Delivering a net-zero energy system in the United States

Ammonia Energy Association Annual Meeting

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U.S. Department of Energy | Office of Nuclear Energy

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U.S. DEPARTMENT OF ENERGY

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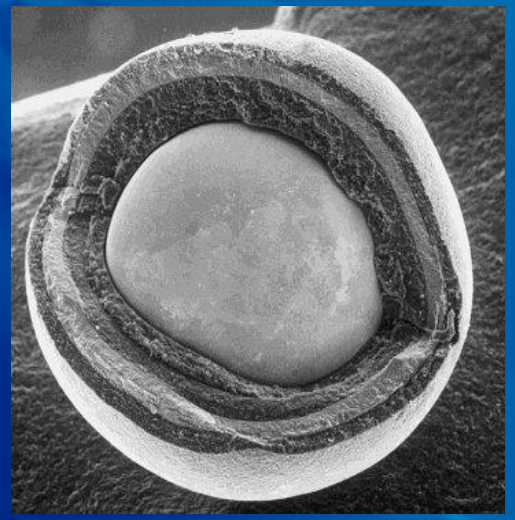
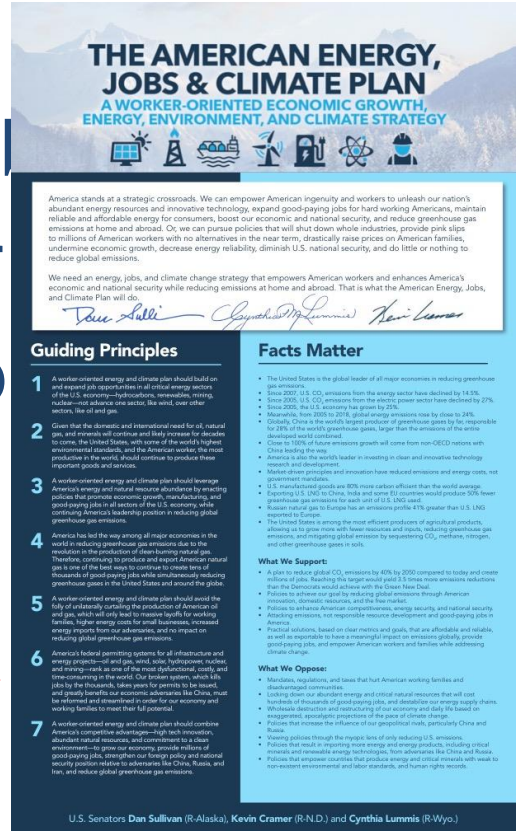
Nuclear Engineering – Advanced nuclear fuels, particulates, and aerosols



US Climate Goals – Commitments to UNFCCC (United Nations Framework Convention on Climate Change) and GOP Plan

1. Decarbonize the electricity sector by 50 to 52% b
2. Achieve a carbon pollution-free electricity sector
3. Puts the United States on an irreversible path to economy by 2050

11/3/2021 - GOP Goal – 40% reduction in GHG by current levels.



THE AMERICAN ENERGY, JOBS & CLIMATE PLAN

A WORKER-ORIENTED ECONOMIC GROWTH, ENERGY, ENVIRONMENT, AND CLIMATE STRATEGY

America stands at a strategic crossroads. We can empower American ingenuity and workers to unleash our nation's abundant energy resources and innovative technology, expand good-paying jobs for hard working Americans, maintain reliable and affordable energy for consumers, boost our economic and national security, and reduce greenhouse gas emissions at home and abroad. Or, we can pursue policies that will shut down whole industries, provide pink slips to millions of American workers with no alternatives in the near term, drastically raise prices on American families, undermine economic growth, decrease energy reliability, diminish U.S. national security, and do little or nothing to reduce global emissions.

We need an energy, jobs, and climate change strategy that empowers American workers and enhances America's economic and national security while reducing emissions at home and abroad. That is what the American Energy, Jobs, and Climate Plan will do.

