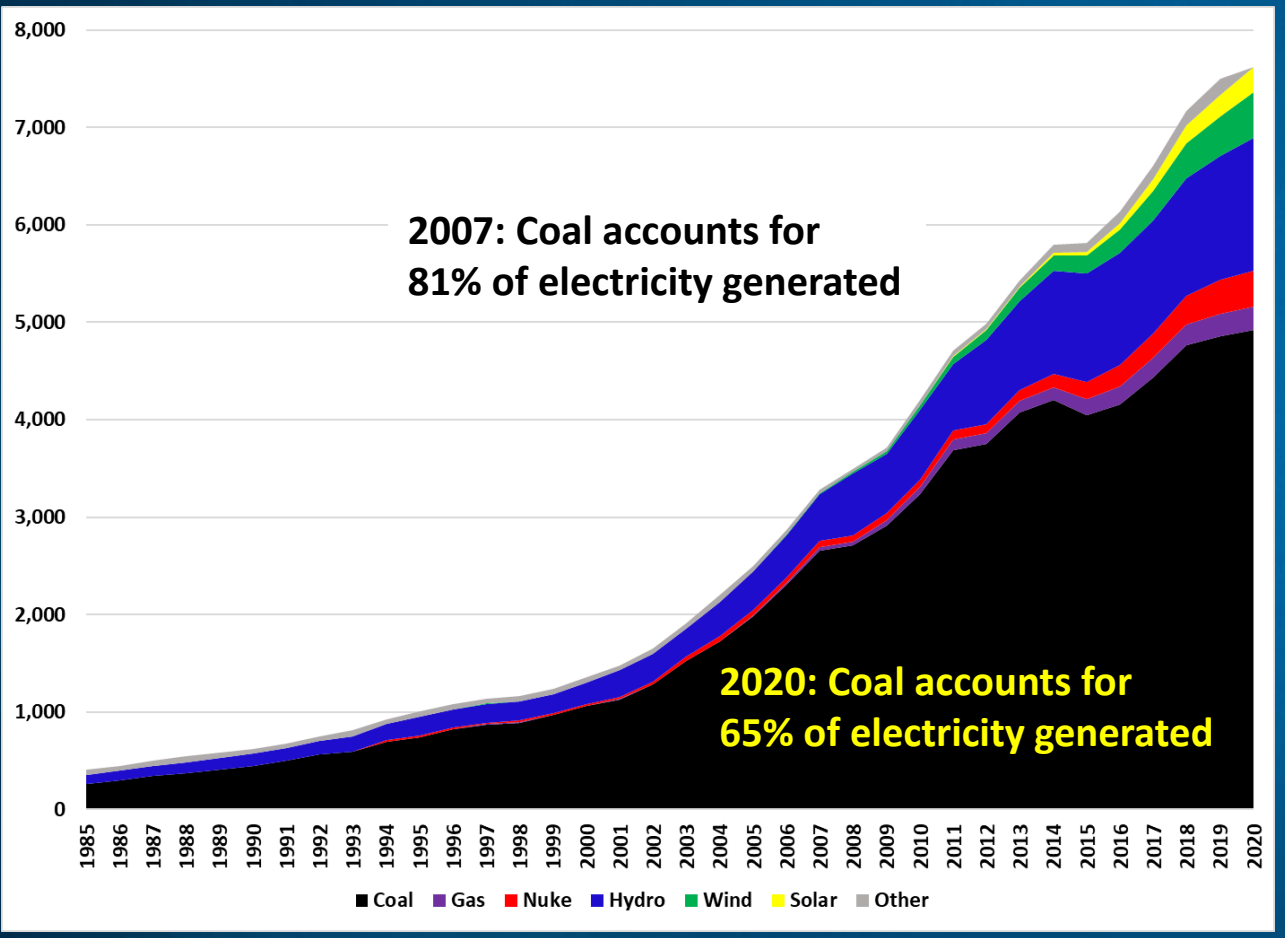
--Will PRC weaponize key supply chains such as rare earths or antibiotics to get U.S. to back down on CBAM applied to PRC-origin goods?

Carbon Taxes Could Cement US Structural Energy Advantages and Create New Strategic Leverage

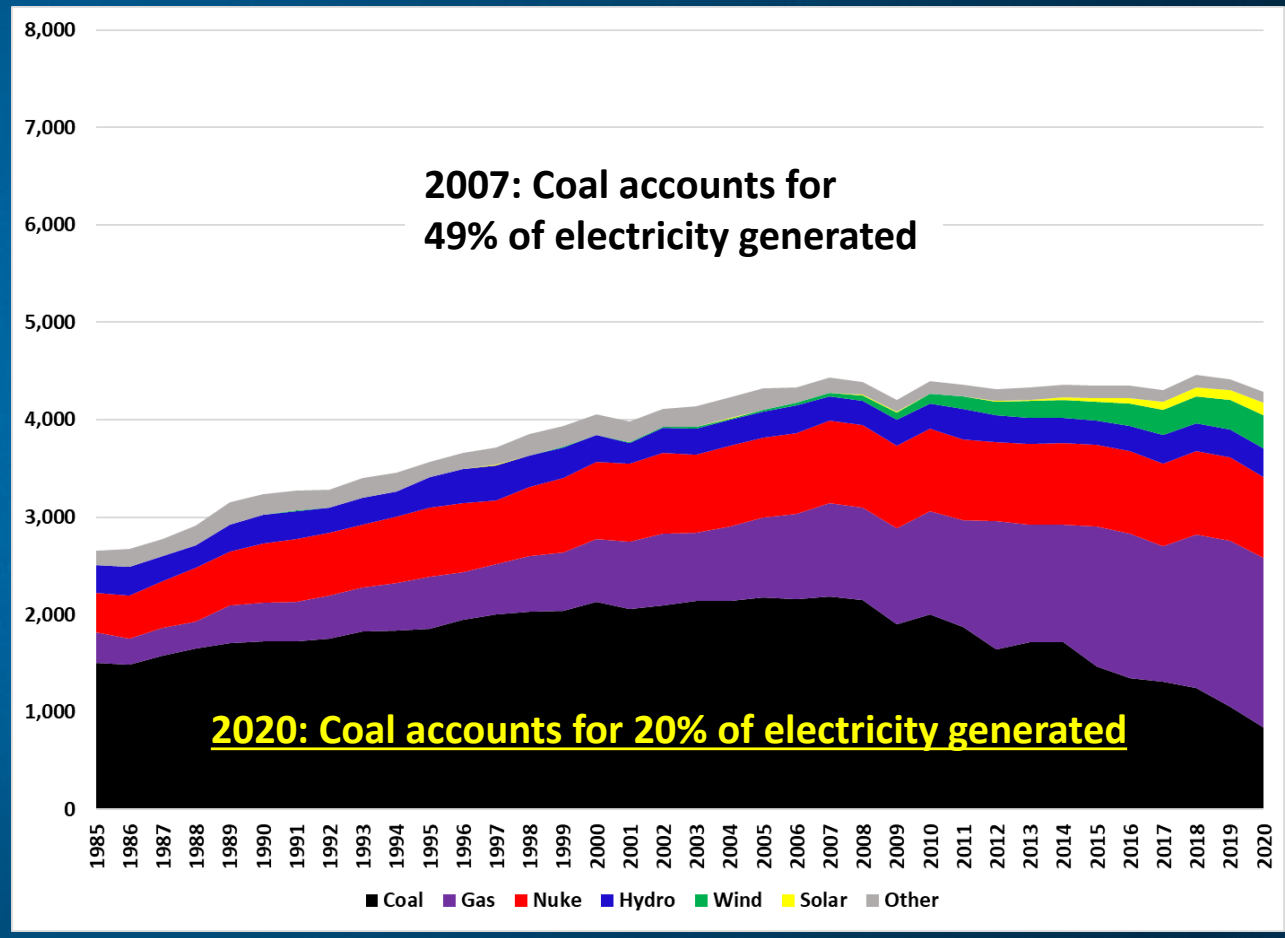
Talk vs. Action: Tale of Two Energy Transitions

Electricity Production, 1985-2020 (TWh, by Fuel)

