



Dynamics of the Evolving Transportation Sector

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Key Discussion Points

Cross-Sector Coupling of
Transportation Sector

Geopolitics and global
interactions

Equity and Energy Justice

Health Co-Benefits

Jobs, Existing Infrastructure

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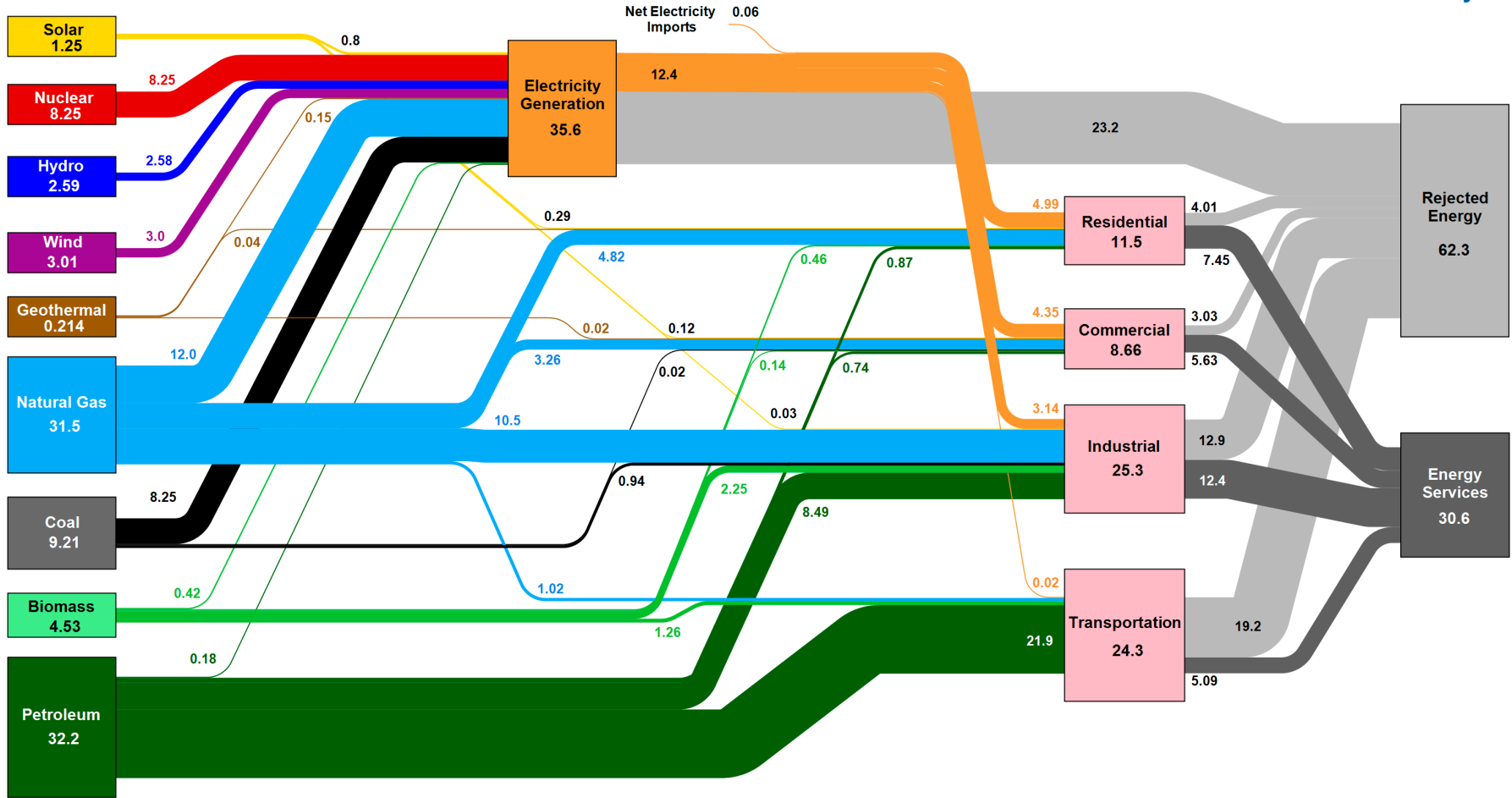
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Health Co-Benefits

