Steps to Accelerate Deep Decarbonization of US Transportation Modes

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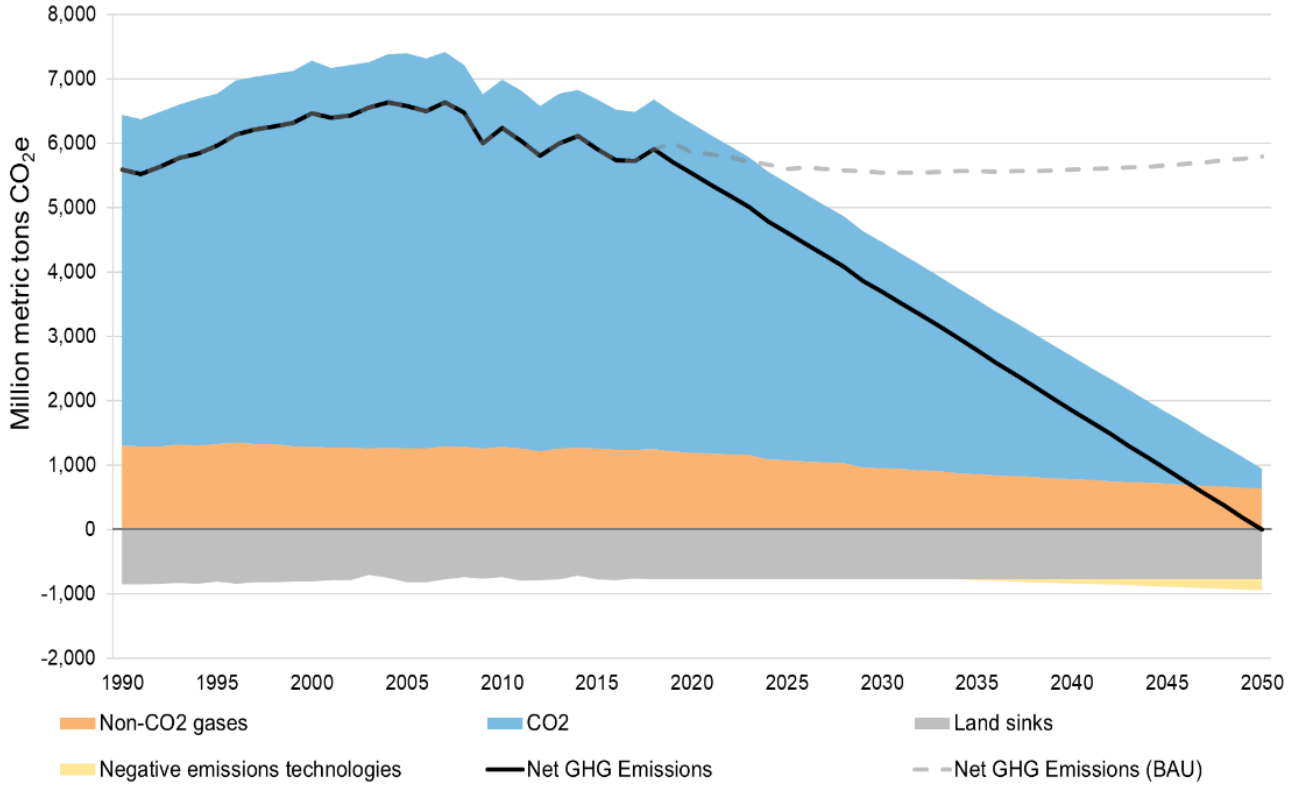
Motivation

- Climate change with sea level rise, heat, drought, extreme weather.
- Conventional air emissions health effects.
- Long term sustainability as fossil fuels are a finite resource.
- Ongoing technology development in alternatives to fossil fuels but lack of US manufacturing
- Political and business tides are turning towards decarbonization

A Potential Trajectory for Net Zero Emissions

Limiting climate change to substantially less than 2 degrees Celsius requires global emissions to reach net-zero by mid-century (IPCC 2018)