People's Republic of China



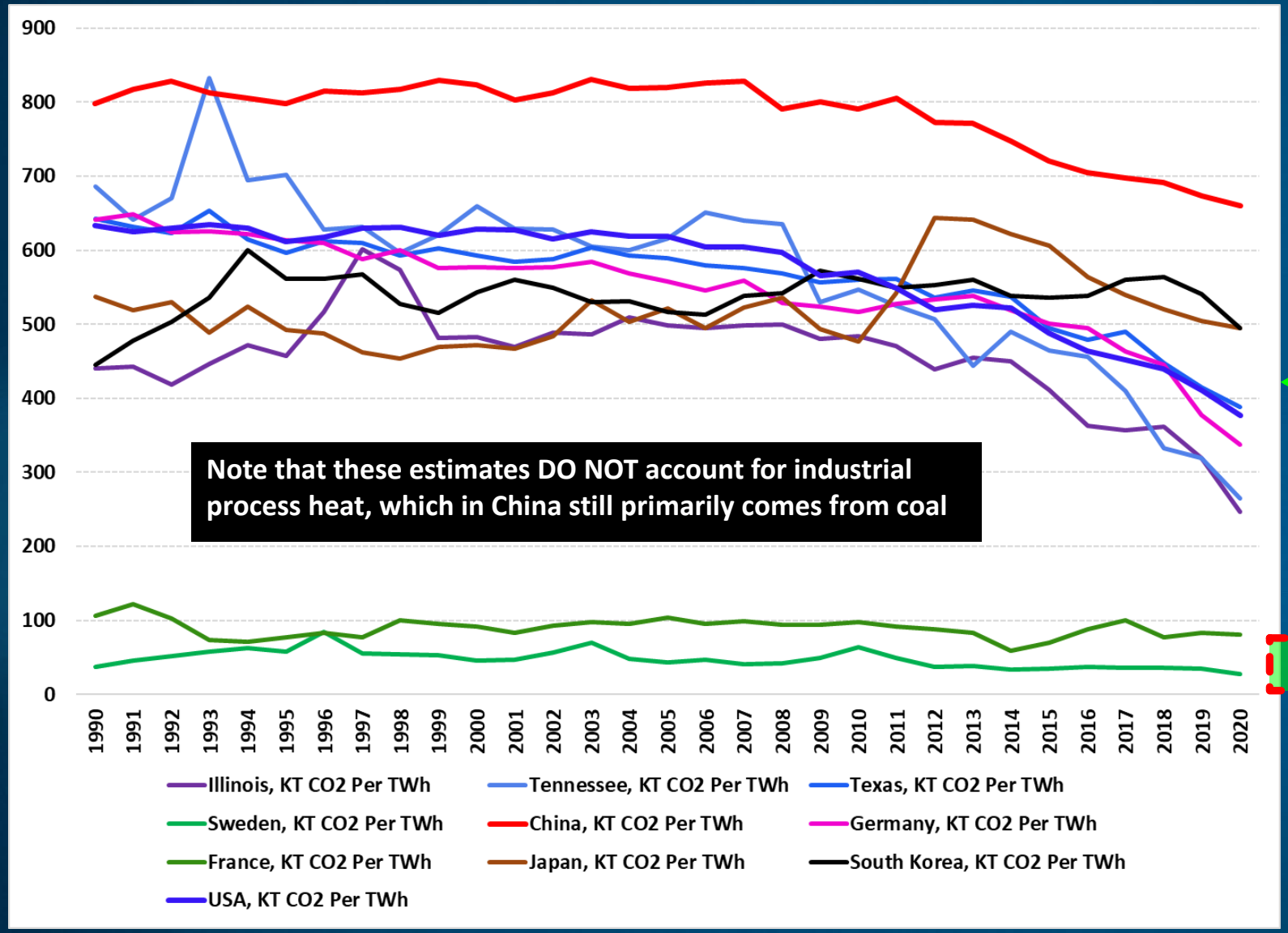
United States



Source: BP Statistical Review of World Energy 2021, Author's Analysis

U.S. Electricity Supply About 1/3 Less Carbon-Intensive Than China's

Thousand Tonnes of Carbon Dioxide Per Terawatt-Hour Generated



Coal: 1,000 KT CO2 /TWh

Natural Gas: 413 KT CO2 /TWh*

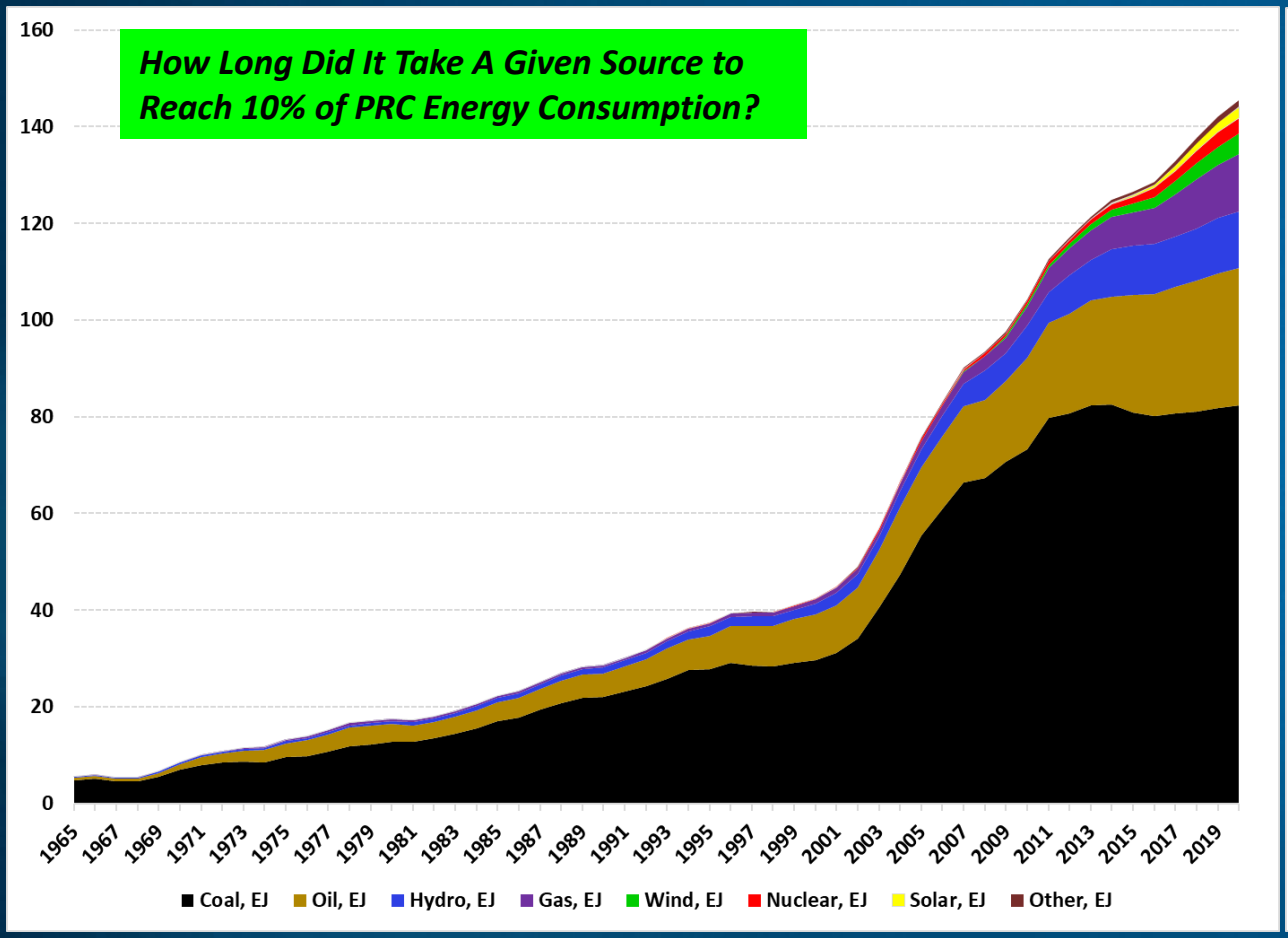
Solar: 44 KT CO2 /TWh
Hydro: 24 KT CO2 /TWh*
Wind: 11 KT CO2 /TWh
Nuclear: 9 KT CO2 /TWh

**Higher total GHG profile due to methane emissions*

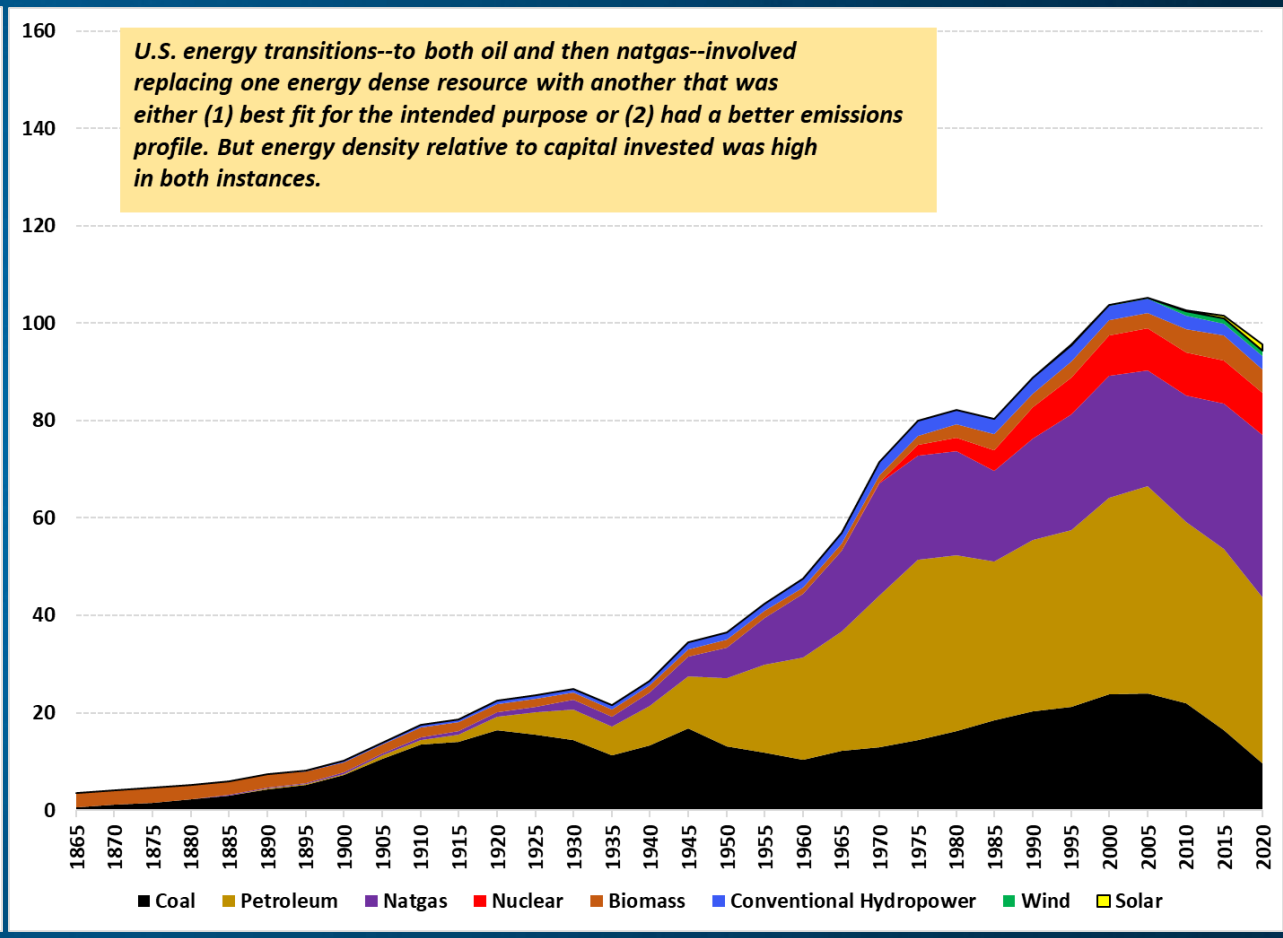
Source: EIA, IPCC, BP Statistical Review of World Energy 2021, Author's Analysis

U.S. Carbon Advantage Endures on Broader Energy Front

China, Primary Energy Consumption, 1965-2020 (EJ, by Fuel)



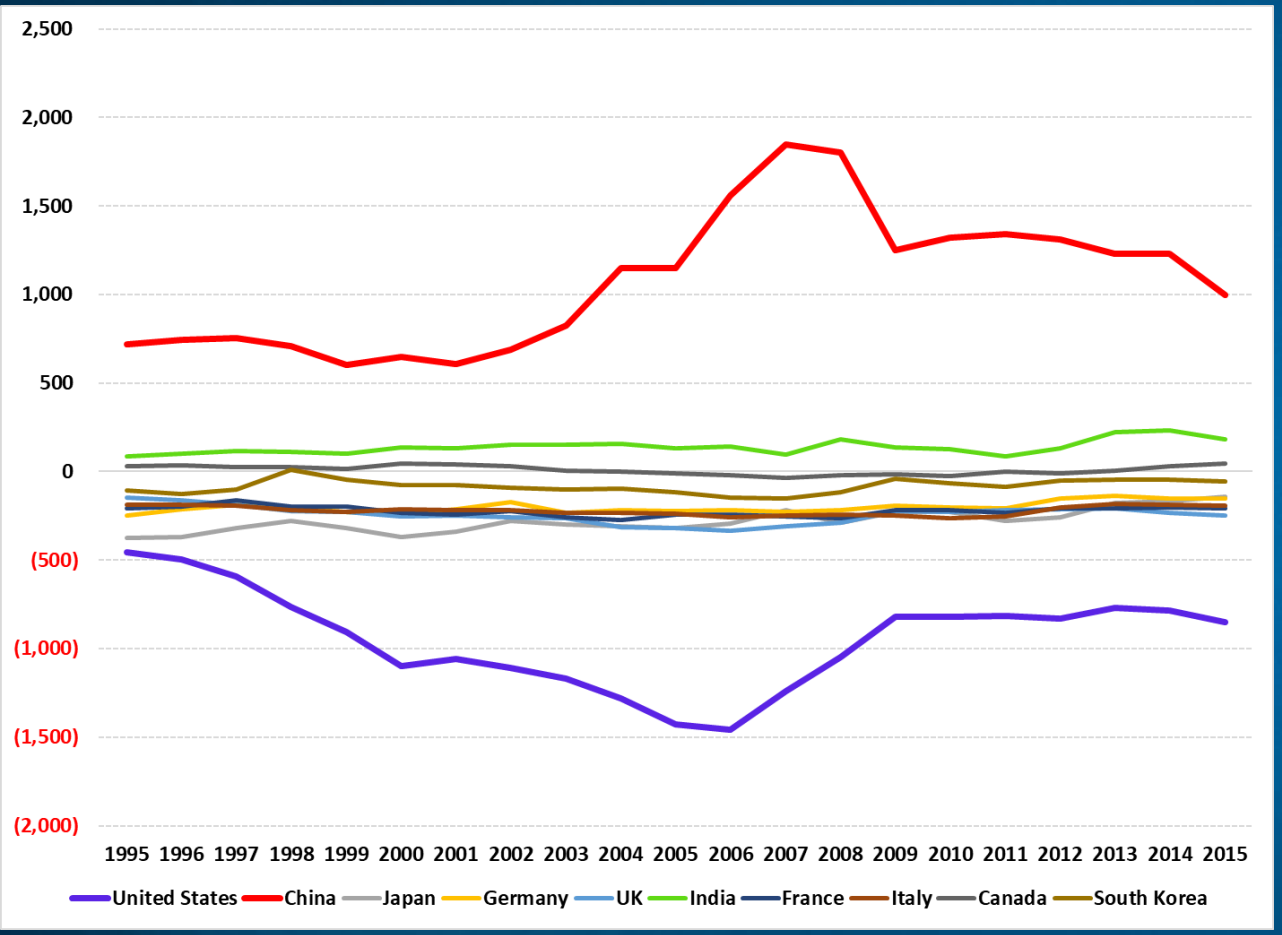
U.S., Primary Energy Consumption, 1865-2020 (EJ, by Fuel)