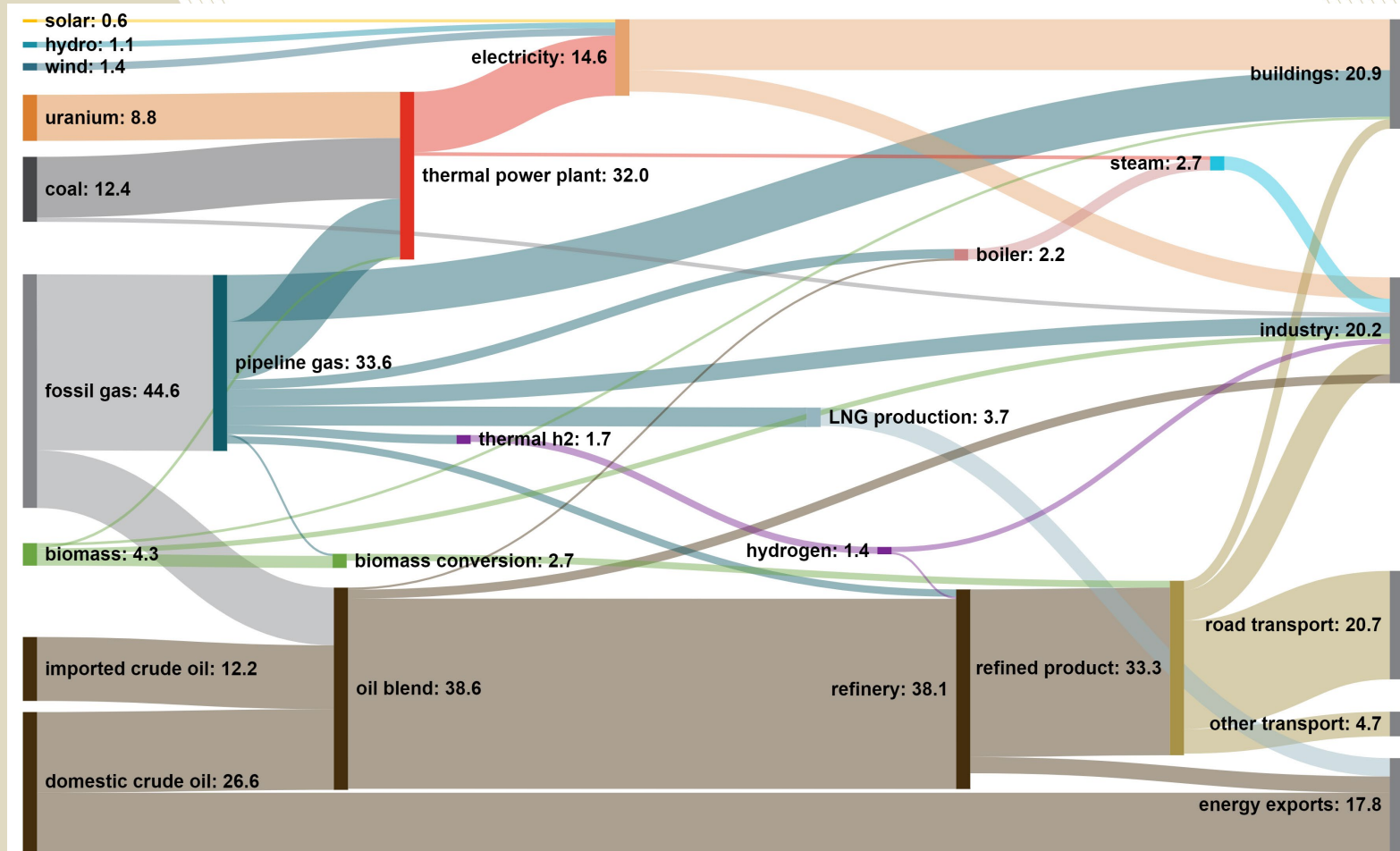
Jobs, Existing Infrastructure

U.S. Energy System – Supply View