U.S. emissions for 2019 were 6 Gt CO_2e/y of all greenhouse gases and 5 Gt CO_2/y, partially offset by a large CO_2 sink from its managed forests



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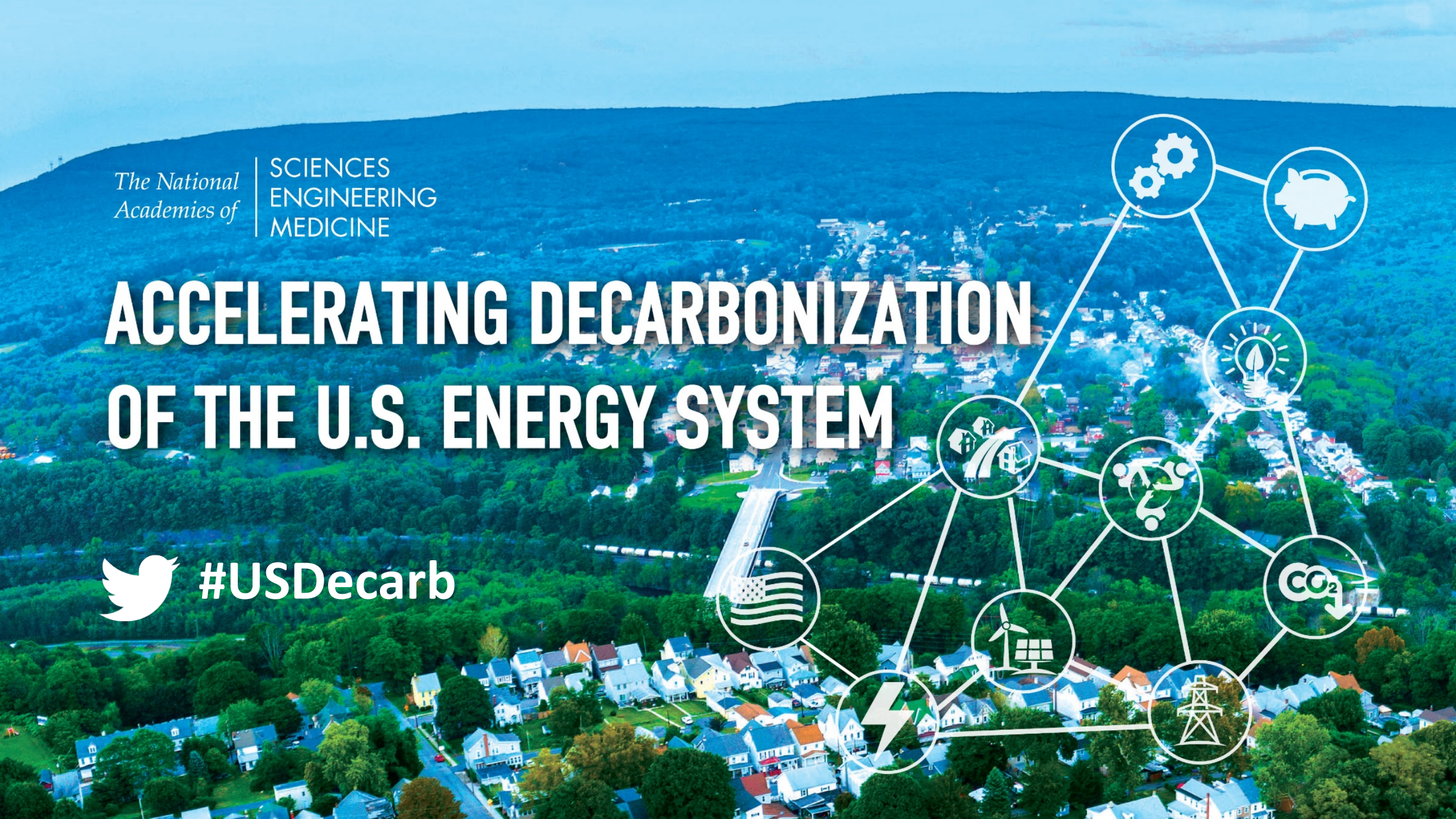
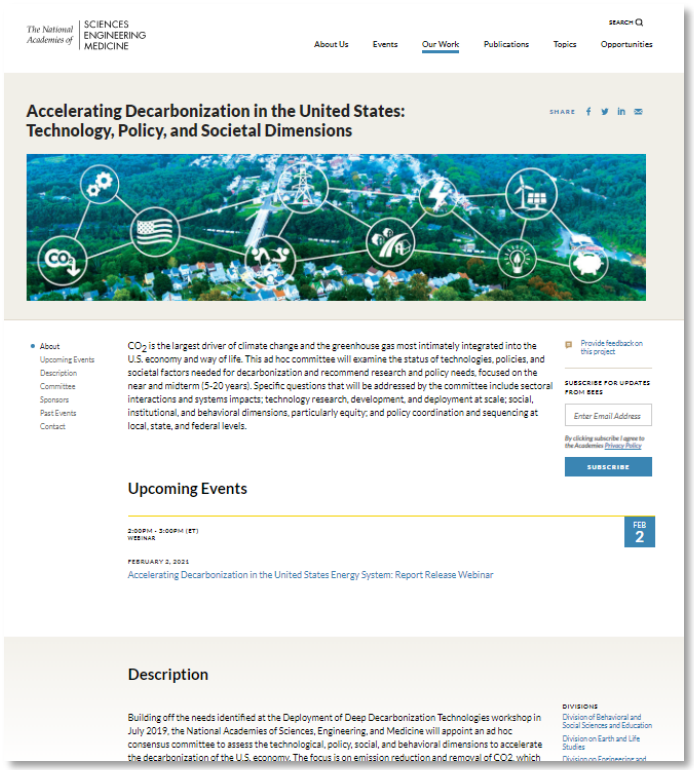
ACCELERATING DECARBONIZATION OF THE U.S. ENERGY SYSTEM