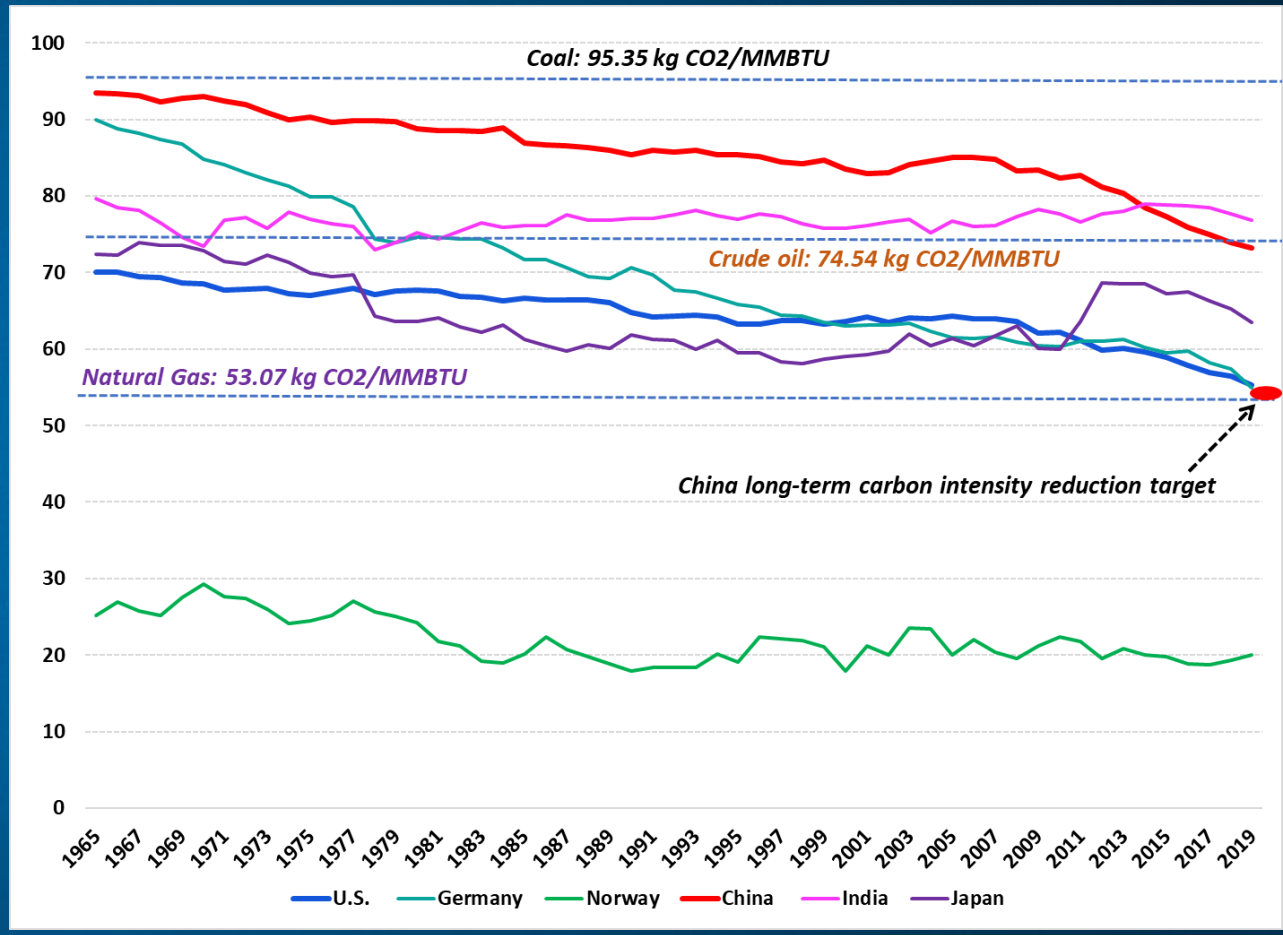
Source: BP Statistical Review of World Energy 2021, Author's Analysis

China's Coal-Centricity + Export Orientation Creates Substantial Relative Exposure to Carbon Border Adjustment Taxes

Net Greenhouse Gas Emissions, Million Tonnes

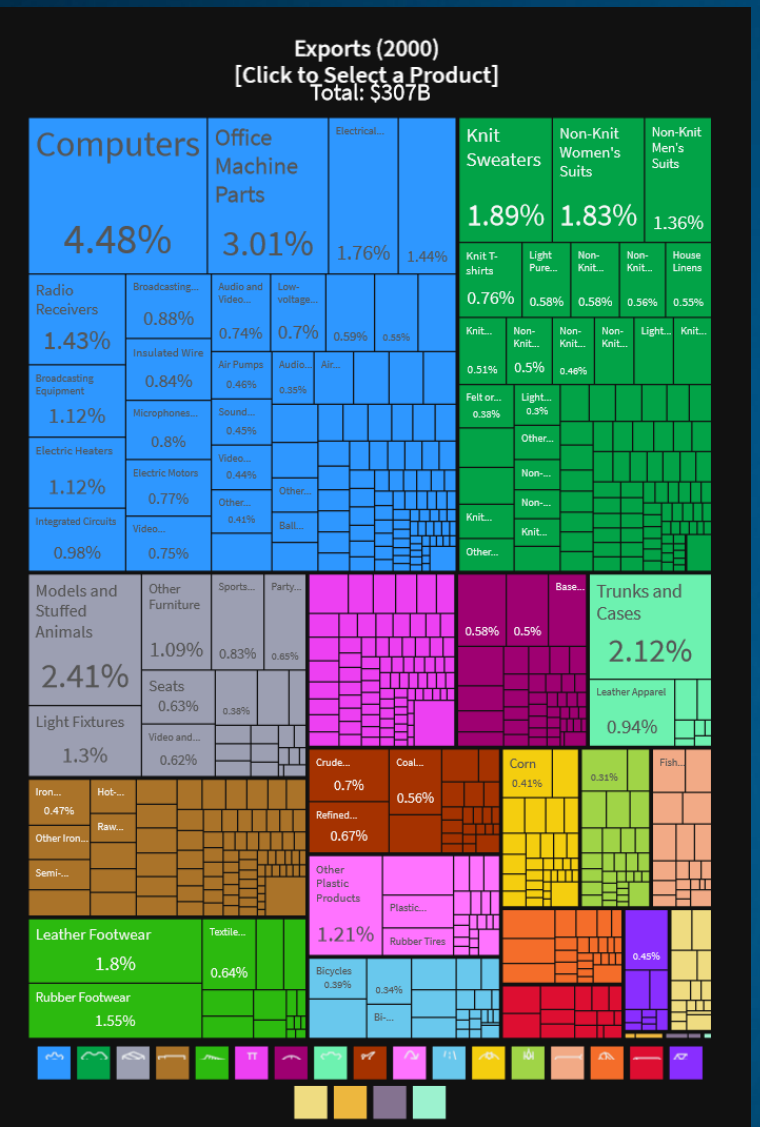


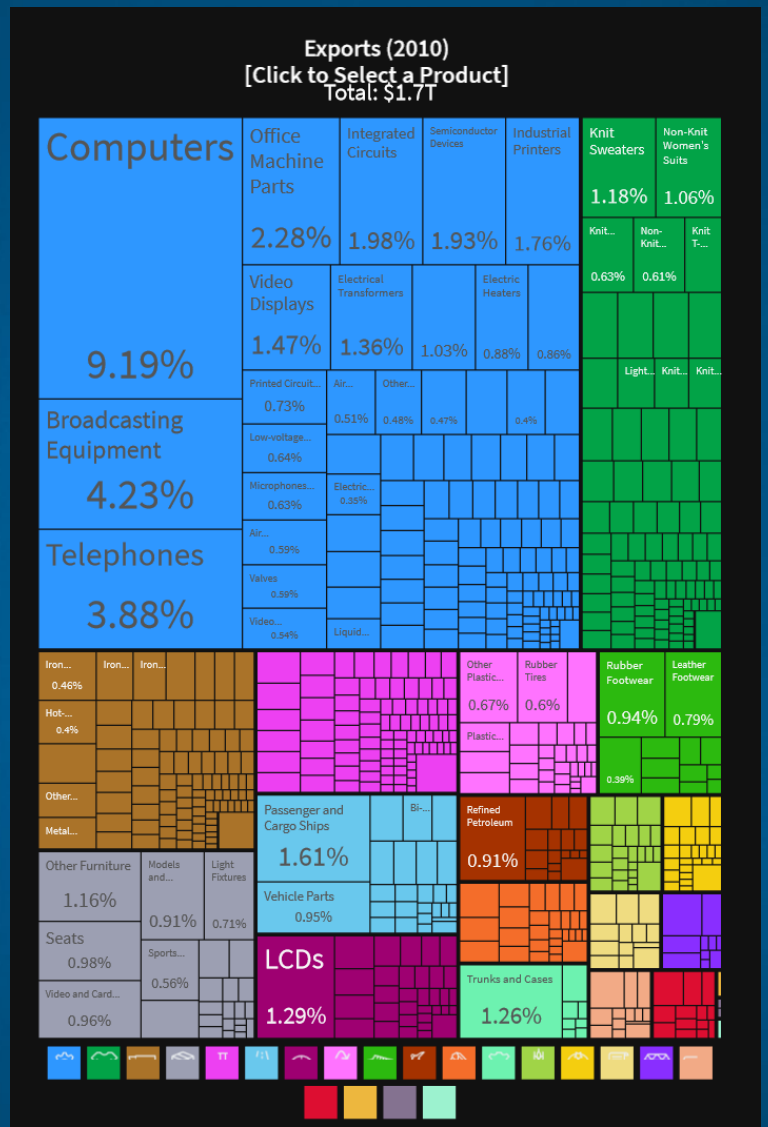
CO2 Emissions Per Million BTU of Primary Energy Used