Estimated U.S. Energy Consumption in 2020: 92.9 Quads

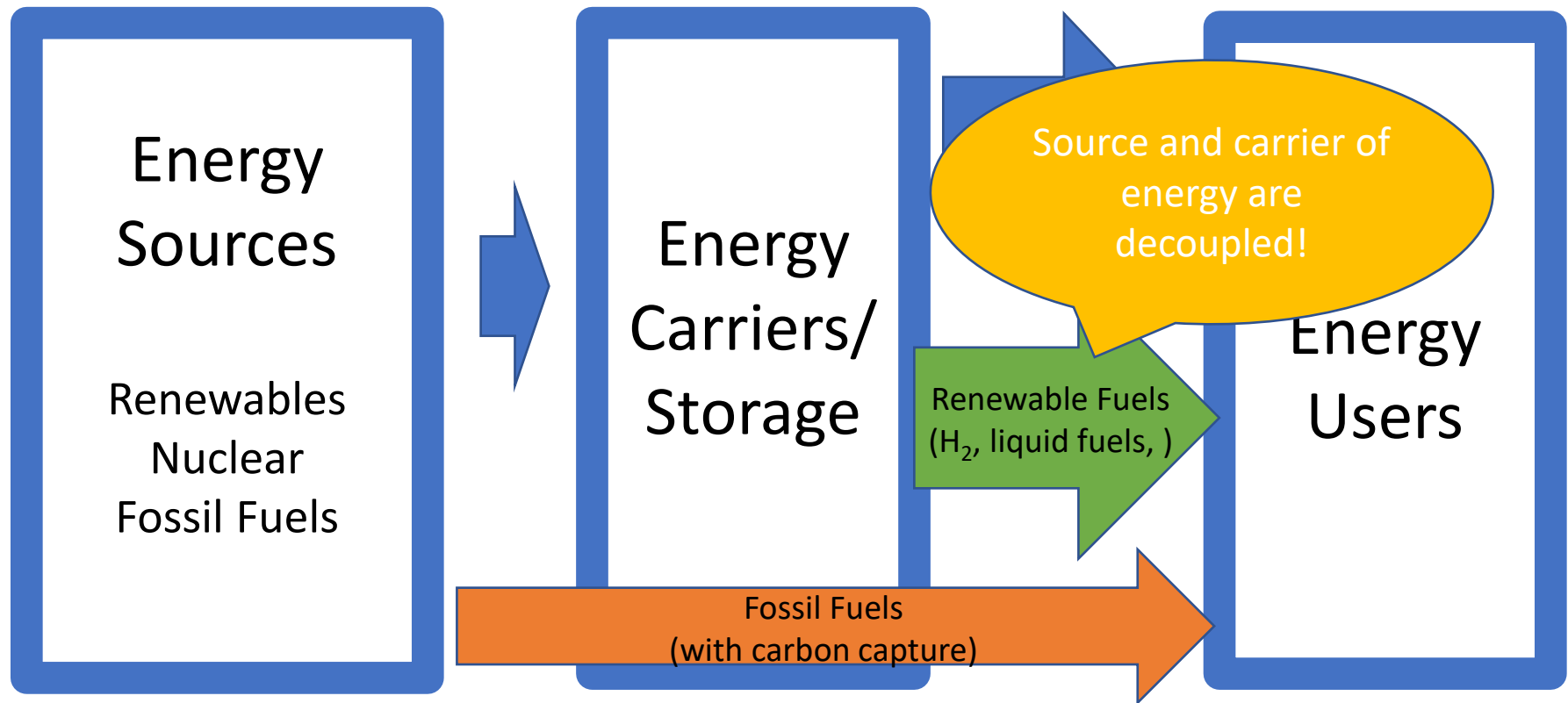


US Energy System – Another view (2021)

