JISEA Joint Institute for Strategic Energy Analysis

Scenarios of a Sustainable Energy Transition: Perspectives from the U.S.

2021 International Institute for Carbon-Neutral Energy Research (I^2CNER) Annual Symposium

A Virtuous Circle: Embedding the Energy Transition in Post-COVID-19 Recovery

26 January 2021 (Virtual)

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Outline

1. Overview of NREL and JISEA
2. U.S. Energy and Impact of COVID
3. Future Scenarios of U.S. Energy Use
4. Perspective on Post-COVID Future

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17 U.S. Department of Energy National Laboratories

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U.S. DEPARTMENT OF ENERGY

National Renewable Energy Laboratory

Mission: NREL advances the science and engineering of energy efficiency, sustainable transportation, and renewable power technologies and provides the knowledge to integrate and optimize energy systems.

Example Technology Areas:

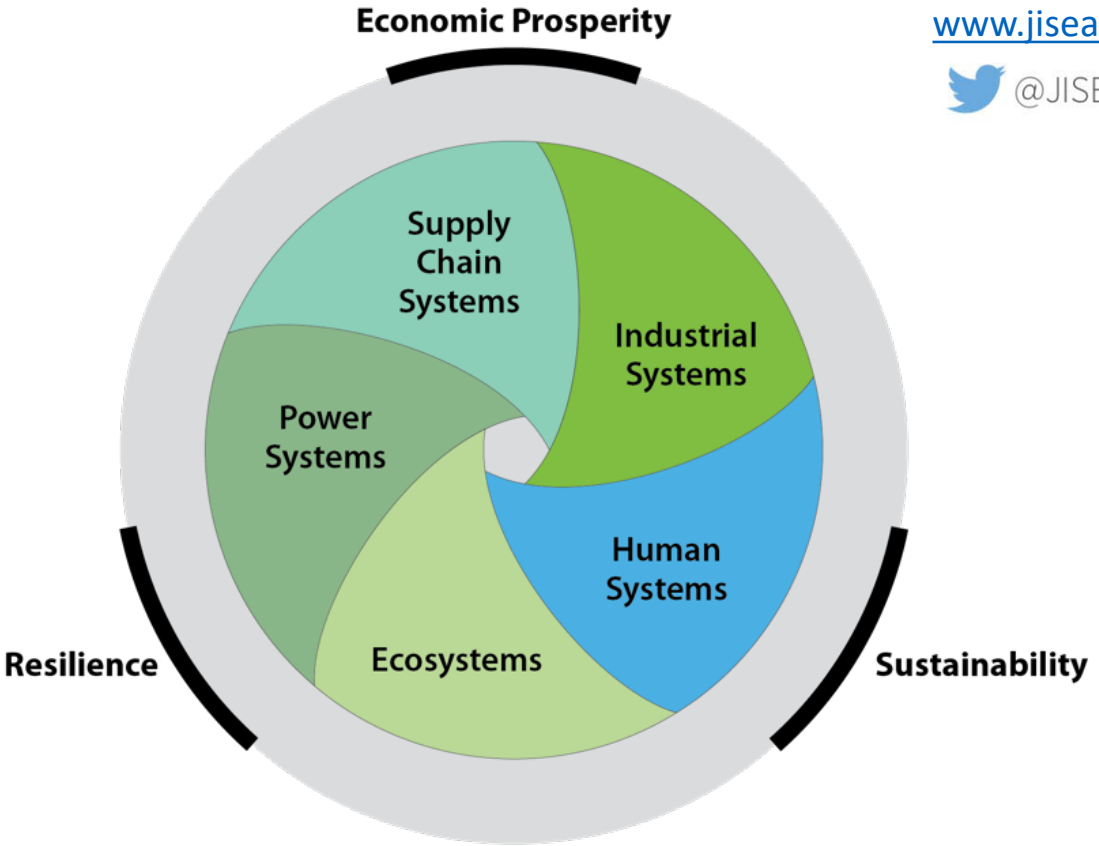
www.nrel.gov/about

- 2,900 employees and postdoctoral researchers, interns, and visiting professionals
- 327-acre main campus in Golden & 305-acre Flatirons Campus with National Wind Technology Center 13 miles north
- 69 R&D 100 awards. More than 1,000 scientific and technical materials published annually

JISEA

Joint Institute for Strategic Energy Analysis

Connecting technologies, economic sectors, and continents to catalyze the transition to the 21st century energy economy.



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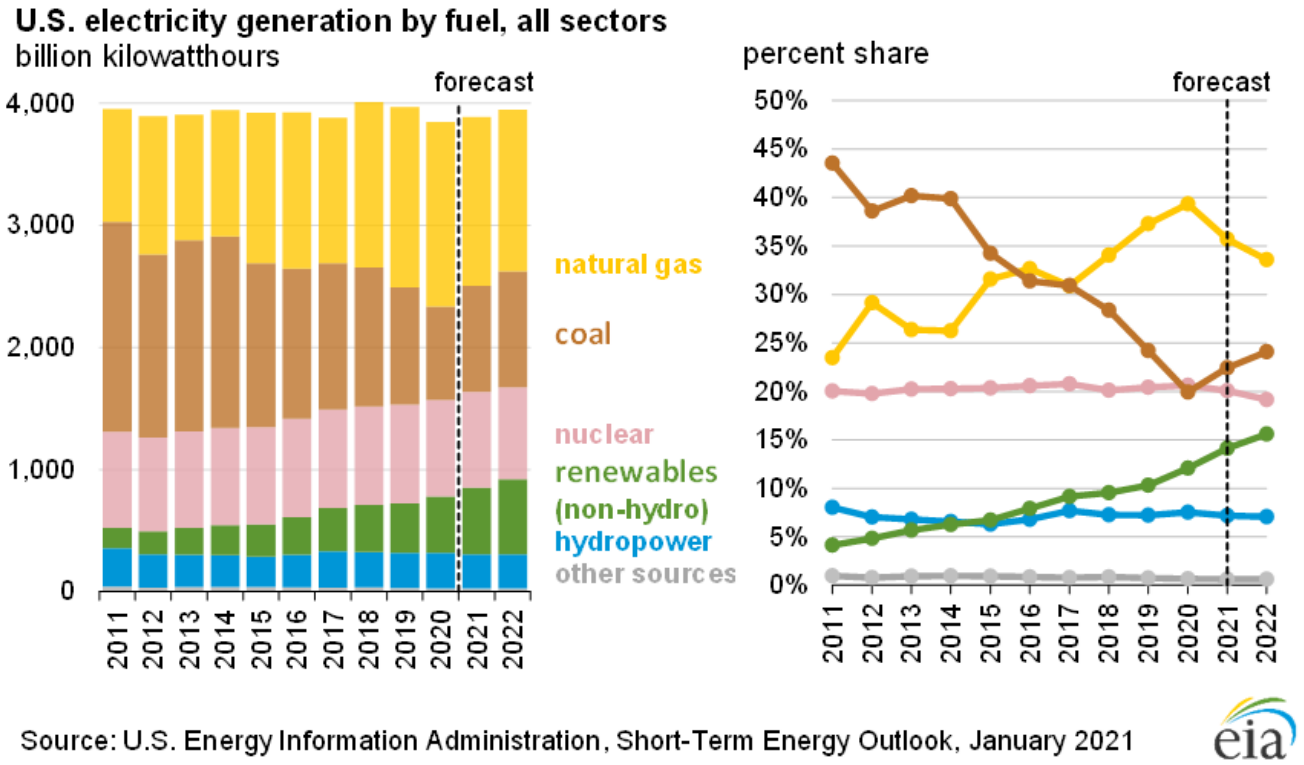
U.S. Electric power generation and percent share



Source: U.S. Energy Information Administration, Short-Term Energy Outlook, January 2021

In 2019, renewable energy—not including hydropower—generated 11% of total U.S. electricity
(about 7% wind, 2% solar, 1.5% biomass, 0.5% geothermal)

