



Electricity Generation and CO₂ Pipeline Requirements

Jack Lewnard, Program Director

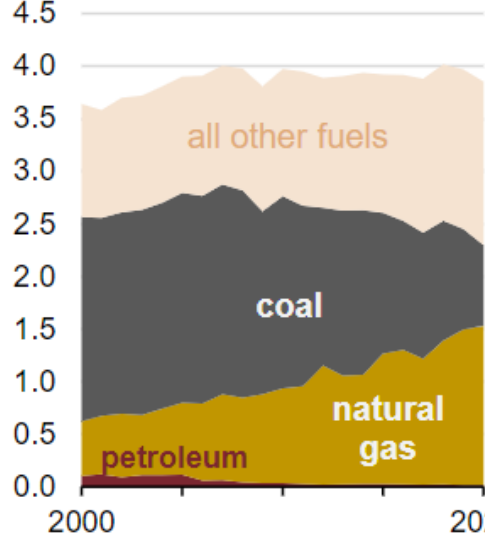
Jack.lewnard@hq.doe.gov

Evolving Fossil Fuel Mix for Electricity

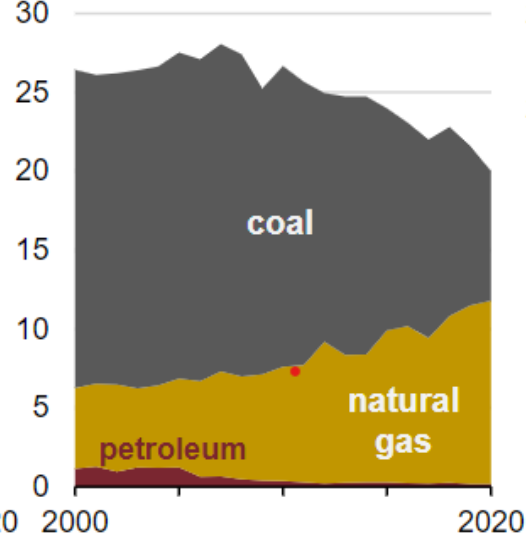
U.S. power sector electricity generation, energy consumption, and carbon dioxide (CO₂) emissions of selected fuels (2000–2020)



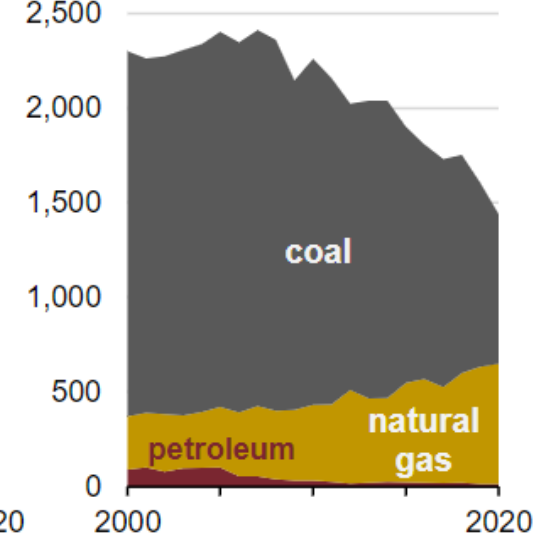
electricity generation
billion megawatthours