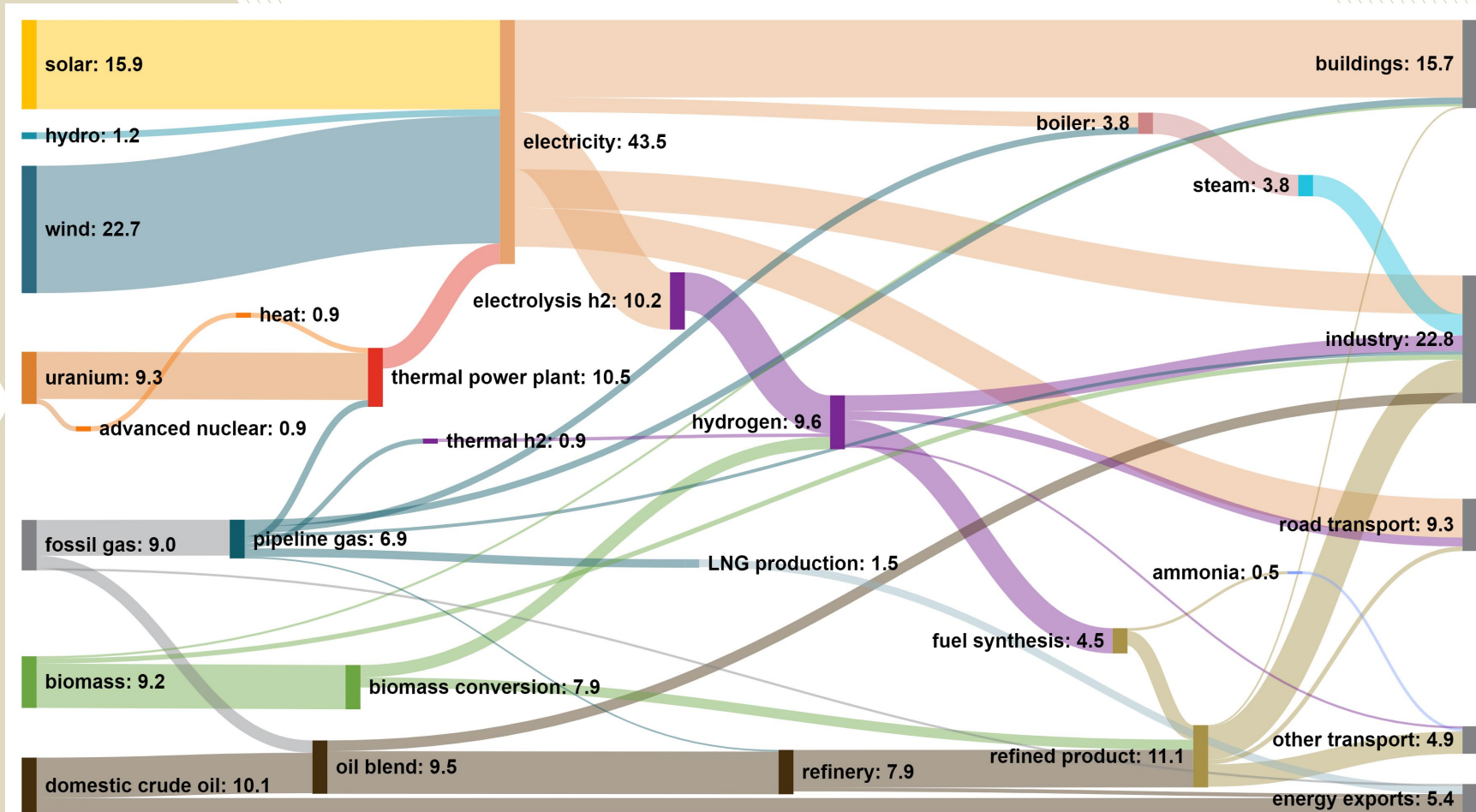


Haley, B., Jones, R.A., Williams, J.H., Kwok, G., Farbes, J., Hargreaves, J., Pickrell, K., Bentz, D., Waddell, A., Leslie, E., Annual Decarbonization Perspective: Carbon Neutral Pathways for the United States 2022. Evolved Energy Research, 2022.

US Energy System – What will the net-zero CO₂ system look like?

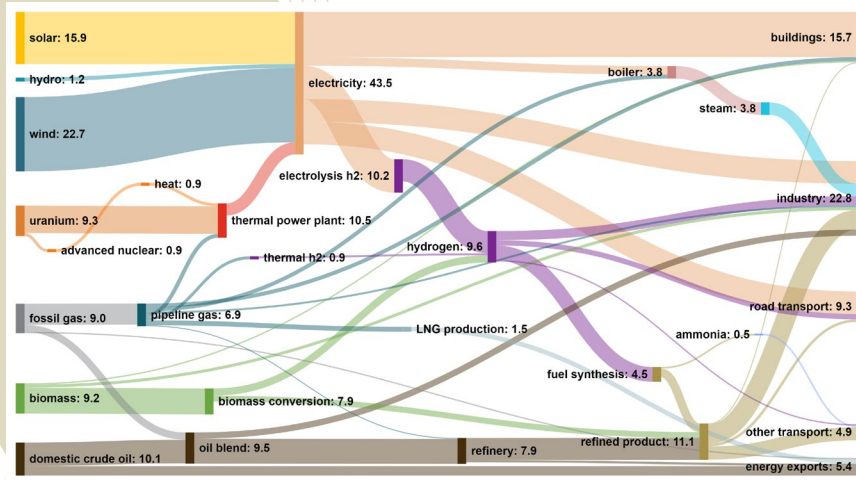


2050 – Net Zero (Central Scenario)