With hydropower, renewable electricity was ~18%

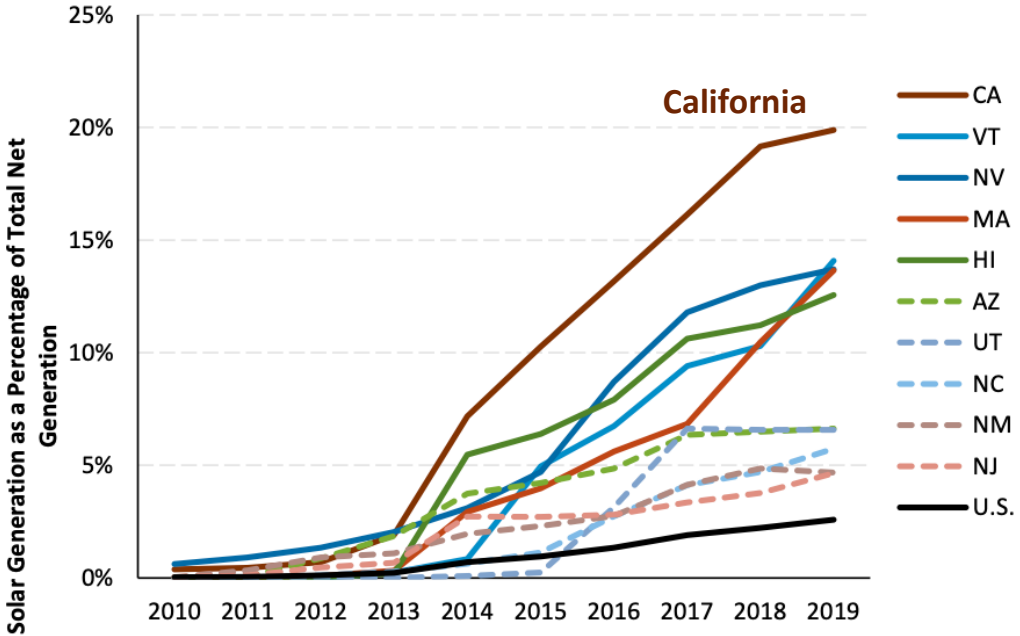
Natural gas power was ~38%

COVID Impact: January-June 2020, renewable electricity = 22.2% (wind 9.1%, solar 3.4%) with natural gas = 39.2% and coal = 16.9%.

Source: https://www.eia.gov/outlooks/steo/data.php?type=figures

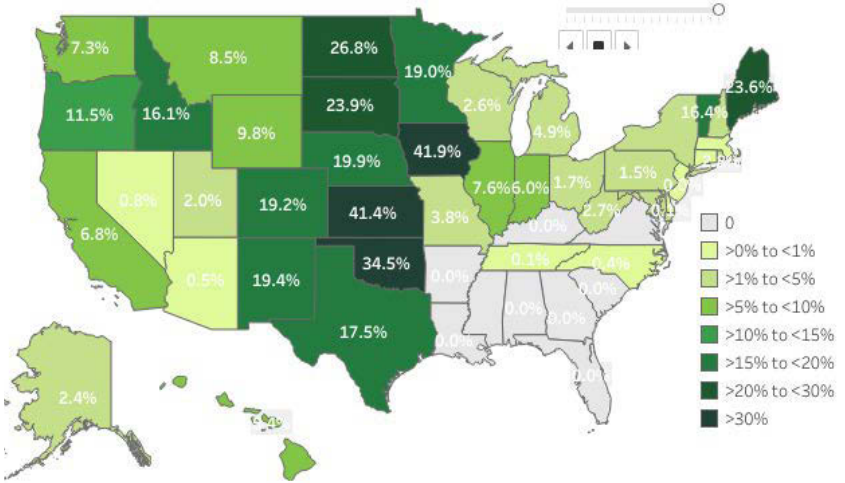
Side Note: Generation varies significantly by location

Solar Generation as a % of Total by U.S. State, 2010-2019



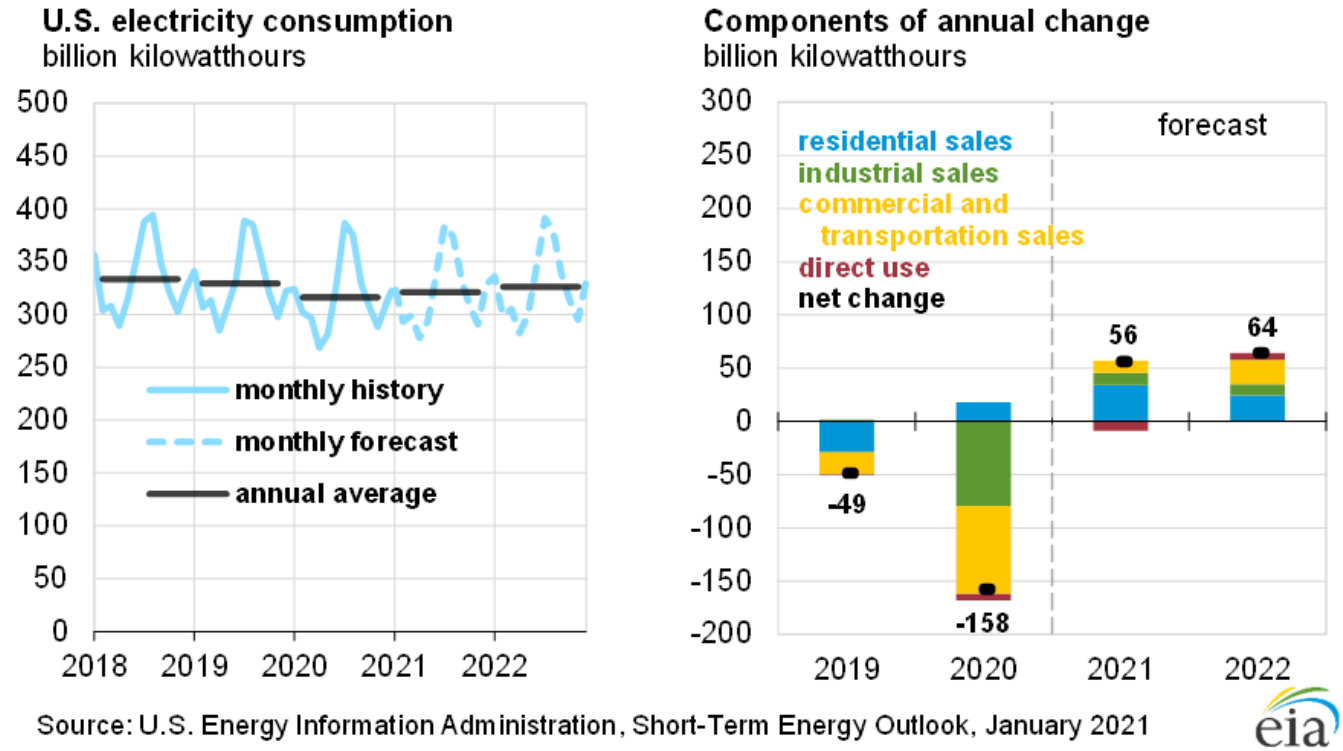
Source: NREL, Q4 2019/Q1 2020 Solar Industry Update, May 2020.

Wind Energy's Share of State Electricity Generation, 2019



Source: AWEA, https://www.awea.org/wind-101/basics-of-wind-energy/wind-facts-at-a-glance

U.S. Electric power generation



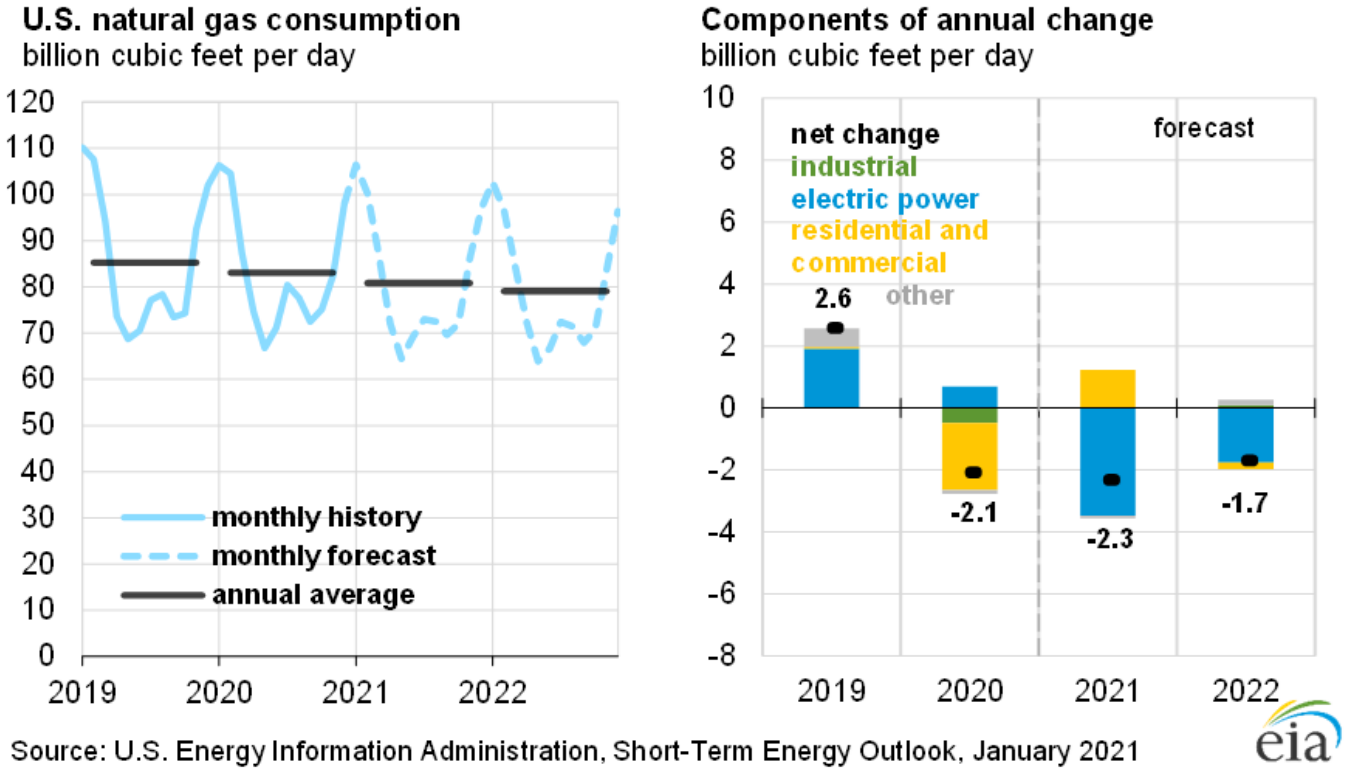
In 2020, electricity demand declined 3.5-4% for the U.S. compared to 2019. Demand down 13% in April relative to previous years