#USDecarb



About the Study



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The committee was asked to evaluate the status of technologies, policies, and societal factors needed for decarbonization and recommend research and policy needs.

This first report focuses on **near and mid-term (5-20 years)** high-value policy improvements, research investments, and approaches required to put the U.S. on a path to achieve long-term net-zero emissions, focusing on federal actions.

The second report (expected 2023) will assess a **wider spectrum of technological, policy, social, and behavioral dimensions** of deep decarbonization and their interactions, including non-federal actions.

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Technology Goals

Electrify energy services in transportation, buildings, and industry

Examples include moving half of vehicle sales (all classes combined) to EV's by 2030, and deploying heat pumps in one quarter of residences.

Improve energy efficiency and productivity

Examples include accelerating the rate of increase of industrial energy productivity (dollars of economic output per energy consumed) from the historic 1% per year to 3% per year.

Produce carbon-free electricity

Roughly double the share of electricity generated by carbon-free sources from 37% to 75%.

Expand the innovation toolkit

Triple federal support for net-zero RD&D.

Plan, permit, and build critical infrastructure

Examples include new transmission lines, an EV charging network, and a CO_2 pipeline network.

Socio-Economic Goals

Strengthen the U.S. economy

Use the energy transition to accelerate US innovation, reestablish US manufacturing, increase the nation's global economic competitiveness, and increase the availability of high-quality jobs.

Support communities, businesses, and workers

Proactively support those directly and adversely affected by the transition

Promote equity and inclusion

Ensure equitable distribution of benefits, risks and costs of the transition to net-zero.

Integrate historically marginalized groups into decision-making by ensuring adherence to best practice public participation laws.

Ensure entities receiving public funds report on leadership diversity to ensure non-discrimination.