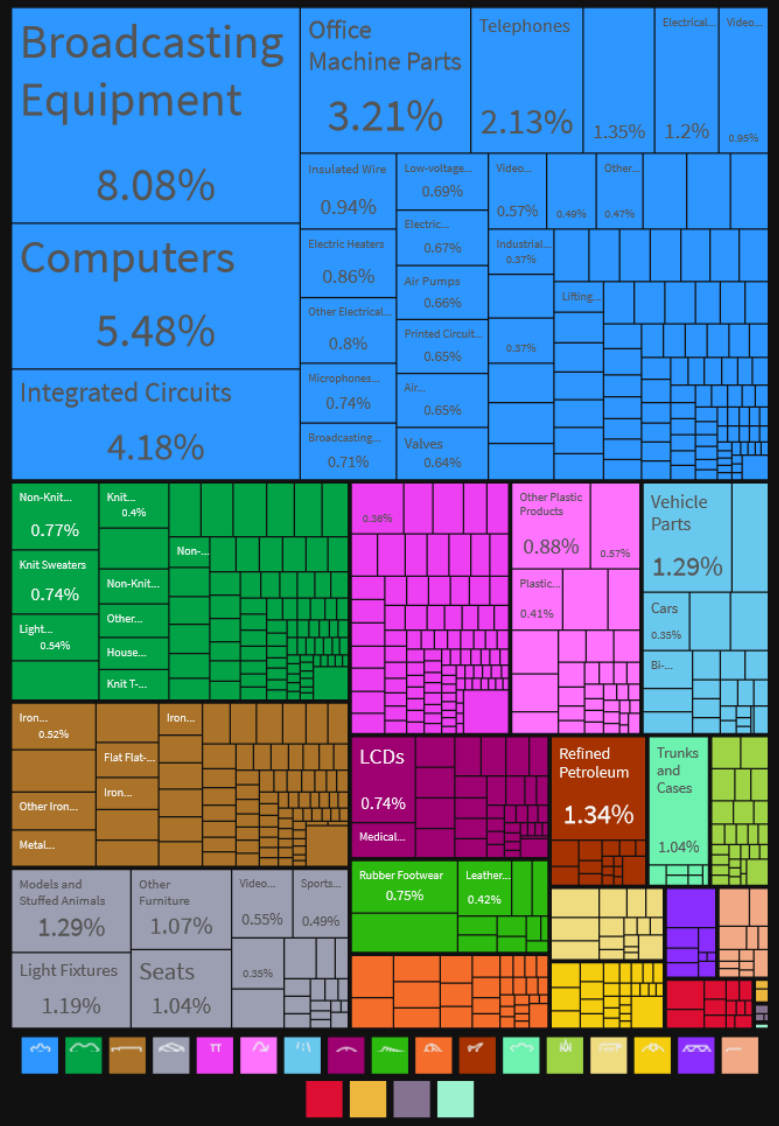


Source: BP Statistical Review of World Energy 2021, environmentalfootprints.org, Exiobase, Author's Analysis

China Has Moved Up the Export Value Chain…







Blue sector is the least energy-intensive relative to goods' value. Brownish shades, green, etc. trend much higher

oec.world/en/profile/hs92/aluminium-plating
oec.world/en/profile/hs92/aluminium-plating

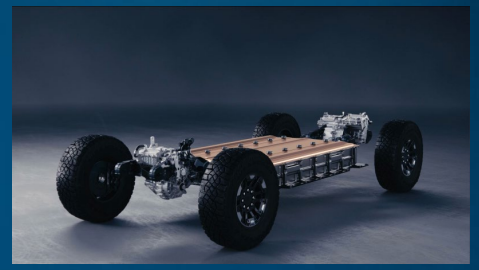
Carbon Border Adjustment: Quantifying Potential Impacts

Basic Materials

Commodity	Total CBAM/Tonne	Approximate Mkt Price (11 October 2021)	CBAM % of Total Underlying Mkt Value
Flat glass	$74.18	$481	15.4%
Primary aluminum	$263.04	$2,900	9.1%
Virgin steel	$78.45	$900	8.7%
Recycled steel	$47.64	$900	5.3%
Copper	$154.91	$9,200	1.7%

Manufactured Good: EV Battery Pack

	Electricity Carbon Intensity (g/kWh)	Process Heat Carbon Intensity (g/kWh)	Embedded Carbon per 100 kWh battery, tonnes	CBAM, $/tonne	Carbon Differential for CBAM Assessment
China	660	320	8.4	$60	267.4
U.S. (TN)	265	180	3.9		
CBAM Assessment on PRC Origin 100 kWh Battery Pack					**$267**



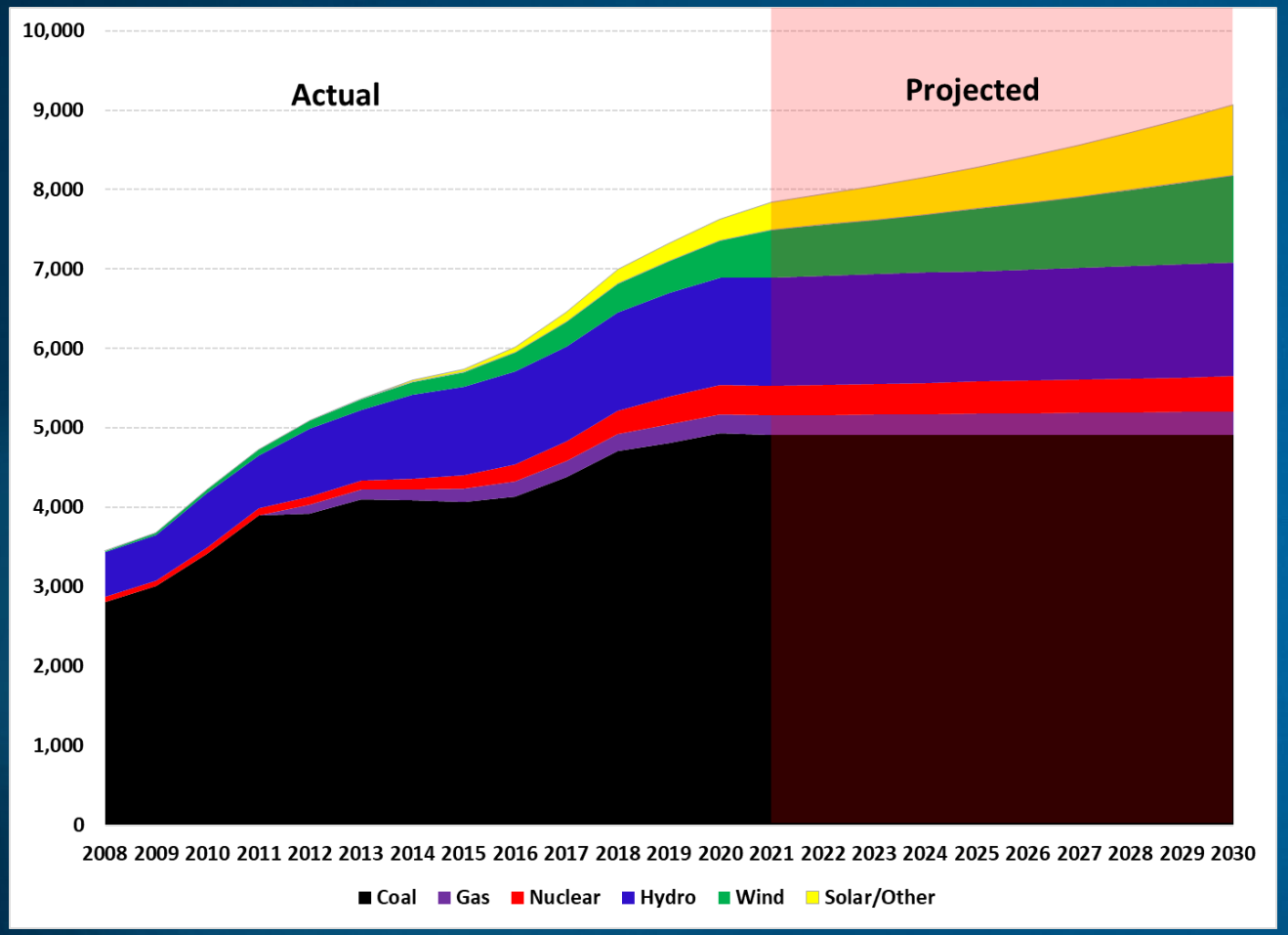
Source: https://www.greencarcongress.com/2020/10/20201022-hummerev.html

Basic Materials and EV battery pack embedded energy calculations shown in Appendix slides

How Fast Could China Potentially Adapt Its Energy System?

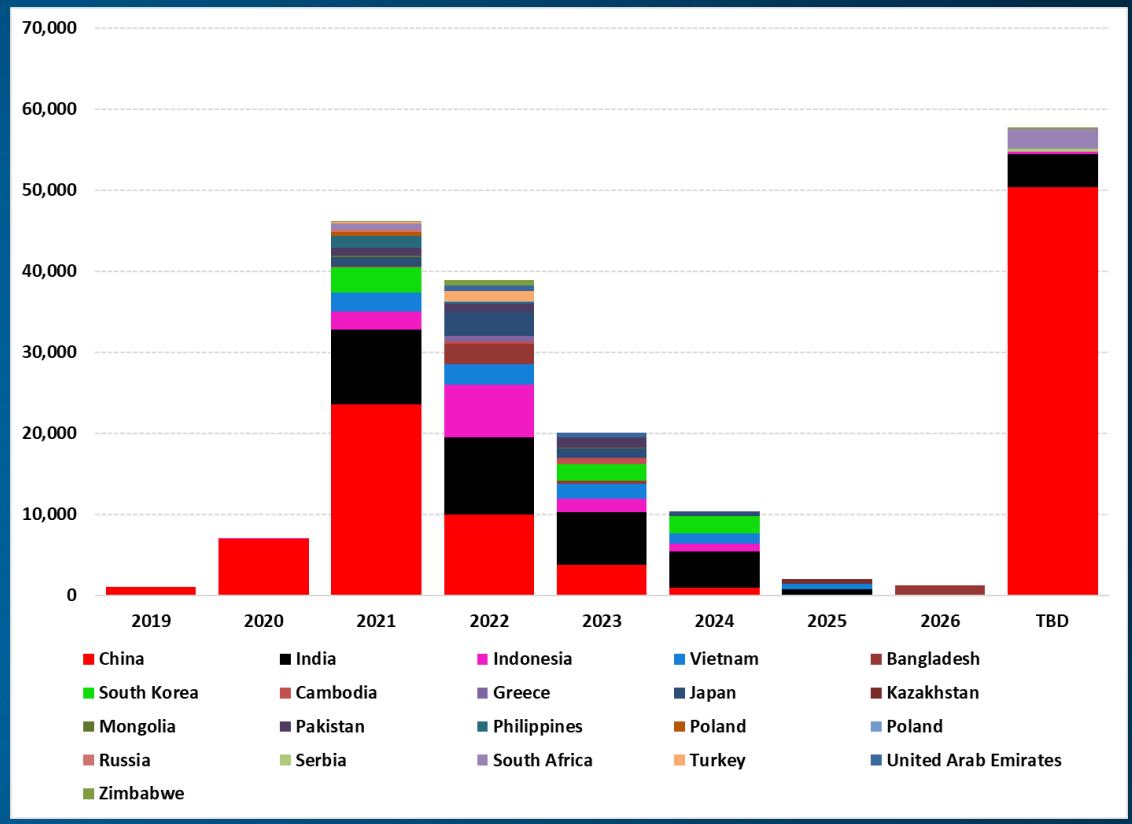
Major Uncertainty For China's Electricity Evolution…But Coal Hard to Dislodge

China Electricity Production, By Source, 2008-2030 (TWh)



Source: China Electricity Council, Gov't Targets, Authors' Analysis

Projected Coal Power Plant Additions, By Country (MW)