Decline in power demand in commercial and industrial sector was 6-8%, with small increase in residential (1.3%)

Expected to partly recover by 2022

Source: EIA, https://www.eia.gov/outlooks/steo/data.php?type=figures; https://www.eia.gov/outlooks/steo/report/
Congressional Research Service, https://crsreports.congress.gov/product/pdf/IN/IN11300;
IEA, https://www.iea.org/reports/electricity-market-report-december-2020/2020-regional-focus-americas#abstrac

U.S. Natural gas consumption

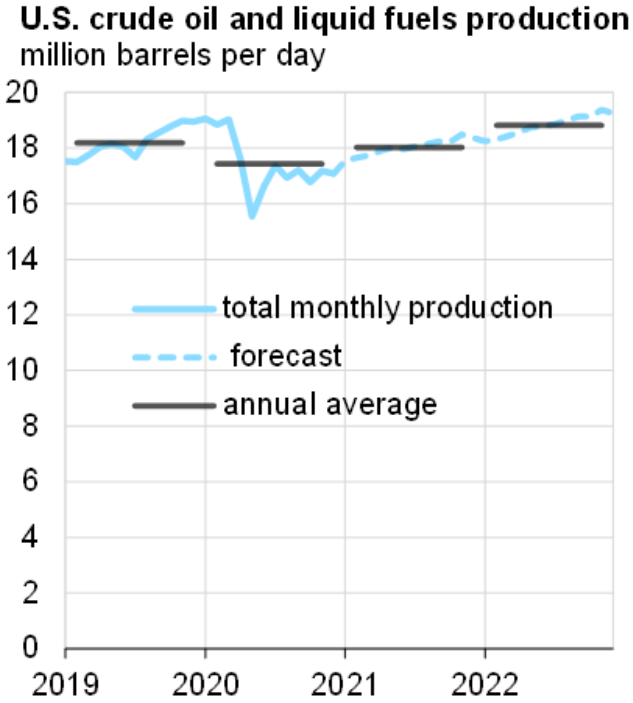


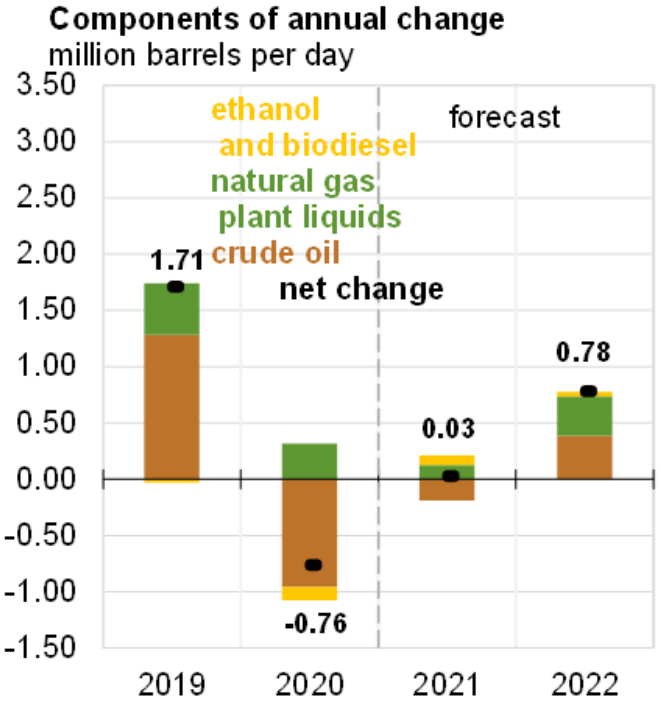
2020 U.S. natural gas consumption down 2.5% from 2019 largely from residential and commercial demand (offset by small increase in demand for power production)

Expected to continue to decline

Source: https://www.eia.gov/outlooks/steo/data.php?type=figures

U.S. oil and liquid fuels production





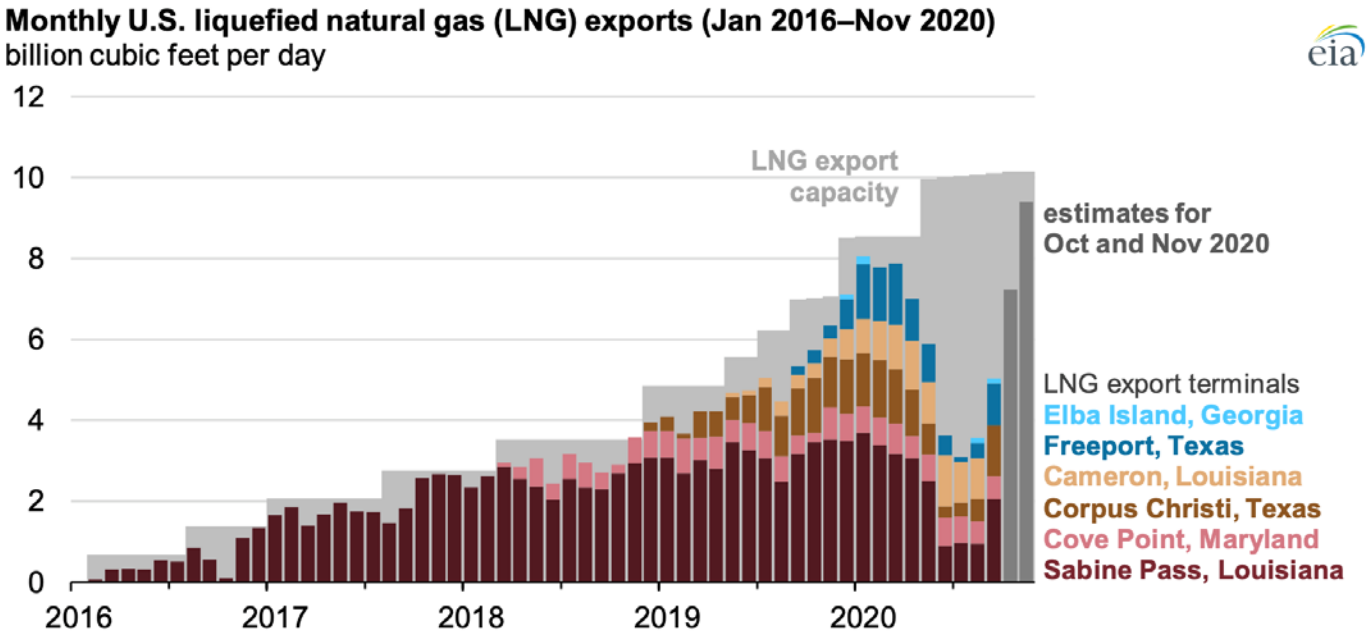
Source: U.S. Energy Information Administration, Short-Term Energy Outlook, January

Source: https://www.eia.gov/outlooks/steo/data.php?type=figures

2020 U.S. liquid fuels production (proxy for consumption) down 12% from 2019 due to decline in transportation and industrial demand