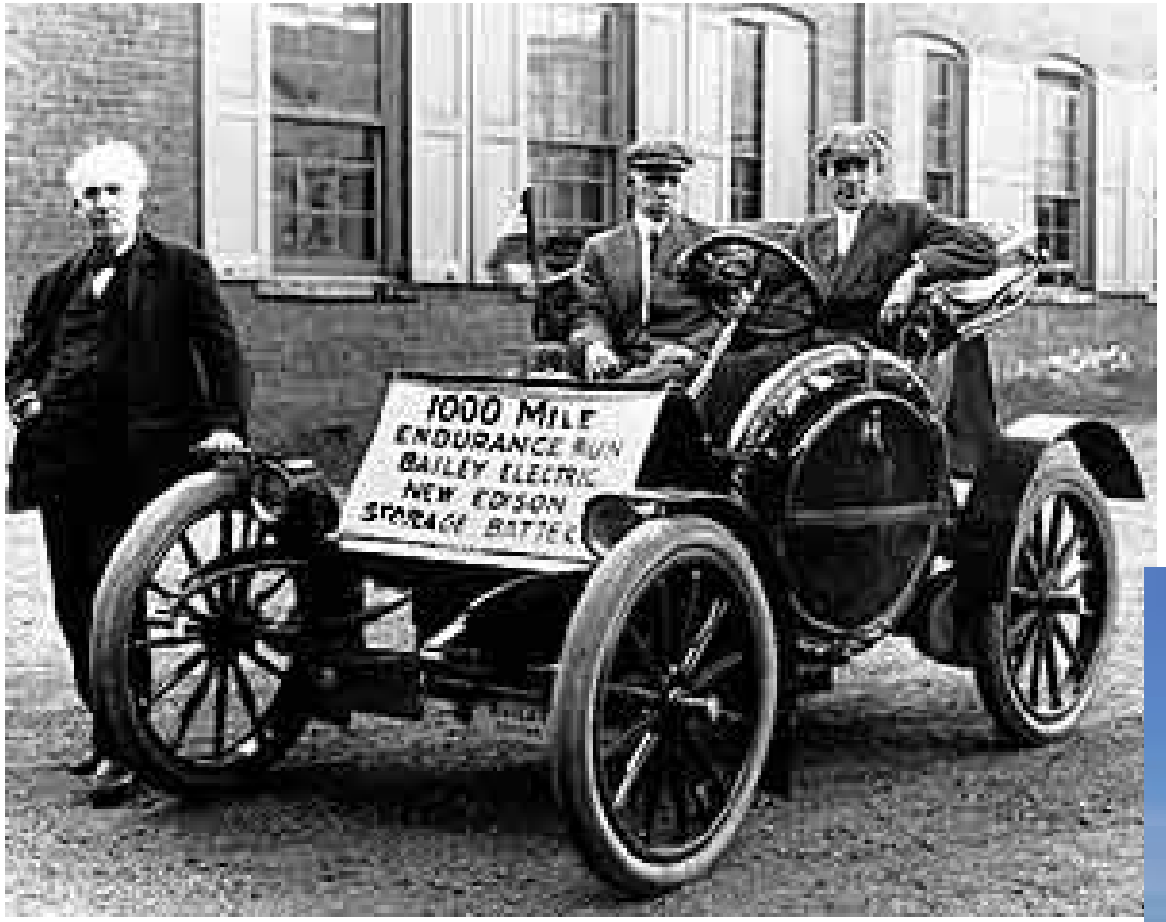
Maximize cost-effectiveness

Million Metric Tons of CO2 Emission (US EPA)

Year	1990	2005	2018
Passenger cars	612	643	764
Light-duty trucks	312	491	306
Other trucks	229	400	432
Buses	8	12	21
Motorcycles	2	2	4
Commercial Aircraft	110	133	130
Other Aircraft	78	59	44
Ships and Boats	46	44	37
Rail	39	50	42
Pipelines	36	32	49
Lubricants	12	10	9