energy consumption
quadrillion British thermal units



CO₂ emissions
million metric tons



Source: U.S. Energy Information Administration, *Monthly Energy Review*

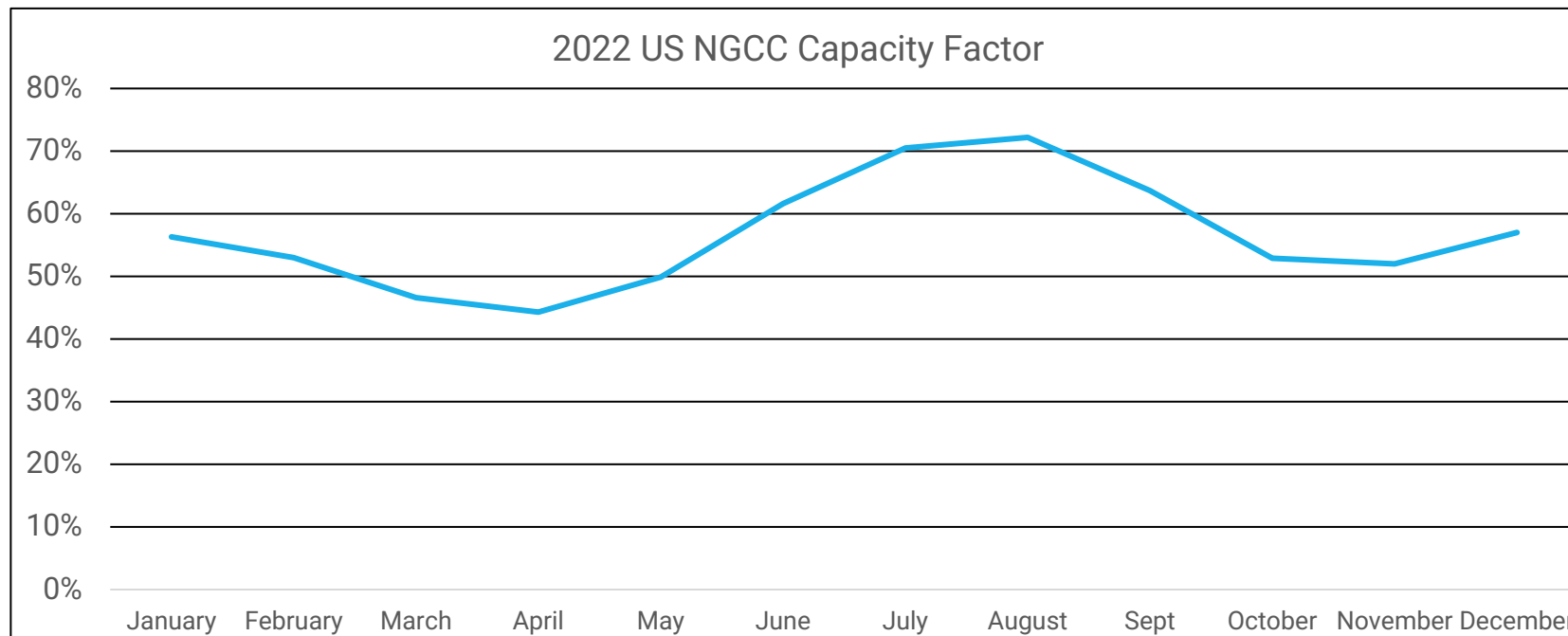
- ▶ Coal – declining
 - Baseload plants operate 24X7
- ▶ Natural Gas – increasing
 - Some baseload plants
 - Most plants operate intermittently
 - Renewables further reduce NGCC operating hours

Electric Market Imposes Intermittency

- ▶ “In 2019, the average number of starts for combined cycle plants was 39 per year. Just three years later, it's likely to hit 70, and the average could break 100 by 2023.”

Power Magazine, Aug 1, 2022

- ▶ NGCCs may ramp up/down while operating



CO₂ Pipelines for Natural Gas Combined Cycle Plants

- ▶ NGCC plants present multiple challenges
 - Plants will be large
 - 300-1000+ MW; 150-500+ tons/hr CO₂
 - Plants will operate intermittently
 - Start up to full load in 30 min
 - Load changes up to 10%/minute
 - Plants will likely all start and stop at similar times
 - Note – CCS systems have slower dynamics than NGCC plants, but will ultimately load follow faster than today

Some Specific Challenges

- ▶ Lack of experience with Flue Gas CO₂
 - CO₂ in pipelines today from O₂-free sources (natural gas processing, geologic CO₂ reservoirs)
 - Flue gas CO₂ from oxidizing environment, with trace O₂ (vs no free oxygen), SO_x (vs H₂S) and NO_x
- ▶ Very difficult to maintain CO₂ purity in intermittently operating plants
 - “Trace” species (O₂, H₂O, SO_x, NO_x) negatively impact corrosion and phase behavior
 - Trace species concentrations typically vary widely during start-up and shutdowns
 - Proposed ppm levels for O₂ and H₂O may require very expensive CO₂ polishing steps
- ▶ Variable CO₂ flowrates may stress pipelines, need hydraulic modeling
 - CO₂ injected as a dense supercritical fluid. Rapid flow changes could “water hammer” pipes/compressor-pumping stations
 - Compressor/pumping stations will also need to be designed for intermittent operation.
 - Plants may be offline for hours, days, weeks; stagnant pipes with little to no flow. See <https://www.osti.gov/servlets/purl/1176874>

CO₂ Dispersion Modeling

- ▶ Setbacks for CO₂ appurtenances
 - Power plant CO₂ compressor stations, Dehy units, Gate/metering stations
 - Impact of CO₂ equipment adjacent to facilities' CO₂ sources like boilers, chemical process units, etc.
 - CO₂ releases include vapor clouds and possibly pressure waves.
 - CO₂ could extinguish flames, leading to release of uncombusted fuel in fired equipment
 - CO₂ dispersion in wind-restricted areas could slow dispersion
- ▶ Recommend starting with a HAZOP analysis for generic industrial/power plant facilities, and then establishing safety requirements