Expected to rebound by 2022

U.S. LNG exports and export capacity

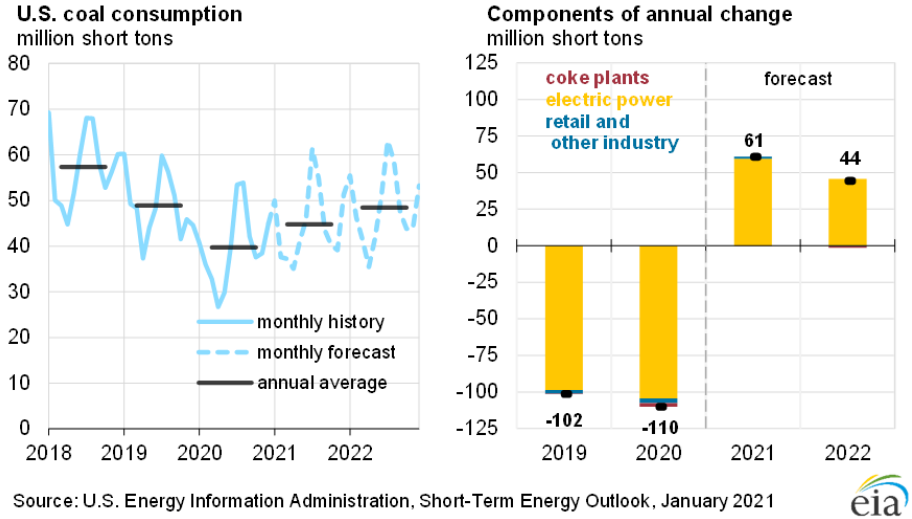


LNG exports declined over 50% during summer 2020 due to decreased international demand and export terminal disruption from hurricanes

Expected to rebound in late 2020 and 2021

Source: EIA, https://www.eia.gov/todayinenergy/detail.php?id=46296

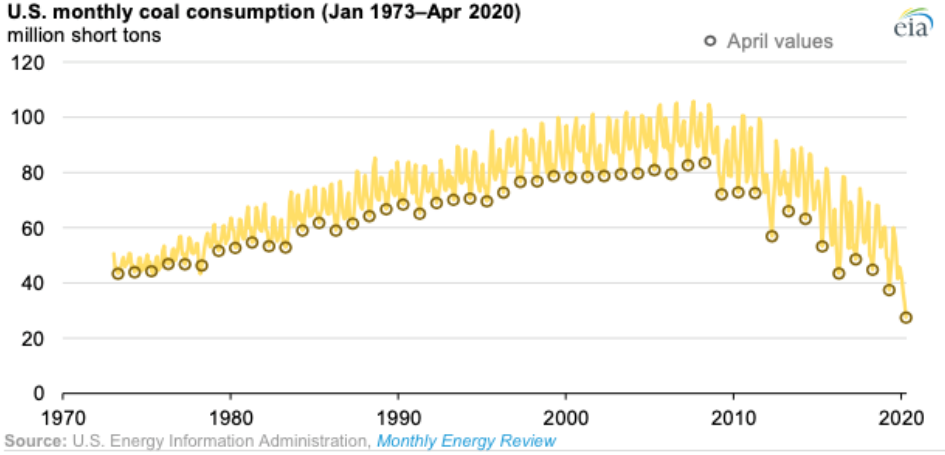
U.S. coal consumption



Source: U.S. Energy Information Administration, Short-Term Energy Outlook, January 2021

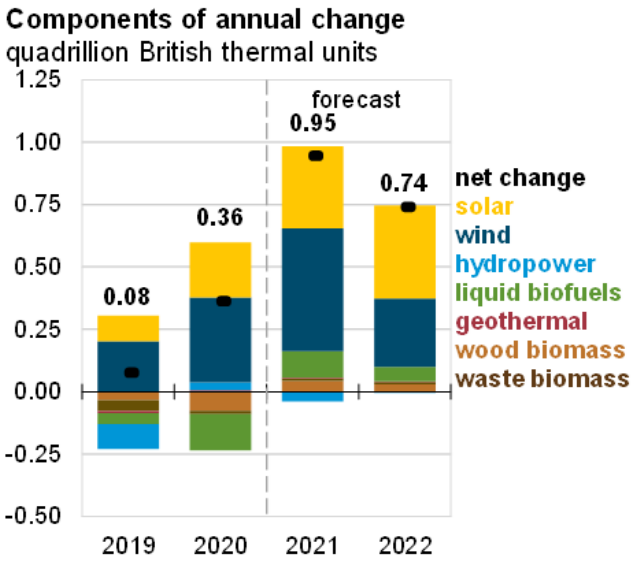
U.S. coal consumption accelerated its decade-long decline in 2020. Consumption in April 2020 was down 27% from April 2019.

Some predict partial recovery in 2021



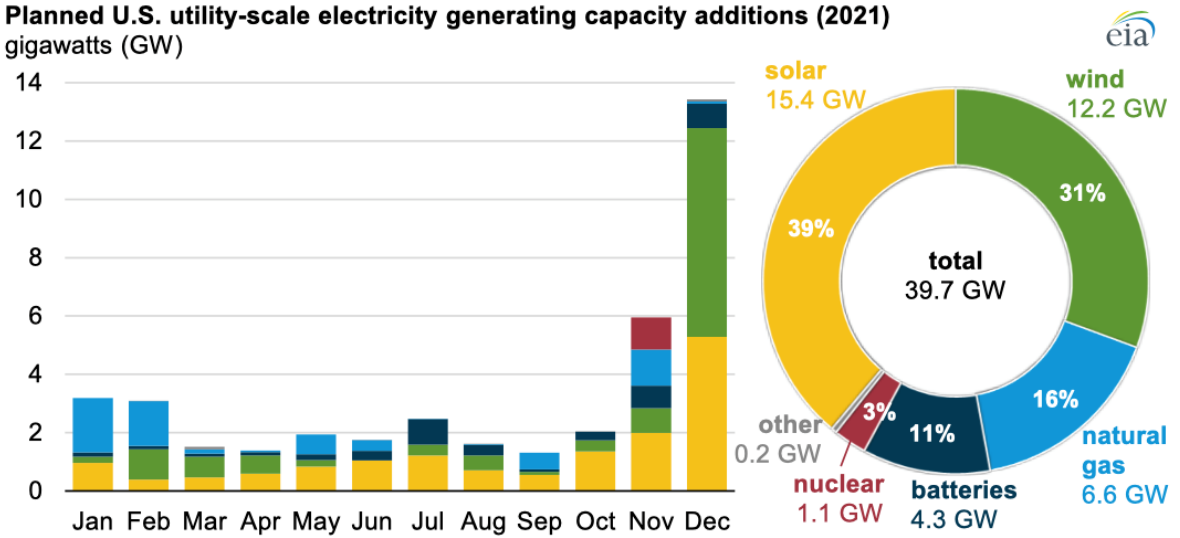
Source: EIA, https://www.eia.gov/outlooks/steo/data.php?type=figures; https://www.eia.gov/todayinenergy/detail.php?id=44556

U.S. Power additions



Solar and wind power capacity continued to grow in 2020

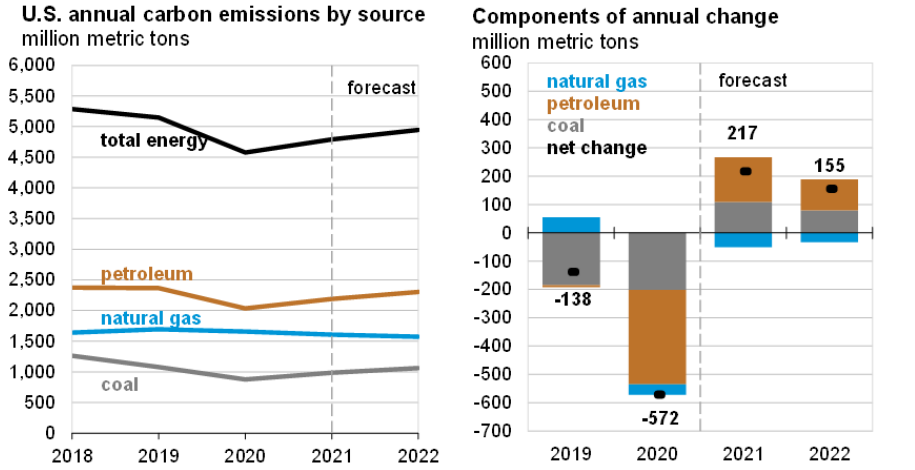
70-75% of the new capacity to be added in 2021 will be low-carbon emission sources



Source: U.S. Energy Information Administration, *Preliminary Monthly Electric Generator Inventory*, October 2020