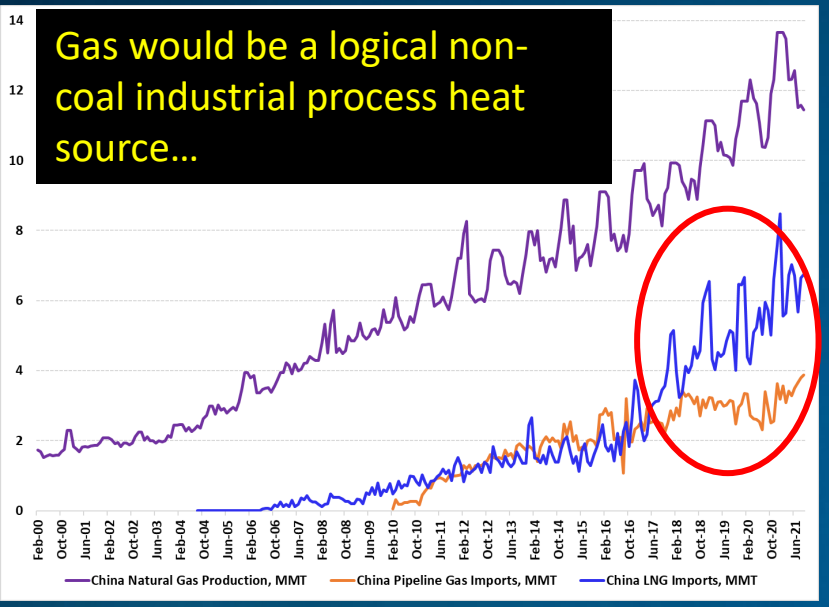
Source: Global Energy Monitor, Authors' Analysis

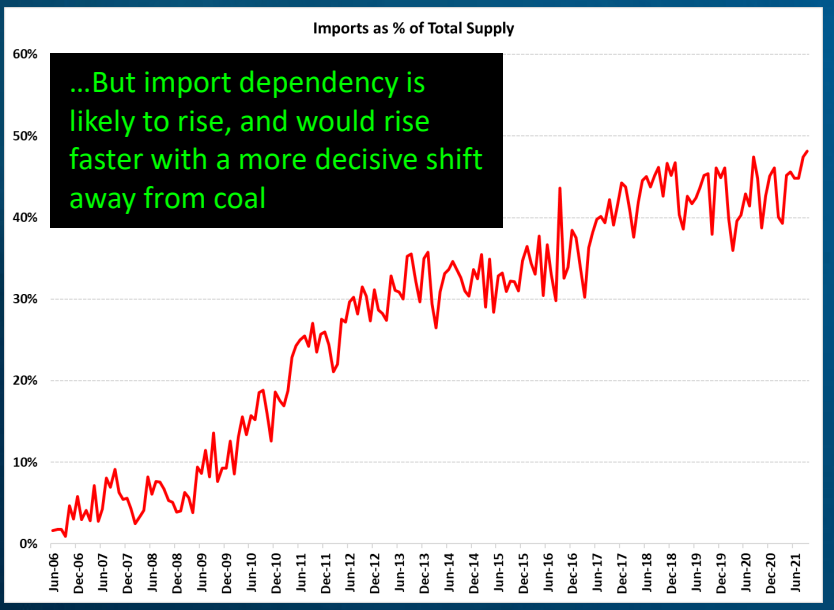
GW installed	Utilization Rate	Annual Coal Use, Billion Tonnes
1,500	45%	1.77
1,200	50%	1.58
1,000	65%	1.71
800	85%	1.79

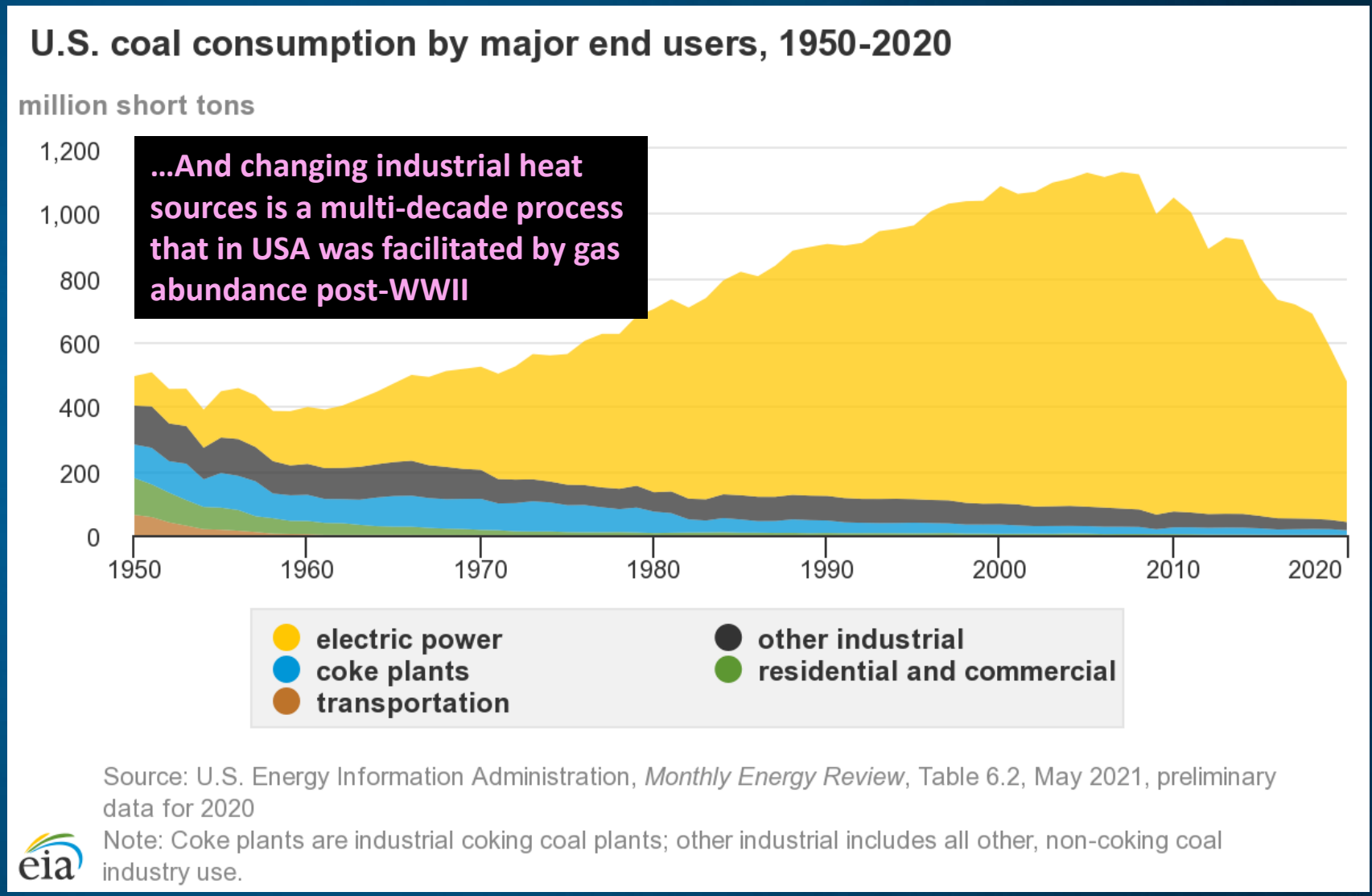
Finally, beware of potential disparity between plant capacity and actual coal use

Substantial Uncertainty For Alternative, Non-Electric Industrial Energy As Well

China Natural Gas Supply, Million Tonnes/Yr







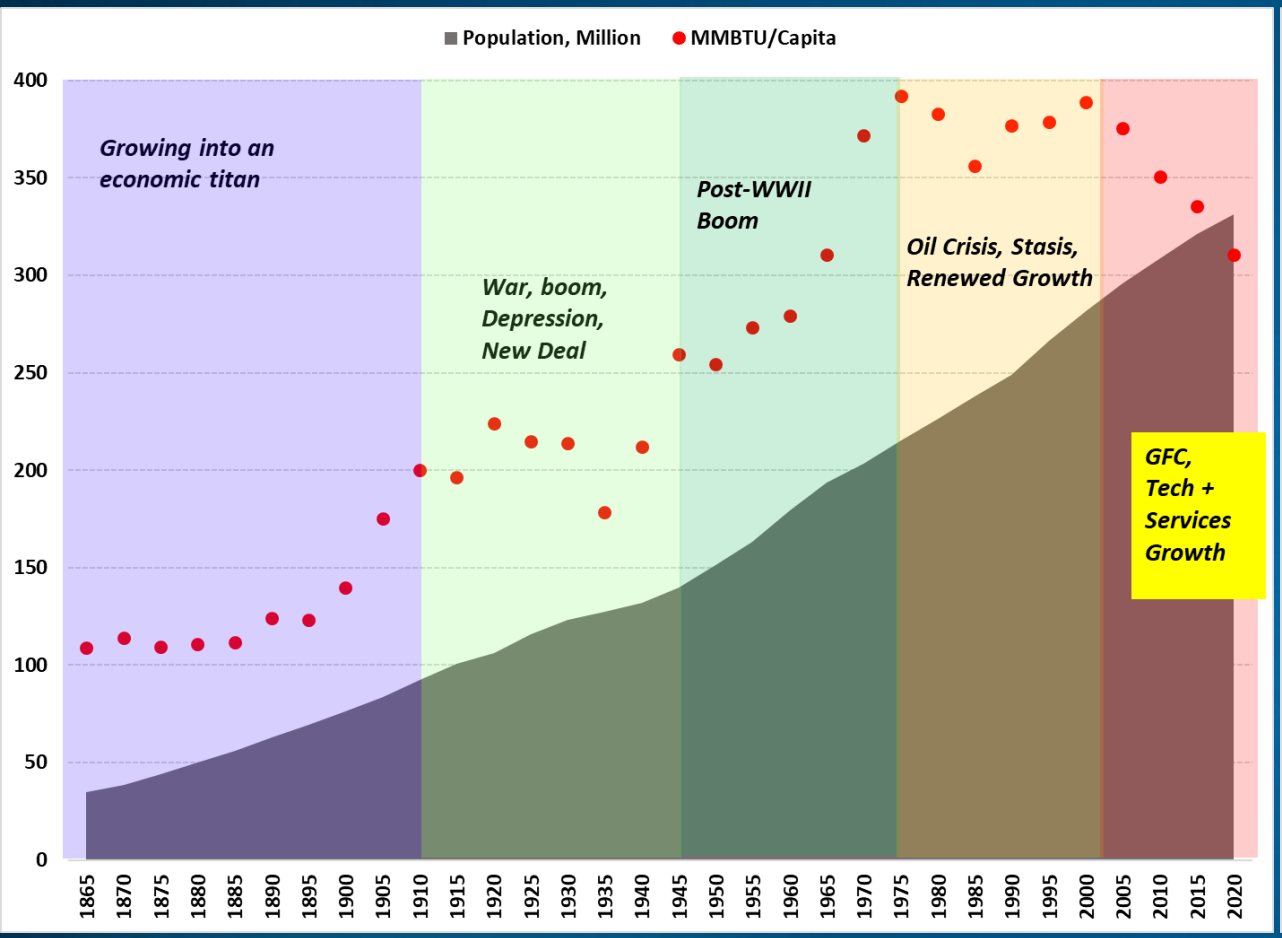
Source: National Bureau of Statistics, China General Customs Administration, Author's Analysis