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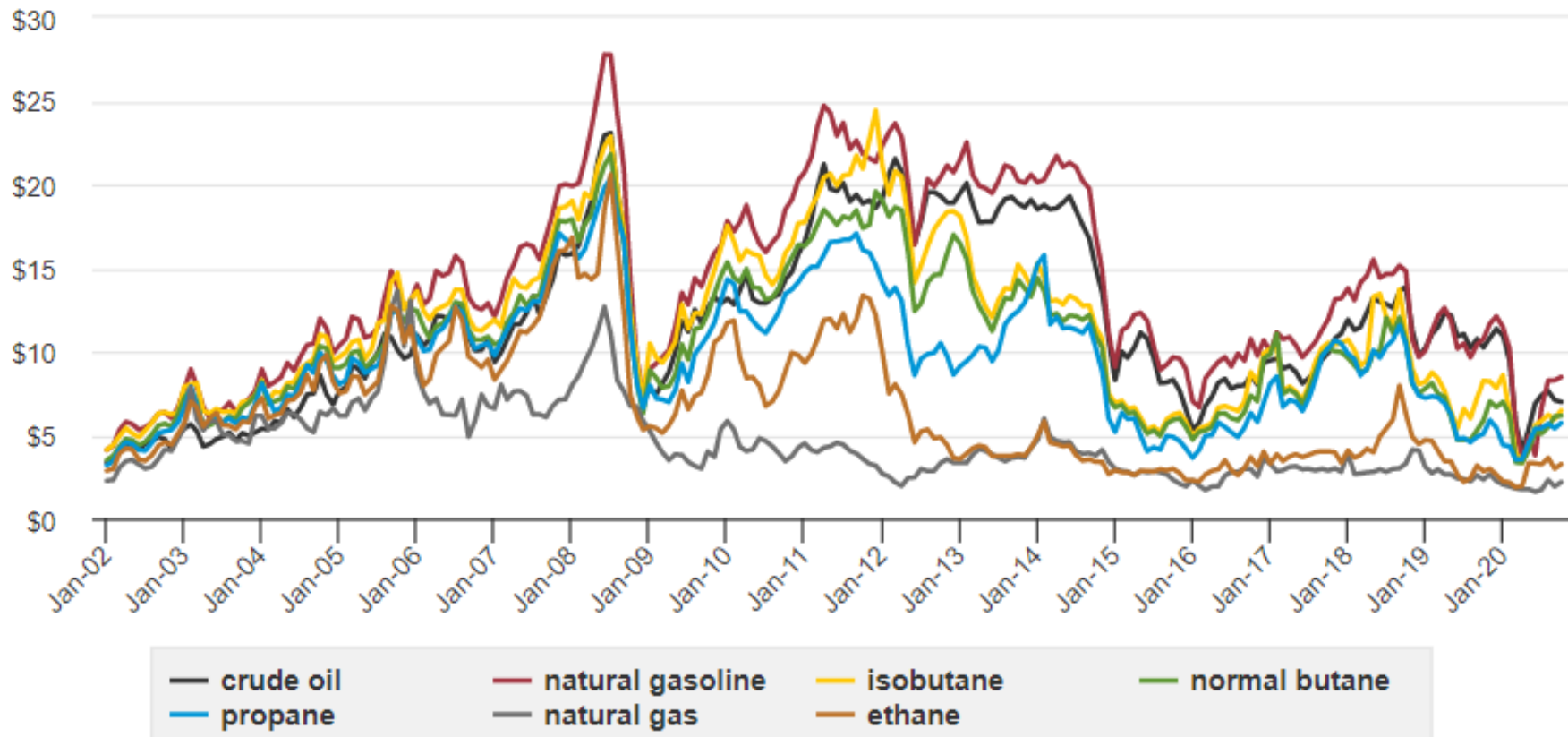


- Hydrogen
- Natural Gas
- Electricity
- Liquid Fuels

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Structural Pricing Differences Between Energy Sectors

dollars per million British thermal units



Note: Prices are monthly average of close-of-day spot prices; crude oil is Brent; natural gas is Henry Hub; HGL products are at Mt. Belvieu non-LST (Lone Star Terminal).