Source: https://www.eia.gov/outlooks/steo/data.php?type=figures; https://www.eia.gov/todayinenergy/detail.php?id=46416

Impact on U.S. GHG Emissions

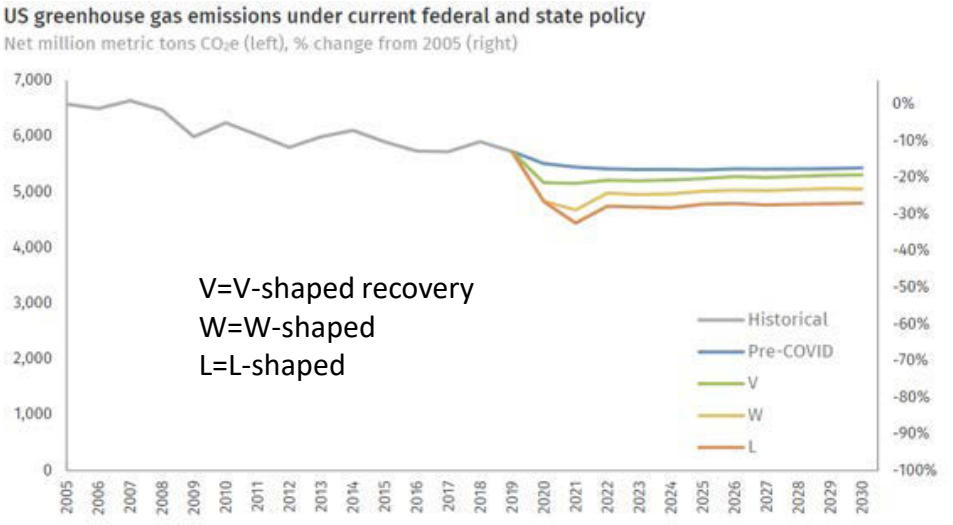


Source: U.S. Energy Information Administration, Short-Term Energy Outlook, January 2021

eia

In 2020, COVID response accelerated U.S. greenhouse gas emissions declines

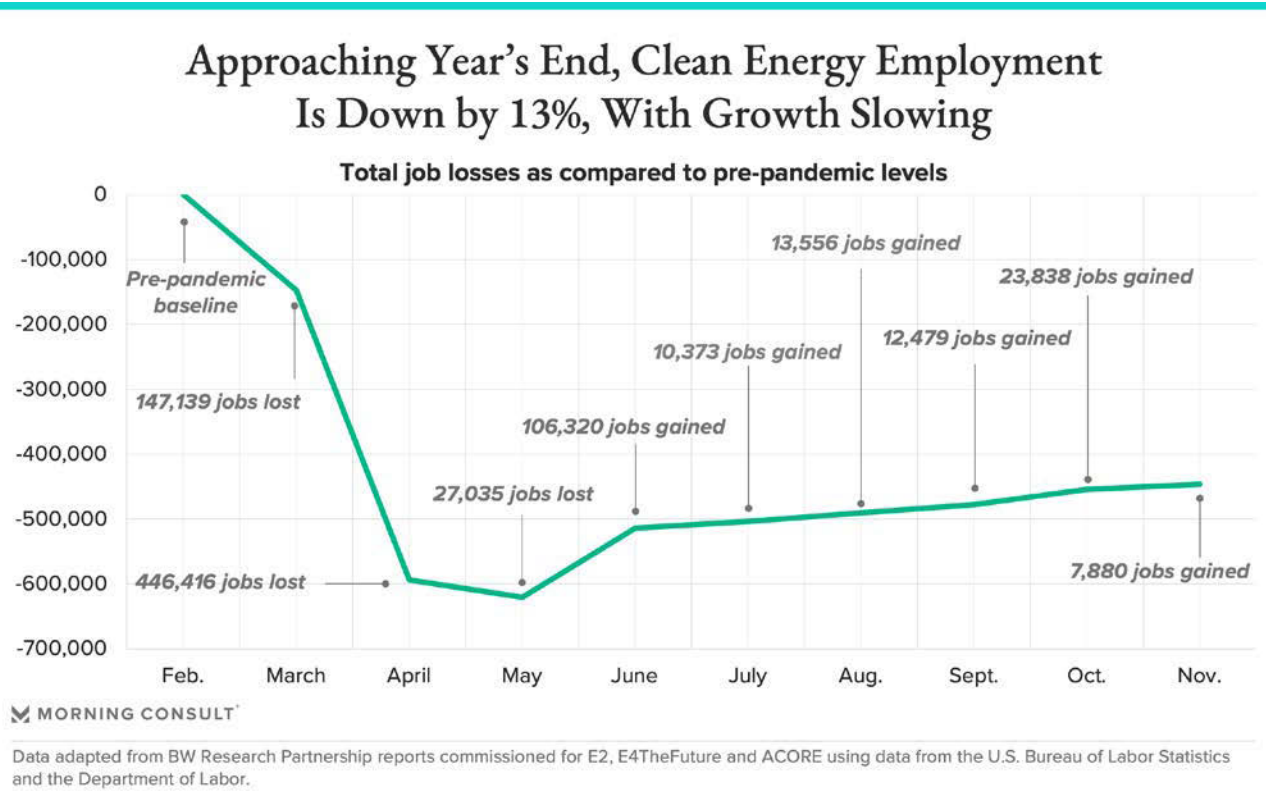
Expected to partially rebound but will decline continue? Is how and where people live, work, and travel changed forever?



Source: EIA, https://www.eia.gov/outlooks/steo/data.php?type=figures

Rhodium Group: https://www.rhg.com/research/taking-stock-2020/

Impact on Clean Energy Employment



Includes energy efficiency, fuels, transmission and distribution, vehicles and power generation

Expected to recover by late 2021-2022

Source: https://morningconsult.com/2020/12/09/clean-energy-jobs-report-november/

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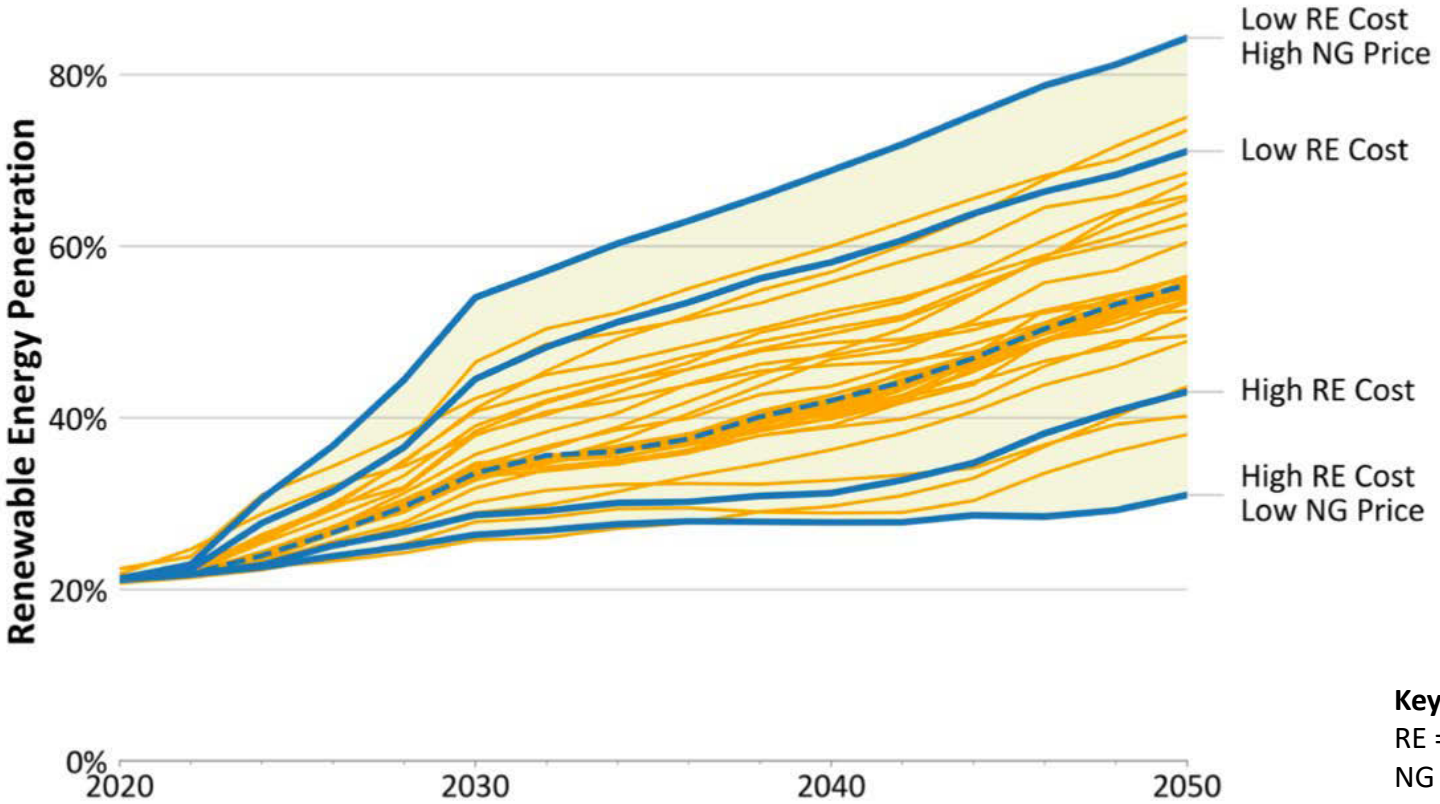
NREL models scenarios of future electricity generation