Potential Domestic Pitfalls

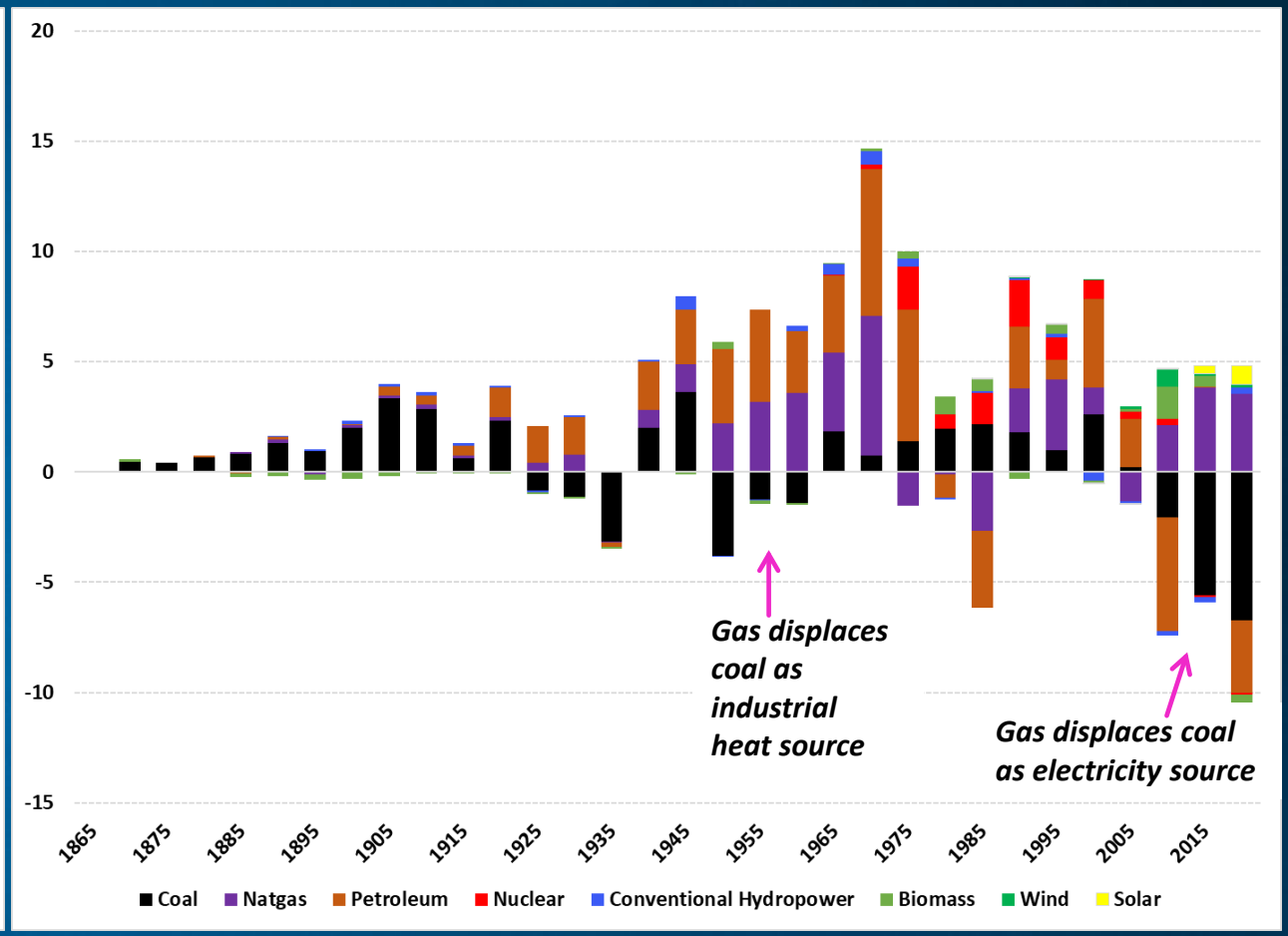
Author’s driveway during Great Texas Blackout, February 2021, Houston, TX

Energy Abundance Underpins U.S. Quality of Life

U.S. Historical Energy Use, MMBTU Per Capita



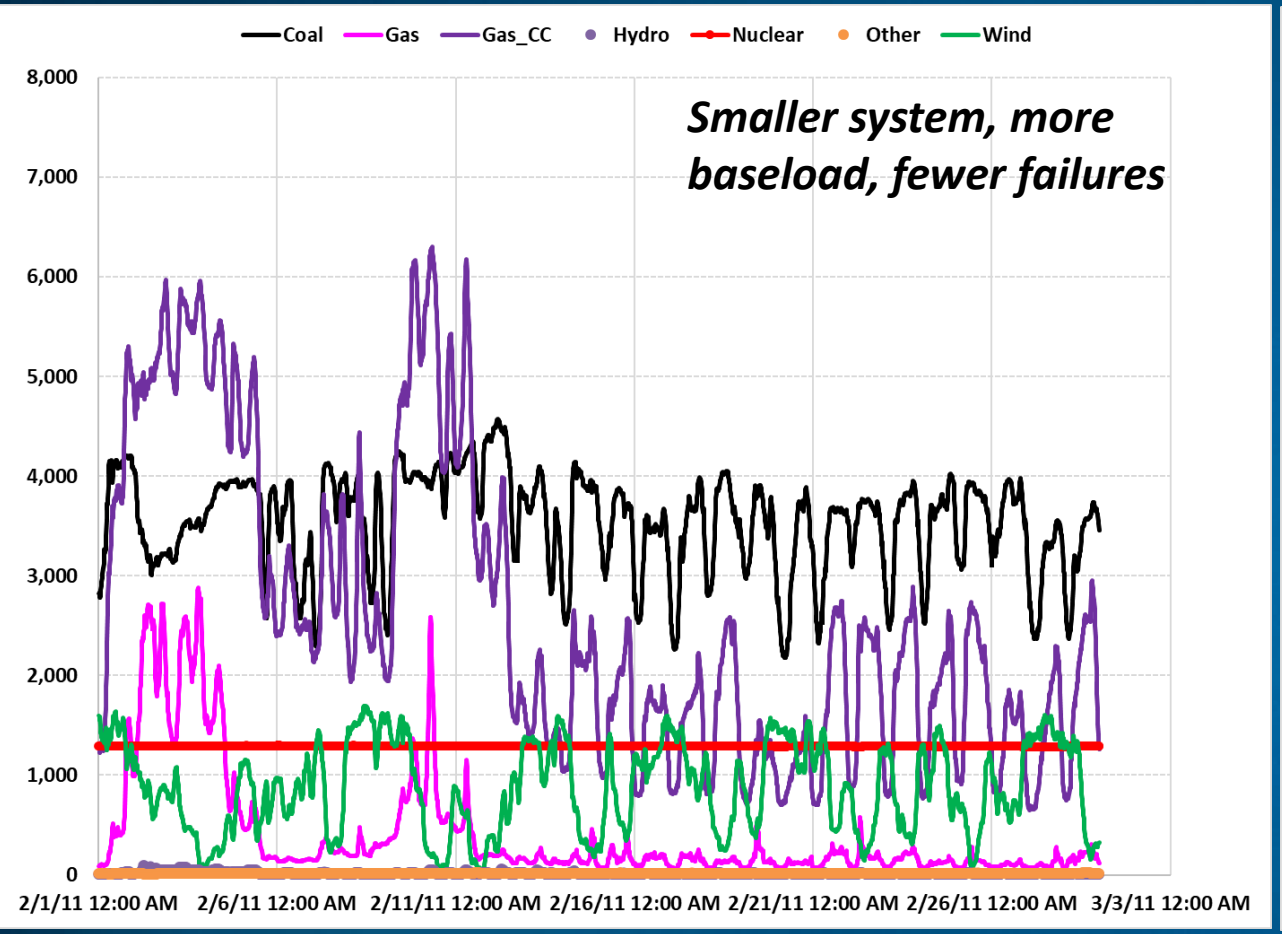
155 Years of U.S. Primary Energy Use Shifts, Exajoules