Source: U.S. Energy Information Administration from Bloomberg



Source: [eia.gov/energyexplained/hydrocarbon-gas-liquids/prices-for-hydrocarbon-gas-liquids.php](https://www.eia.gov/energyexplained/hydrocarbon-gas-liquids/prices-for-hydrocarbon-gas-liquids.php)

Date: February 19, 2021

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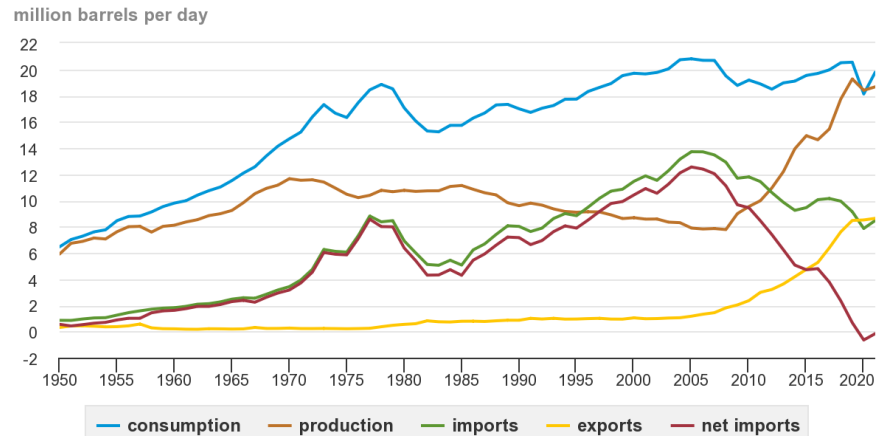
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Global Interactions and Geopolitics

- US is energy independent in so far as electric power generation
 - Pricing decoupled from electricity prices globally
 - Caveats: LNG exports effects on natural gas prices
- Oil: US is net exporter, but also a major importer and prices fully coupled to global markets
- Energy security issue is coupled to transportation, oil imports

U.S. petroleum consumption, production, imports, exports, and net imports, 1950-2021



Data source: U.S. Energy Information Administration, *Monthly Energy Review*, Table 3.1, March 2022, preliminary data for 2021

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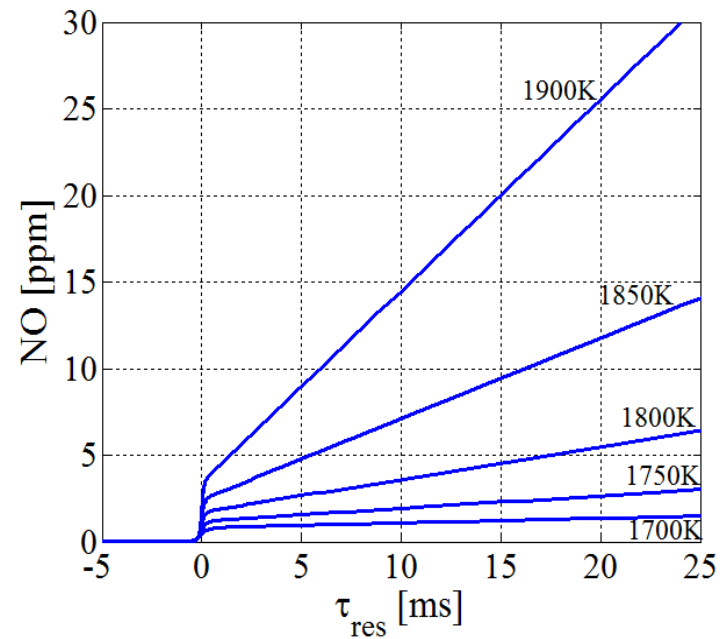
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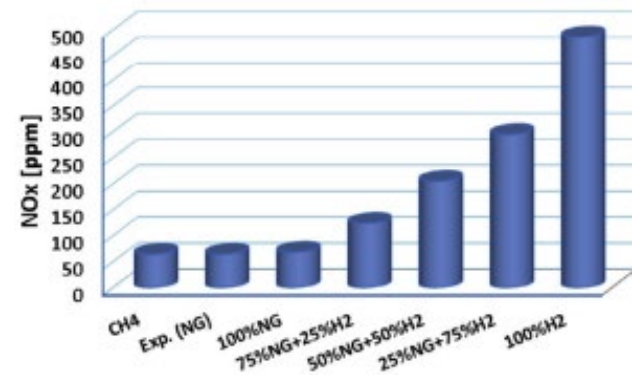
Environmental Justice –Hydrogen Combustion