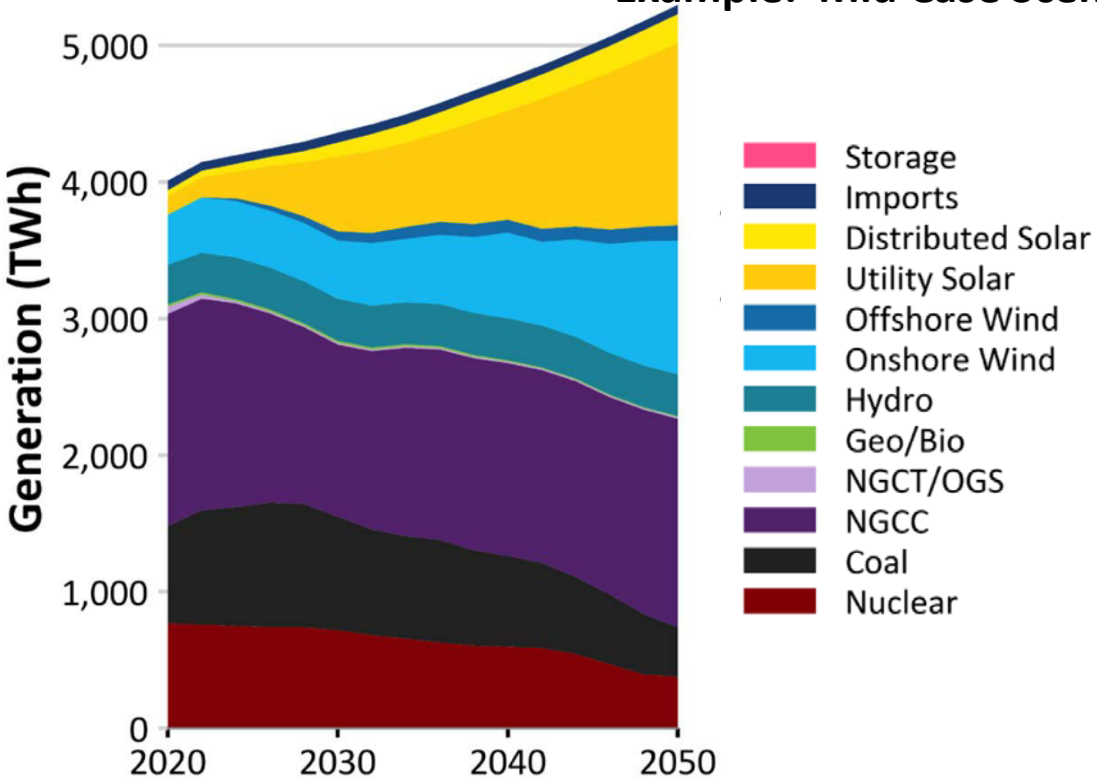


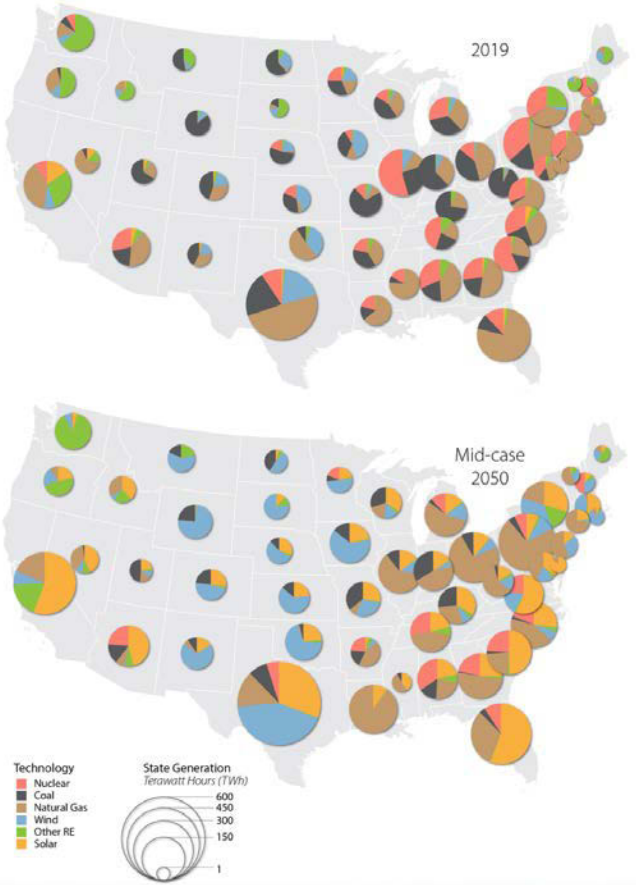
Key:
RE = Renewable Energy
NG = Natural Gas
VRE – Variable Renewable Energy

Generation projections across 45 scenarios: NREL 2020 Standard Scenarios Report: A U.S. Electricity Sector Outlook, https://www.nrel.gov/analysis/standard-scenarios.html