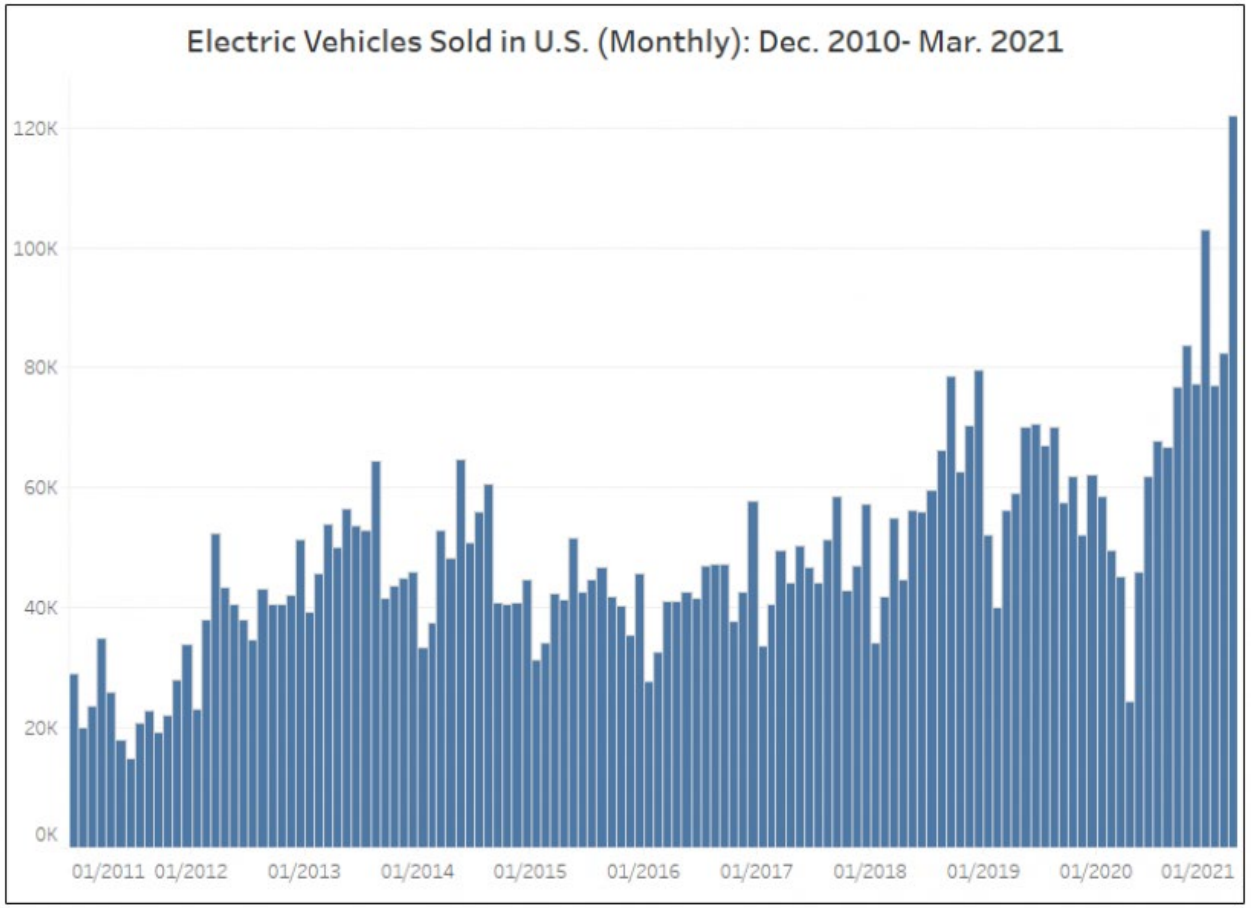
Electrify Transportation as Much as Possible

- Plug-in battery electric vehicles become dominant, especially in urban areas.
- Can fuel cell vehicles become competitive with BEV for long hauls?
- Charging and hydrogen infrastructure available throughout the US.
- Railroads can be BEV, fuel cell or connect to power lines.
- Ships switch to fuel cell, nuclear or low carbon liquid fuels.