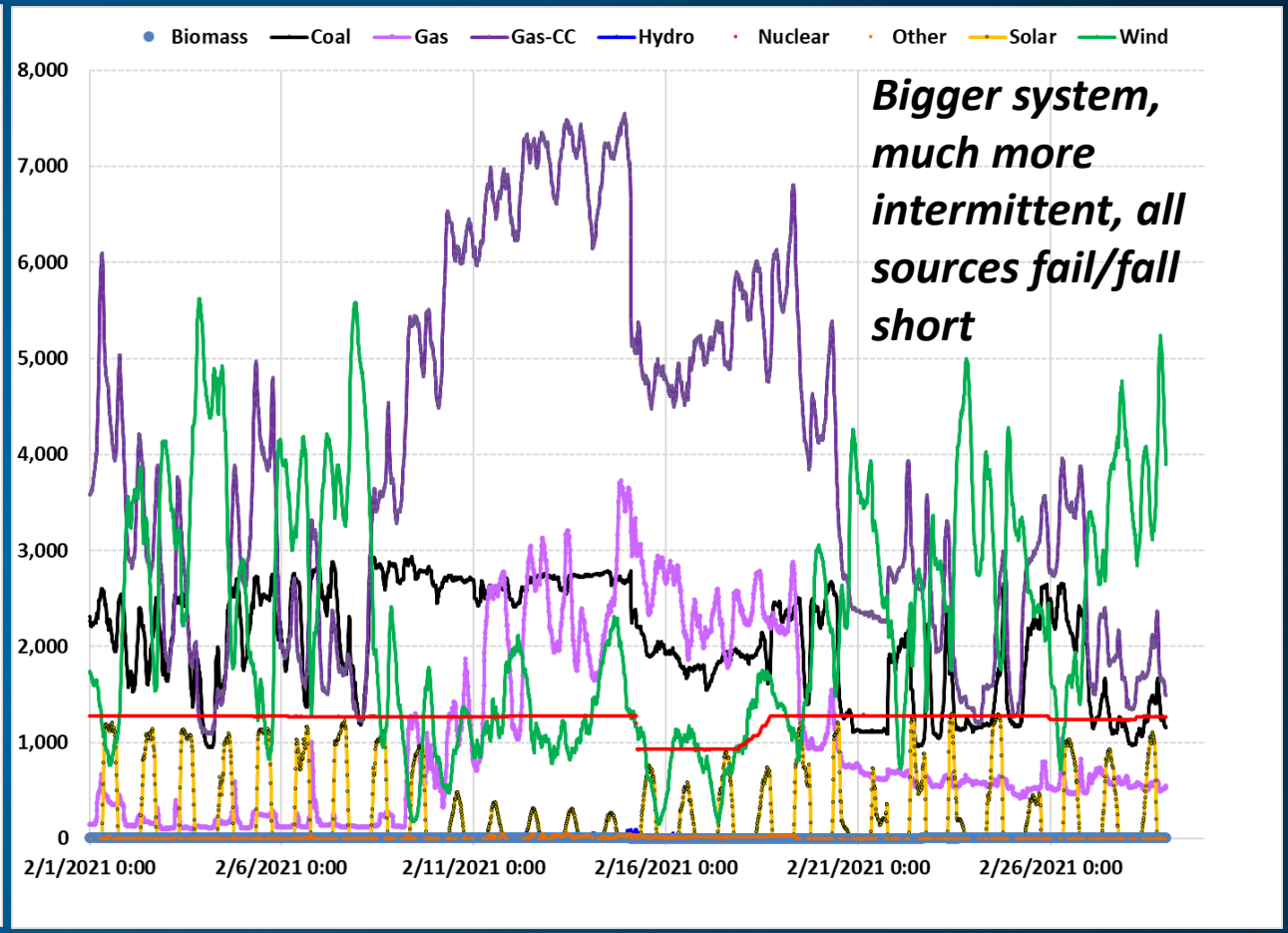
Source: EIA, Author's Analysis

Avoiding Energy Monoculture: Source Diversity Promotes Reliability

February 2011, ERCOT Generation, 15-min Intervals, MWh



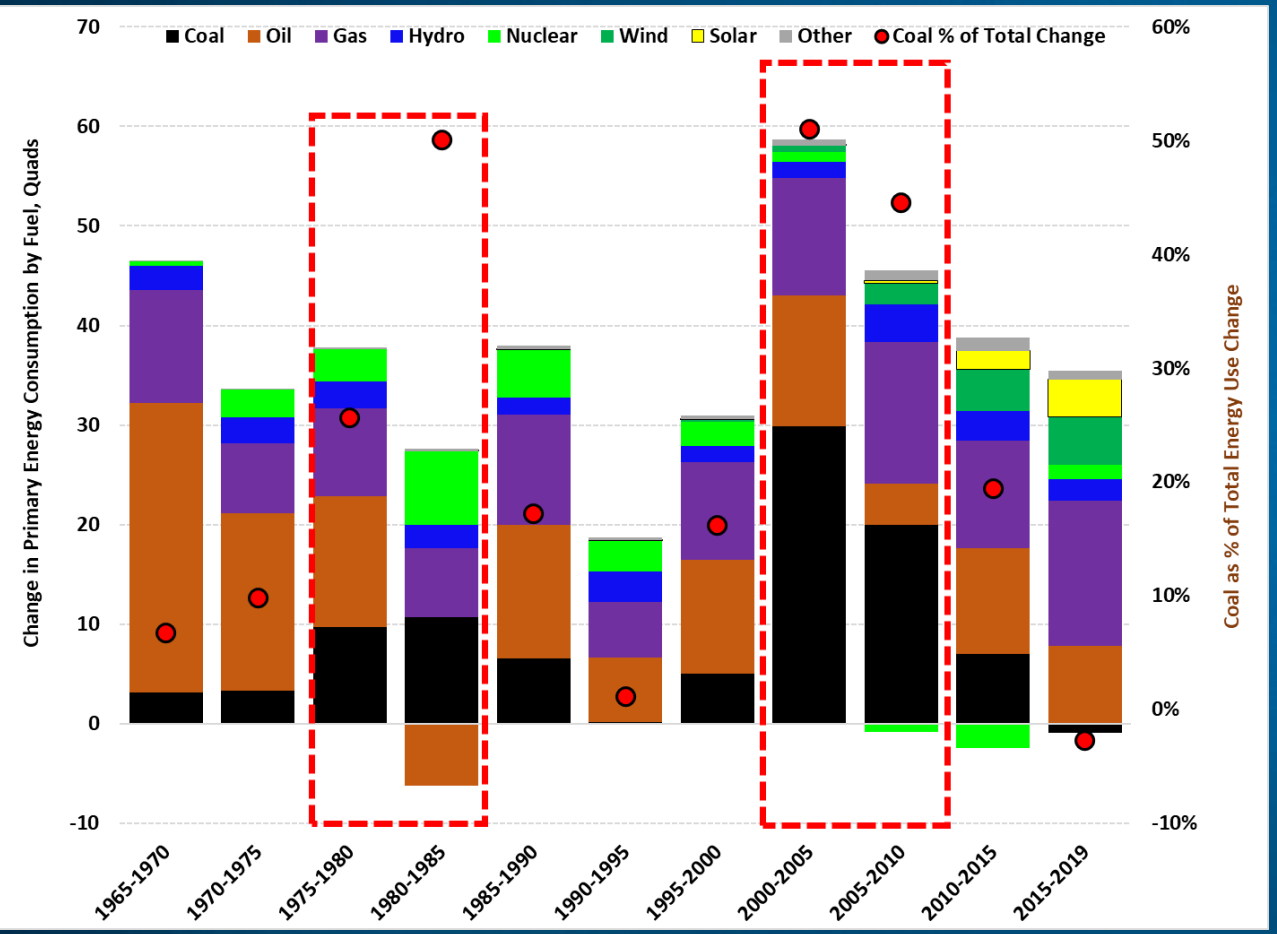
February 2021, Same



Source: ERCOT, Author's Analysis

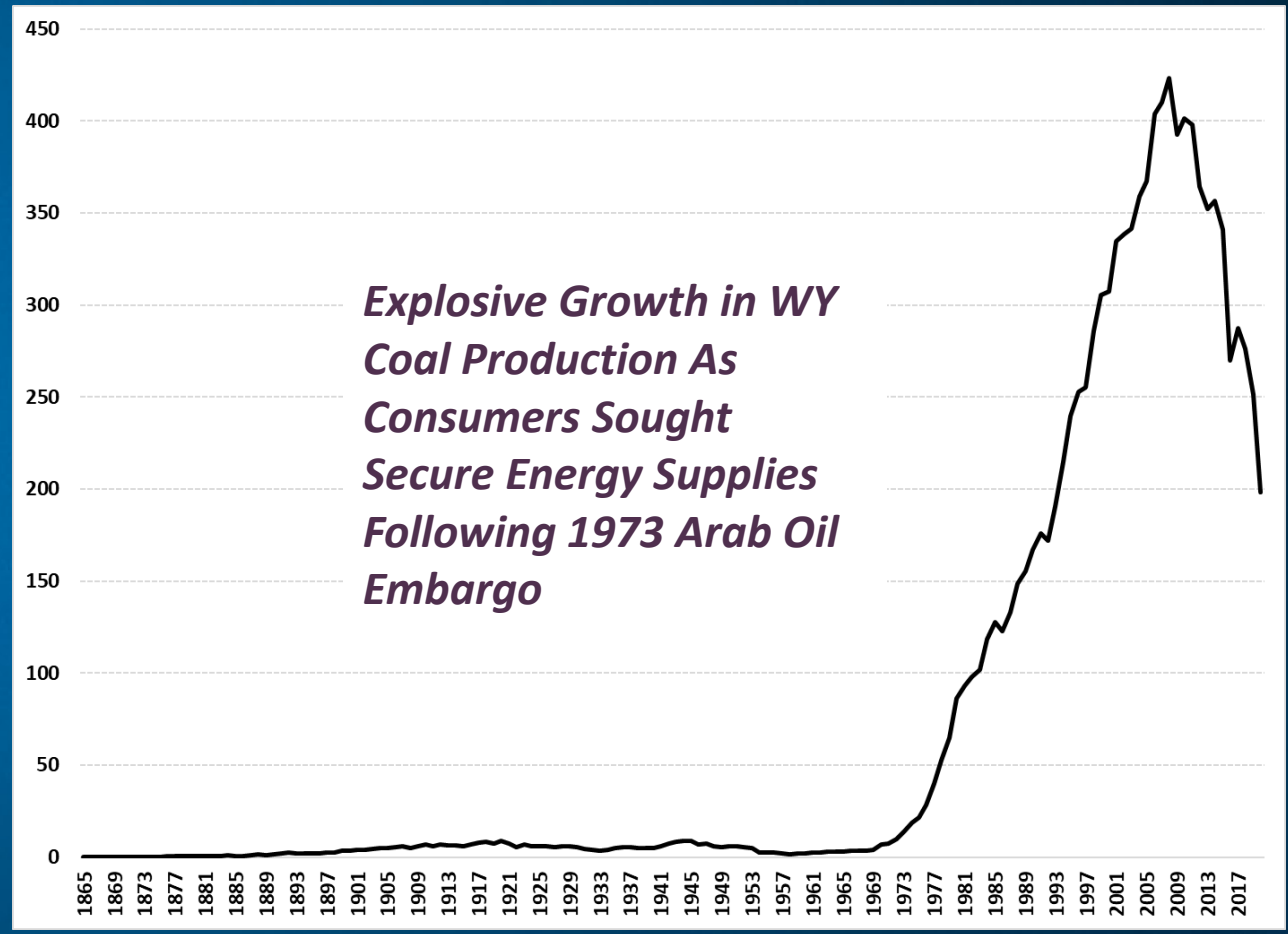
Energy Insecurity Can Undermine Climate Goals

Change in Global Energy Consumption By Source (Quadrillion BTU)



Source: BP Statistical Review of World Energy 2021, Author's Analysis

Wyoming Coal production (Million Tonnes)



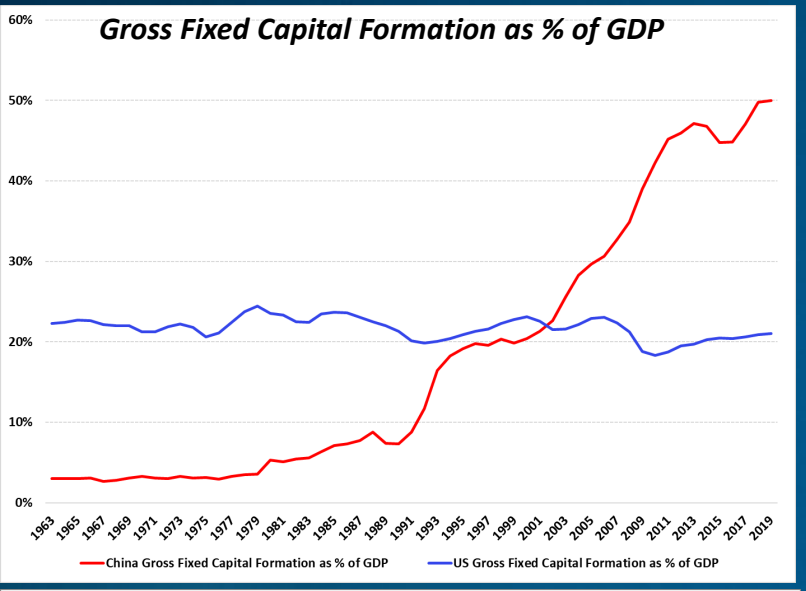
Source: Wyoming State Geological Survey

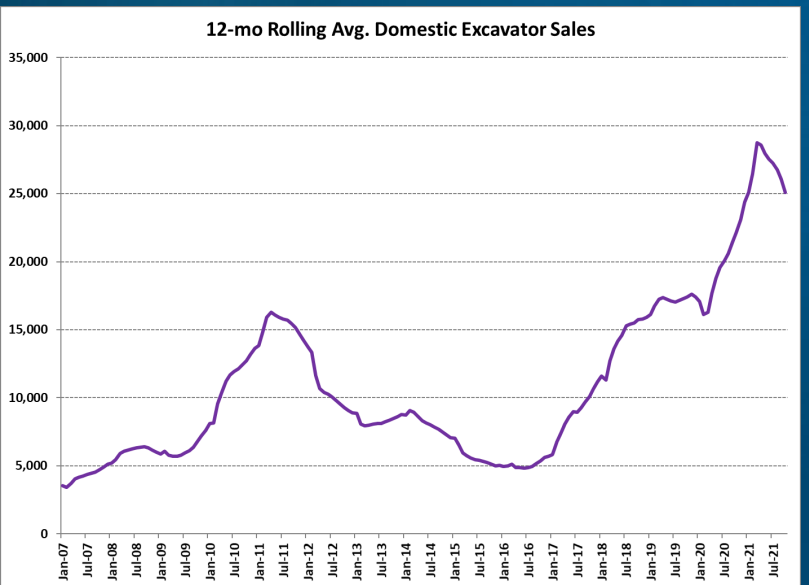
A quadrillion BTU is equivalent to the gasoline usage of 11 million large V8-powered pickups or SUVs each driving 12,000 miles per year.

Concluding Thoughts

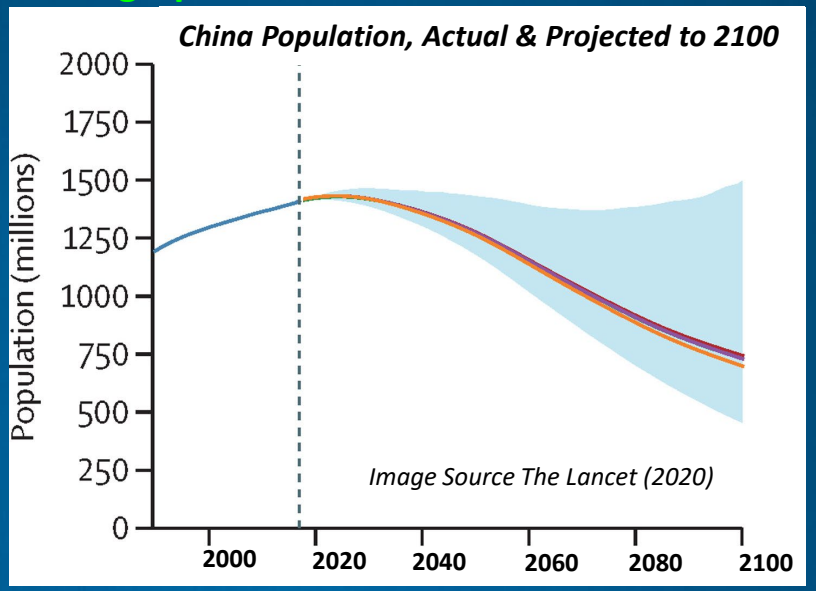
Where Could I Be Wrong on China?