NREL models scenarios of future electricity generation

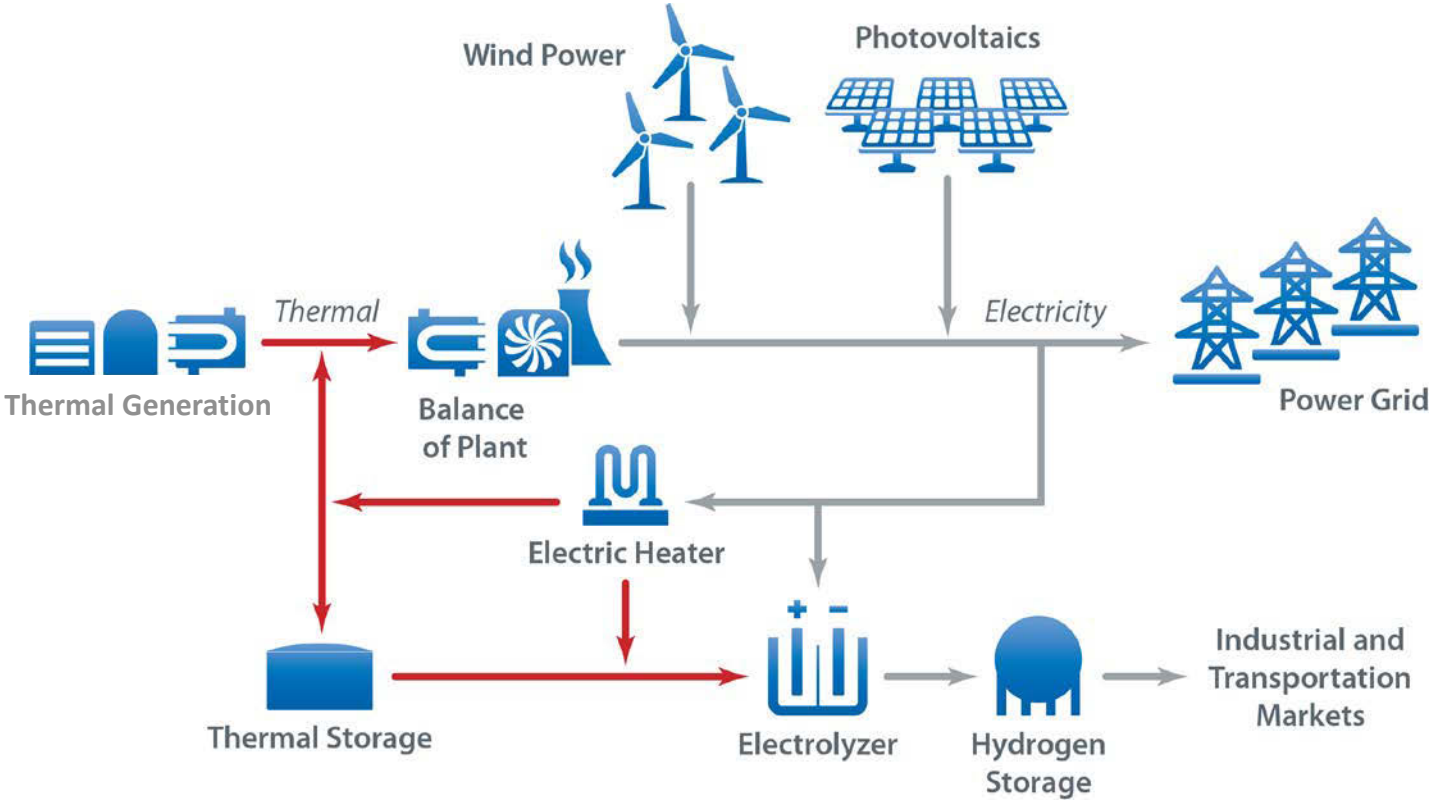
Example: Mid Case Scenario





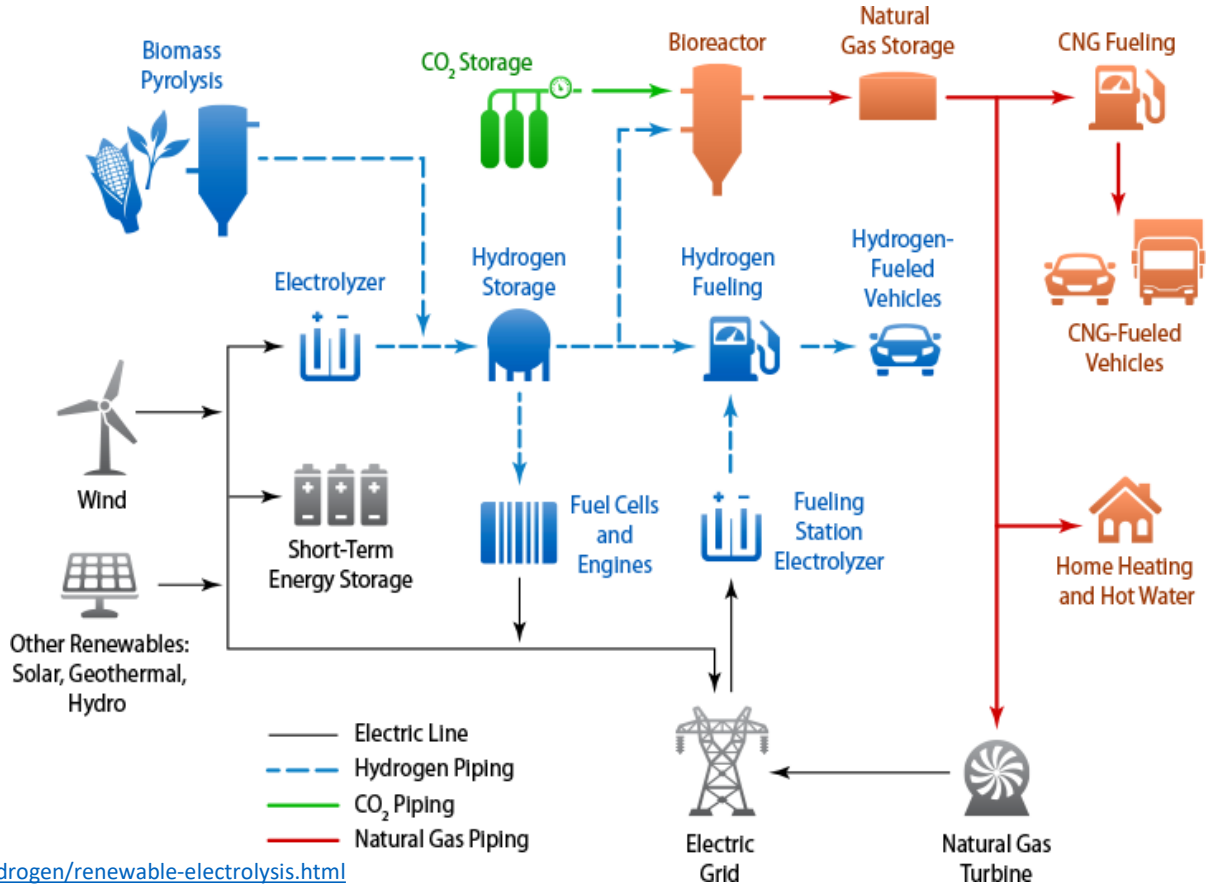
Generation projections across 45 scenarios: NREL 2020 Standard Scenarios Report: A U.S. Electricity Sector Outlook, https://www.nrel.gov/analysis/standard-scenarios.html

Hybrid energy solutions will be needed



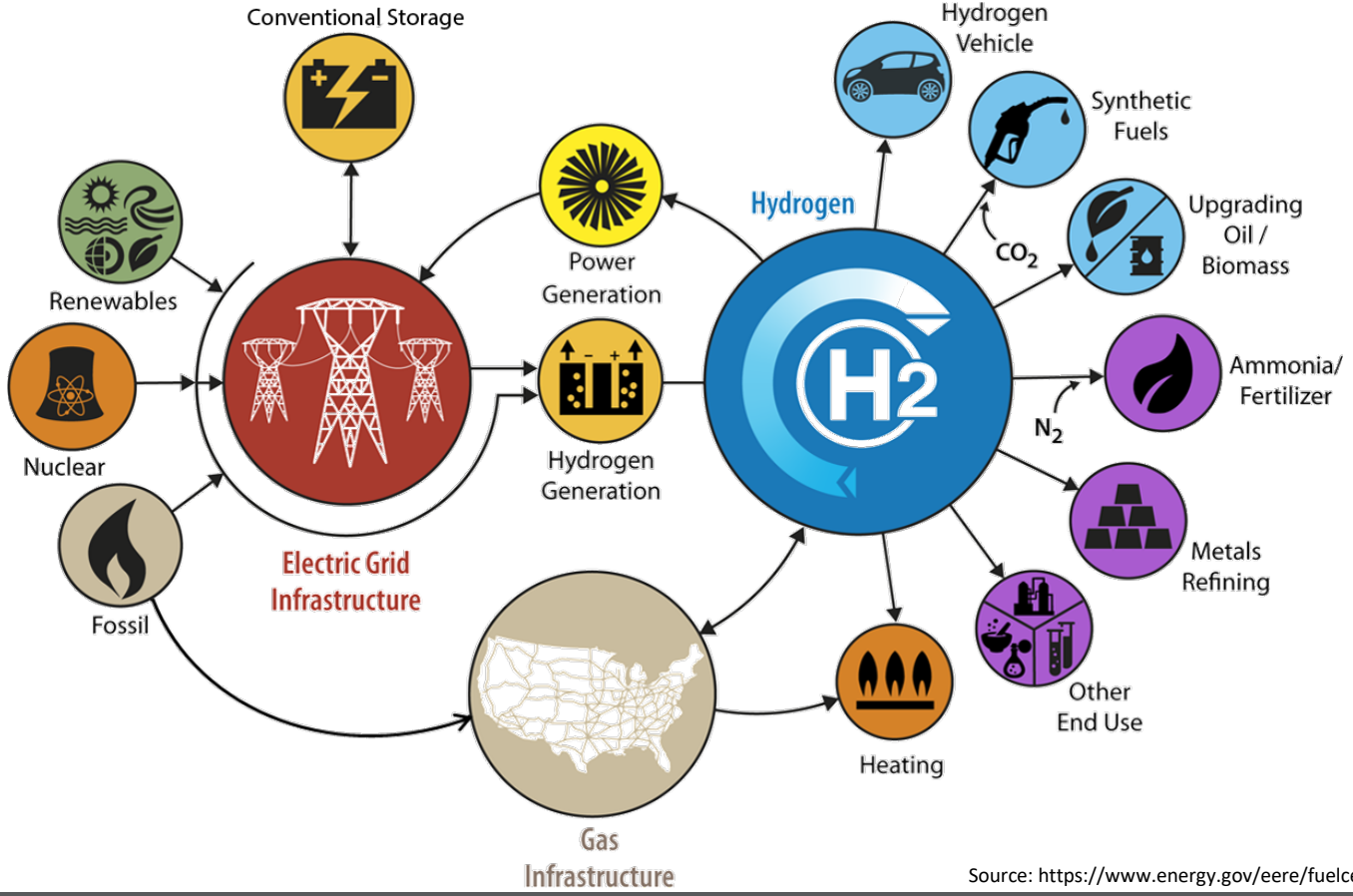
Sources: Ruth et al. 2016; Bragg-Sitton et al. 2016