- NO is a regulated pollutant; leads to smog and respiratory issues
- Heating up air ($N_2 + O_2$) leads to NO production, even from 100% renewable fuels



Environmental Impacts of H₂ Combustion

- “When hydrogen is burned it emits little or no carbon dioxide — that’s the good news. The bad news is that hydrogen combustion produces dangerously [high levels of nitrogen oxides](#) – scientific studies indicate that burning hydrogen could produce NO_x levels [six times higher](#) than burning methane.”
<https://morningconsult.com/opinions/dont-fall-for-the-hydrogen-hype/>
- “The bad news is that H₂ combustion can produce dangerously high levels of nitrogen oxide (NO_x). Two European studies have found that burning hydrogen-enriched natural gas in an industrial setting can lead to NO_x emissions up to **six times that of methane** (the most common element in natural gas mixes). There are numerous other studies in the scientific literature about the difficulties of controlling NO_x emissions from H₂ combustion in various industrial applications.”
<https://www.renewableenergyworld.com/hydrogen/hydrogen-hype-in-the-air/#qref>
- HOWEVER,....
 - Absolute vs. relative effects?
 - Results from “old-fashioned”, high NO_x devices; need for data in modern lean, premixed configurations
- At this point, it appears that NO_x emissions from H₂ combustion can be managed to similar levels, but work ongoing...



*Reference: Mehmet Salih Celtek , Ali Pınarbası,
“Investigations on performance and emission characteristics
of an industrial low swirl burner while burning natural gas,
methane, hydrogen-enriched natural gas and hydrogen as
fuels”*

Environmental Justice – Carbon Capture

GEOENGINEERING 101

CARBON CAPTURE AND STORAGE



CLIMATE JUSTICE ALLIANCE
COMMUNITIES UNITED FOR A JUST TRANSITION

An Array of False Solutions

Carbon Capture and Storage

In Carbon Capture and Storage (CCS), carbon dioxide (CO₂) is collected from industrial smokestacks, compressed into a liquid and transported by pipeline to a site where it can be pumped underground for storage in saline aquifers, oil or gas reservoirs, or beneath the ocean. This is a dangerous practice. There is no guarantee the CO₂ will stay underground. Imagine, for example, an earthquake under a CCS storage site that causes a release of large amounts of CO₂ into the atmosphere.

CCS was developed over 40 years ago for use in enhanced oil recovery (EOR), a practice in which oil companies pump liquid CO₂ into old, nearly depleted wells to access deep pools of

the environment and atmosphere when these products are incinerated or decompose. This is (at best) postponing the problem of CO₂ emissions and perpetuating the problem of acute environmental injustice from these polluting operations. CCUS creates more emissions than it reduces² and contributes to the production of plastics and other polluting materials. Even if some of the emissions are temporarily captured, all the problems with CO₂ storage remain.

Direct Air Capture: The New False Hope

Direct Air Capture (DAC) is a largely theoretical technique to remove CO₂ (and potentially other greenhouse gases) directly from the atmosphere, using chemical and mechanical means. The current proposed technique would use large fans to move air through a filter, where it passes through a chemical adsorbent to produce a pure CO₂ stream that could be stored. To have any significant effect on global CO₂ concentrations,

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- Health co-benefits of evolving transport sector could be large
- What if health impacts associated with regulated pollutants (NO_x, SO_x, PM, etc.) were incorporated into least cost decision making around transport infrastructure?
 - Toronto study – if 100% EV and all EVs charged with non-emitting energy sources prevents 330 premature deaths per year (\$3.8 Billion in 2016\$CAD in social benefits).²

²Gai, Y., Minet, L., Posen, I. D., Smargiassi, A., Tétreault, L.-F., & Hatzopoulou, M. (2020). Health and climate benefits of Electric Vehicle Deployment in the Greater Toronto and Hamilton Area. *Environmental Pollution*, 265, 114983. <https://doi.org/10.1016/j.envpol.2020.114983>

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Thank You

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