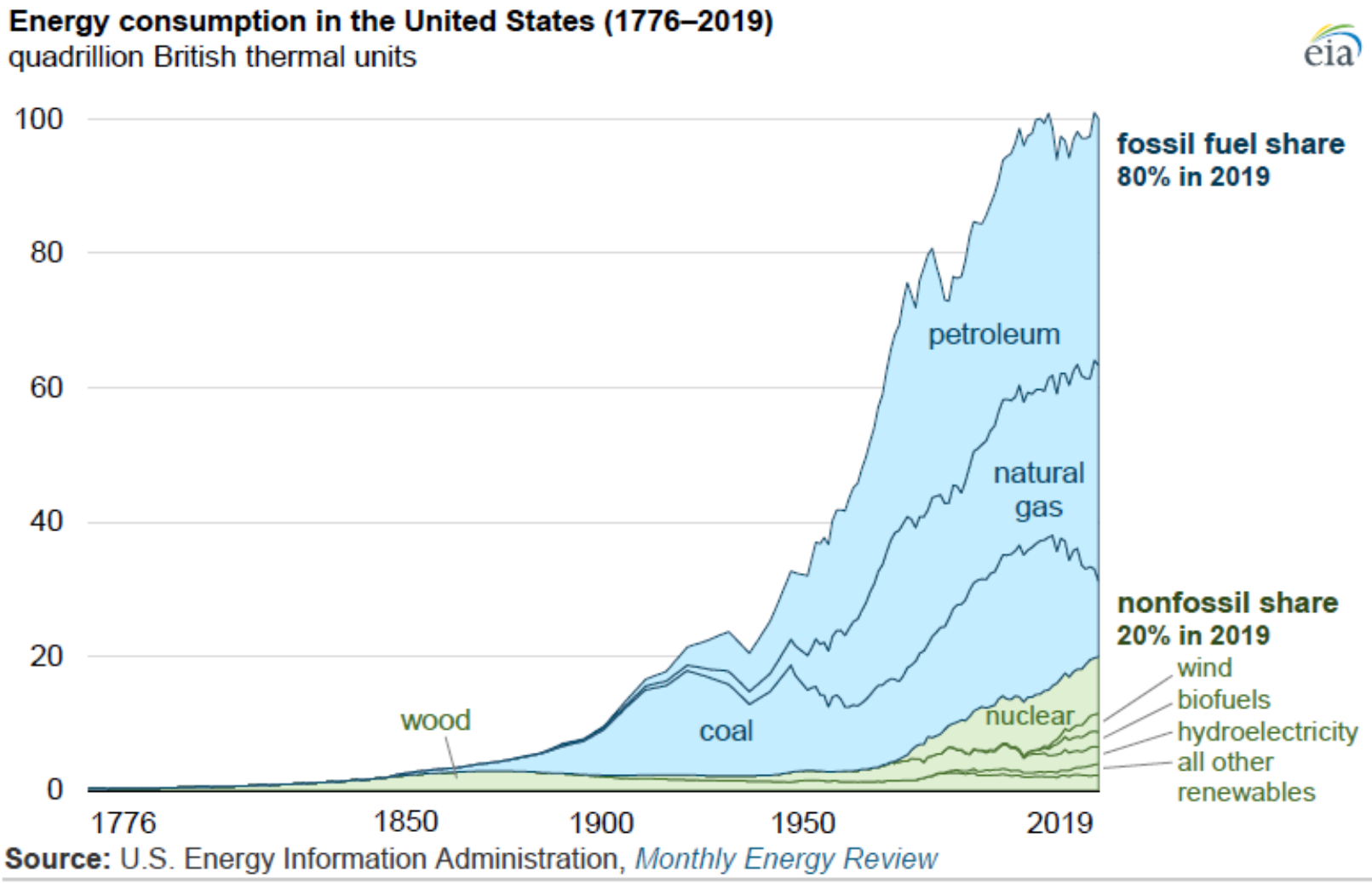

1000 MILE
ENDURANCE RUN
BAILEY ELECTRIC
NEW EDISON


TESLA
TESLA
TESLA
Electric vehicle recharging point only
At any time

Electric Vehicle Sales Increasing (>2%!) - BTS



US Non Fossil Share of Energy is 20% in 2019



Pursue useful innovations

- Zero emission hydrogen production.
- Synthesis of low carbon liquid methane and liquid hydrocarbon fuels (important for air transport and residual IC vehicles)
- New manufacturing processes (e.g. hydrogen direct reduction of iron, energy efficient cement)
- Carbon dioxide capture and storage processes.
- High yield bioenergy crops.
- Direct air capture of carbon dioxide.

Build Critical Infrastructure

- Electricity transmission and charging stations.
- Hydrogen filling stations.
- Carbon capture and storage infrastructure.
- Battery and renewable power manufacturing
- Connectivity for energy efficiency.

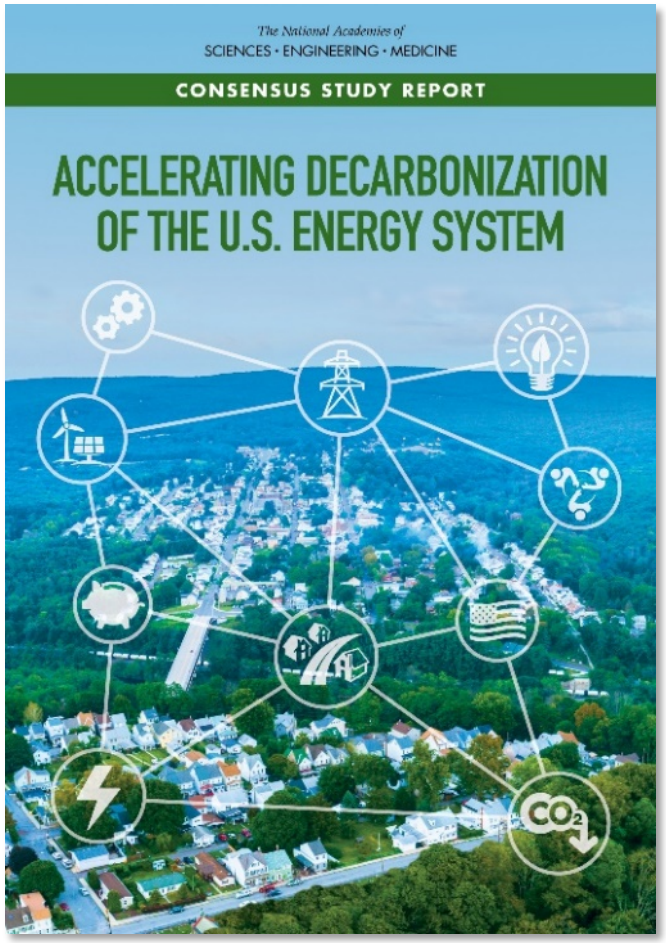
Numerous Deep Decarbonization Studies Exist

- Global, Regional (e.g. European Union), National and Statewide Studies.
- Varying time frames and goals.
- Varying attention to costs, milestones, socio-economic impacts and policy options.
- Often scenario based.

Consensus emerging from studies

- Net zero emissions has technically feasible pathways but is difficult
- Transportation electrification is a critical element, but many other actions can contribute such as energy efficiency.
- Battery electric vehicles are currently less costly than fuel cell vehicles but suffer from limited range and charging availability.
- Despite industry claims, extra costs should not be prohibitive (and likely are less than the social costs of climate change and air emissions). Cost reductions in renewable power generation and batteries have been game changers.

Thank you!



Download the report and report resources at nap.edu/decarbonization

Subscribe for updates on the study website at nationalacademies.org/decarbonization

Second report expected early 2023.