Integration of renewable & carbon capture systems



Source: https://www.nrel.gov/hydrogen/renewable-electrolysis.html

New fuels for multiple uses: Hydrogen @Scale



Source: https://www.energy.gov/eere/fuelcells/h2scale

Adaptation of current renewable tech to enable growth

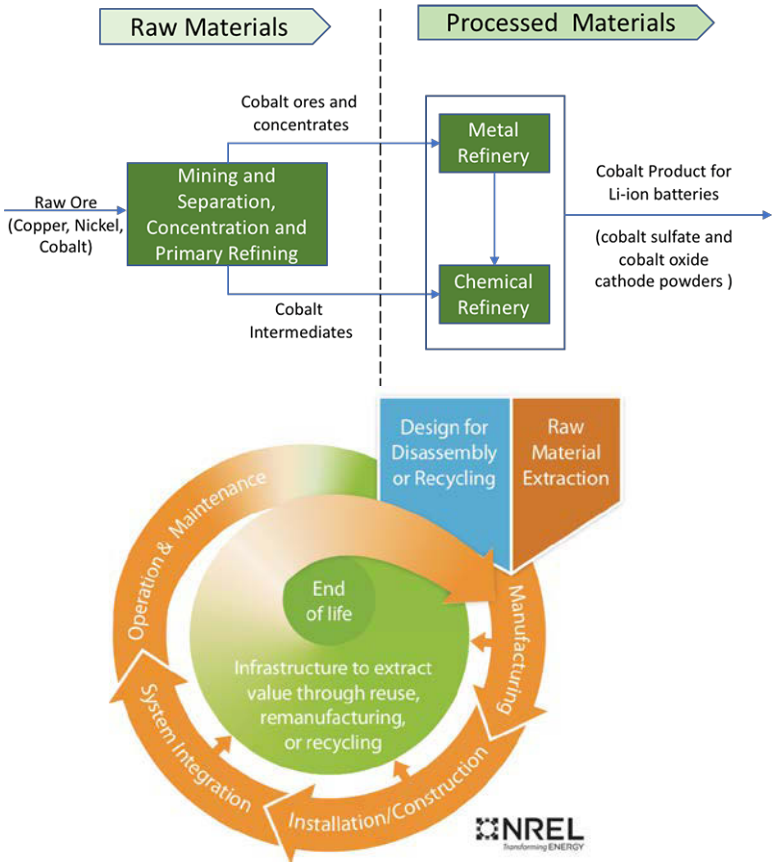
Growing food crops under solar panels and wind turbines provides income to farmers, conserves soils, and increases energy production

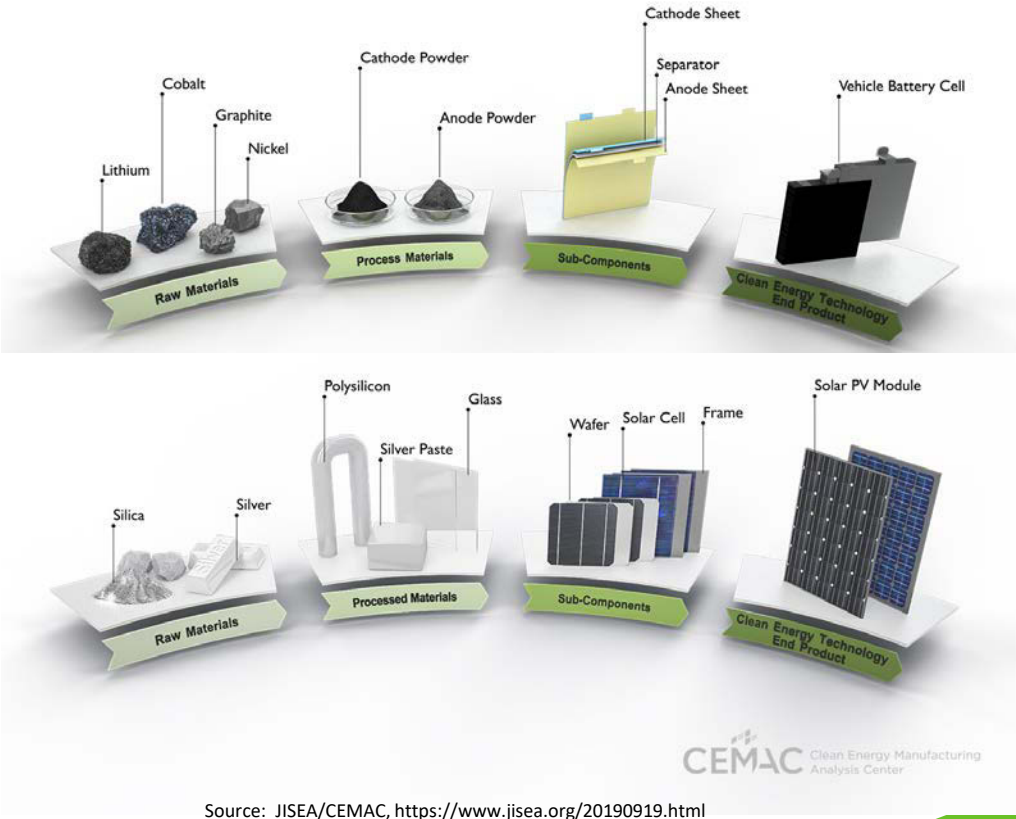
https://openei.org/wiki/InSPIRE

Hypothetical 50-megawatt offshore down-wind facing wind turbine for 25-meter deep waters in Gulf of Mexico

Source: https://www.energy.gov/eere/articles/wind-turbines-extreme-weather-solutions-hurricane-resiliency; https://www.colorado.edu/ecee/2016/02/17/paos-morphing-wind-turbine-inspired-nature

Sustainable materials, supply chains, circular economy





Source: JISEA/CEMAC, https://www.jisea.org/20190919.html

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Select Elements of Biden Energy Plan

- Rejoin the Paris Accord
- Carbon-free power sector by 2035
- Reduce building carbon footprint 50% by 2035
- Economy-wide net-zero emissions by 2050
- Environmental justice, with emphasis on rural and disadvantaged communities
- Climate-smart agriculture
- Modern infrastructure investments, including rail, public transit, building upgrades, water systems, green spaces, broadband communications
- Reverse environmental de-regulation

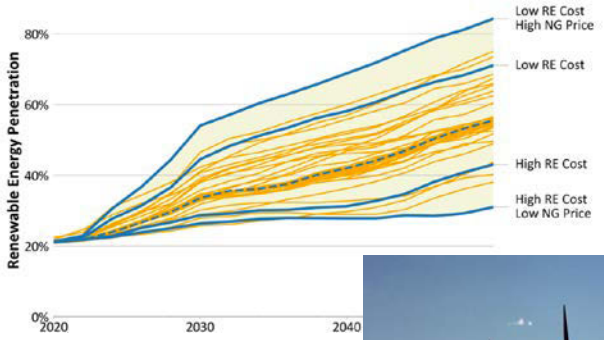
Sources: https://joebiden.com/clean-energy/

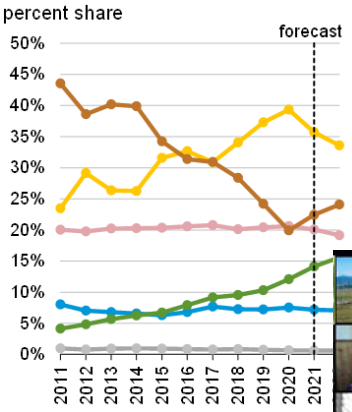
Select Elements of Biden Energy Plan - Research

- Grid-scale storage
- Advanced small nuclear reactors
- Refrigeration and air conditioning with no global warming potential refrigerants
- Zero net energy buildings at zero net cost
- Renewable-generated hydrogen
- Decarbonized industrial heat for steel, concrete, chemicals
- Decarbonized food and agriculture
- Carbon dioxide capture from industry and direct air capture
- Supply chain resilience

Sources: https://joebiden.com/clean-energy/

Perspectives from a Pandemic Year





- It is hard to predict the future – **Scenarios can help plan approaches and investments to maximize desired objectives**
- Long-term trend toward cleaner energy continues – **Focus on fundamental drivers of change including research, economics, policy, and social values**
- Disruption can take 10 years or 10 months – **Resilience, flexibility, and diversity are as important as cost and quality**
- Our lives were radically changed this year – **Remember that can do more than ever imagined when we work together**

Thank you!

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