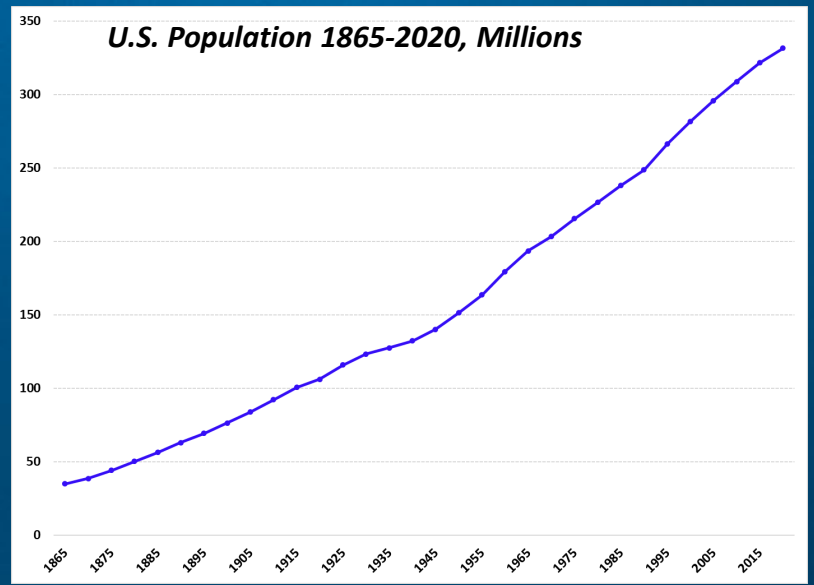
1. China Unleashes Another Round of Cement and Steel Growth



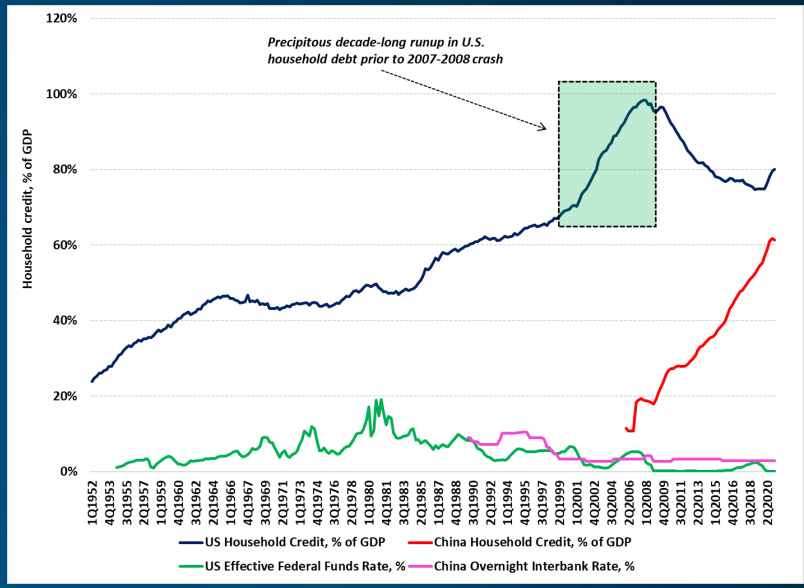


2. China Overcomes/Avoids Demographic Crisis





3. China Defies Debt Burdens and Unleashes Consumer-Led Growth



- China's consumers have increasingly turned to debt
- Does U.S. begin to pull back from QE amidst inflation?
- "China Dream" vs. "□ □ □ □ □ □ □ □"

Thank you!

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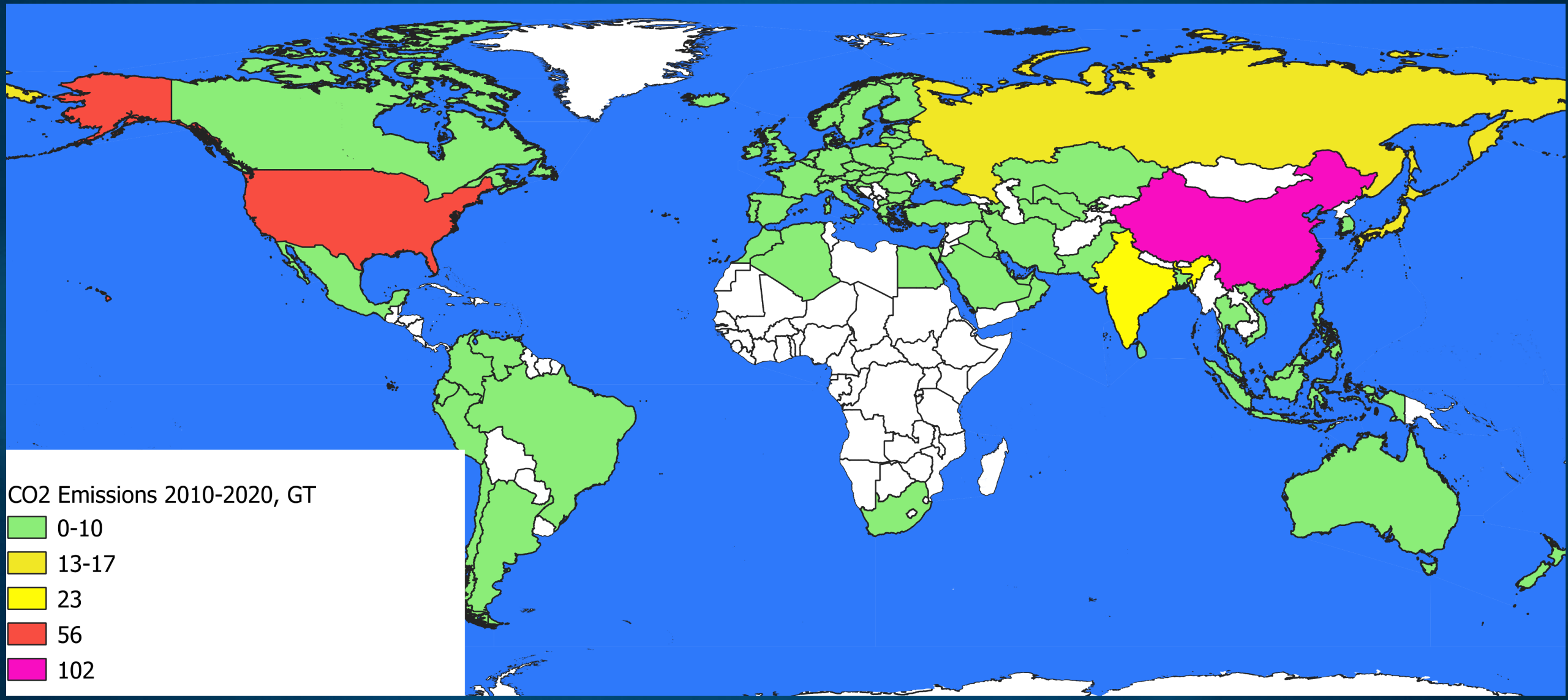
Supplemental Slides

Last 10 Years Mark a Key Inflection Point: China Now Global CO2 Leader on Flow AND Stock Basis



Appendix 1: Basic Materials Embedded Energy

Embodied Energy

	kbtu/lb	MJ/kg	kbtu/tonne	kWh/tonne	Elec % of input energy	Electricity Used Per Tonne, kWh	China Carbon Intensity of Electricity, g/kWh	US Carbon Intensity of Electricity	China Excess Carbon Emissions, g/tonne material produced	China Excess Carbon Emissions, tonne/tonne material produced	Carbon Tax, $/tonne	CBAM Payable Per Tonne of Material Imported
Flat glass	11		23,362	6,847	28%	1,942	660	377	549,542	0.55	$60	$32.97
Virgin steel	10		22,944	6,724	38%	2,560	660	377	724,474	0.72	$60	$43.47
Primary aluminum	29		64,335	18,855	65%	12,198	660	377	3,451,916	3.45	$60	$207.11
Copper	19		41,347	12,118	51%	6,191	660	377	1,752,095	1.75	$60	$105.13
Recycled steel		10.1		2,806	100%	2,806	660	377	793,972	0.79	$60	$47.64

	Other Primary Energy/Tonne, kWh	Coal Process Heat, g/CO2 per kWh	Gas Process Heat, g/CO2 per kWh	China Excess Carbon Emissions, g/tonne material produced	China Excess Carbon Emissions, tonne/tonne material produced	Carbon Tax, $/tonne	CBAM Payable Per Tonne of Material Imported
Flat glass	4,905	320	180	686,740	0.69	$60	$41.20
Virgin steel	4,164	320	180	583,019	0.58	$60	$34.98
Primary aluminum	6,658	320	180	932,100	0.93	$60	$55.93
Copper	5,927	320	180	829,776	0.83	$60	$49.79
Recycled steel	0	320	180	0	0.00	$60	$0.00

Sources: Dixit et.al, “Environ. Sci. Technol. 2015, 49, 3, 1936–1945, January 5, 2015
https://doi.org/10.1021/es503896v ; Embodied Energy Coefficients – Alphabetical, https://www.wgtn.ac.nz/architecture/centres/cbpr/resources/pdfs/ee-coefficients.pdf

Appendix 2: EV Battery Embedded Energy

	MJ		kWh	
	Electricity	**Fuel**	**Electricity**	**Fuel**
Aluminum	101.0	50.8	28.1	14.1
Cell production	29.9	140.0	8.3	38.9
Copper	7.3	13.7	2.0	3.8
Electrolyte solvents	0.8	11.5	0.2	3.2
Electronic parts	36.1	25.1	10.0	7.0
Graphite/carbon	17.9	6.6	5.0	1.8
LiPF6	9.6	0.0	2.7	0.0
NMC111 Precursors	17.4	57.7	4.8	16.0
NMC111 Production	44.5	75.2	12.4	20.9
Others	2.8	7.9	0.8	2.2
Plastics	0.6	1.5	0.2	0.4
Total	267.9	390.0	74.4	108.3
Total	**657.9**		**182.8**	
			41%	**59%**

NMC111 battery pack embedded energy per kWh of battery capacity (kWh)	183

	Electricity Carbon Intensity (g/kWh)	**Process Heat Carbon Intensity (g/kWh)**	**Embedded Carbon per 100 kWh battery, tonnes**	**CBAM, $/tonne**	**Carbon Differential for CBAM Assessment**
China	660	320	8.4	**$60**	267.4
U.S. (TN)	265	180	3.9		
CBAM Assessment on PRC Origin 100 kWh Battery Pack					**$267**

Sources: Dai, Q.; Kelly, J.C.; Gaines, L.; Wang, M. Life Cycle Analysis of Lithium-Ion Batteries for Automotive Applications. Batteries 2019, 5, 48; EIA/BP Statistical Review of World Energy/Author's Estimates (carbon intensity of electricity), EIA, https://www.eia.gov/environment/emissions/co2_vol_mass.php (carbon intensity of process heat)