Guiding Principles

1 A worker-oriented energy and climate plan should build on and expand job opportunities in all critical energy sectors of the U.S. economy—hydrocarbons, renewables, mining, nuclear—not advance one sector, like wind, over other sectors, like oil and gas.

2 Given that the domestic and international need for oil, natural gas, and minerals will continue and likely increase for decades to come, the United States, with some of the world's highest environmental standards, and the American worker, the most productive in the world, should continue to produce these important goods and services.

3 A worker-oriented energy and climate plan should leverage America's energy and natural resource abundance by enacting policies that promote economic growth, manufacturing, and good-paying jobs in all sectors of the U.S. economy, while continuing America's leadership position in reducing global greenhouse gas emissions.

4 America has led the way among all major economies in the world in reducing greenhouse gas emissions due to the revolution in the production of clean-burning natural gas. Therefore, continuing to produce and export American natural gas is one of the best ways to continue to create tens of thousands of good-paying jobs while simultaneously reducing greenhouse gases in the United States and around the globe.

5 A worker-oriented energy and climate plan should avoid the folly of unilaterally curtailing the production of American oil and gas, which will only lead to massive layoffs for working families, higher energy costs for small businesses, increased energy imports from our adversaries, and no impact on reducing global greenhouse gas emissions.

6 America's federal permitting systems for all infrastructure and energy projects—oil and gas, wind, solar, hydropower, nuclear, and mining—rank as one of the most dysfunctional, costly, and time-consuming in the world. Our broken system, which kills jobs by the thousands, takes years for permits to be issued, and greatly benefits our economic adversaries like China, must be reformed and streamlined in order for our economy and working families to meet their full potential.

7 A worker-oriented energy and climate plan should combine America's competitive advantages—high tech innovation, abundant natural resources, and commitment to a clean environment—to grow our economy, provide millions of good-paying jobs, strengthen our foreign policy and national security position relative to adversaries like China, Russia, and Iran, and reduce global greenhouse gas emissions.

Facts Matter

- The United States is the global leader of all major economies in reducing greenhouse gas emissions.
- Since 2007, U.S. CO_2 emissions from the energy sector have declined by 14.5%.
- Since 2005, U.S. CO_2 emissions from the electric power sector have declined by 27%.
- Since 2005, the U.S. economy has grown by 25%.
- Meanwhile, from 2005 to 2018, global energy emissions rose by close to 24%.
- Globally, China is the world's largest producer of greenhouse gases by far, responsible for 28% of the world's greenhouse gases, larger than the emissions of the entire developed world combined.
- Close to 100% of future emissions growth will come from non-OECD nations with China leading the way.
- America is also the world's leader in investing in clean and innovative technology research and development.
- Market-driven principles and innovation have reduced emissions and energy costs, not government mandates.
- U.S. manufactured goods are 80% more carbon efficient than the world average.
- Exporting U.S. LNG to China, India and some EU countries would produce 50% fewer greenhouse gas emissions for each unit of U.S. LNG used.
- Russian natural gas to Europe has an emissions profile 41% greater than U.S. LNG exported to Europe.
- The United States is among the most efficient producers of agricultural products, allowing us to grow more with fewer resources and inputs, reducing greenhouse gas emissions, and mitigating global emission by sequestering CO_2, methane, nitrogen, and other greenhouse gases in soils.

What We Support:

- A plan to reduce global CO_2 emissions by 40% by 2050 compared to today and create millions of jobs. Reaching this target would yield 3.5 times more emissions reductions than the Democrats would achieve with the Green New Deal.
- Policies to achieve our goal by reducing global emissions through American innovation, domestic resources, and the free market.
- Policies to enhance American competitiveness, energy security, and national security.
- Attacking emissions, not responsible resource development and good-paying jobs in America.
- Practical solutions, based on clear metrics and goals, that are affordable and reliable, as well as exportable to have a meaningful impact on emissions globally, provide good-paying jobs, and empower American workers and families while addressing climate change.

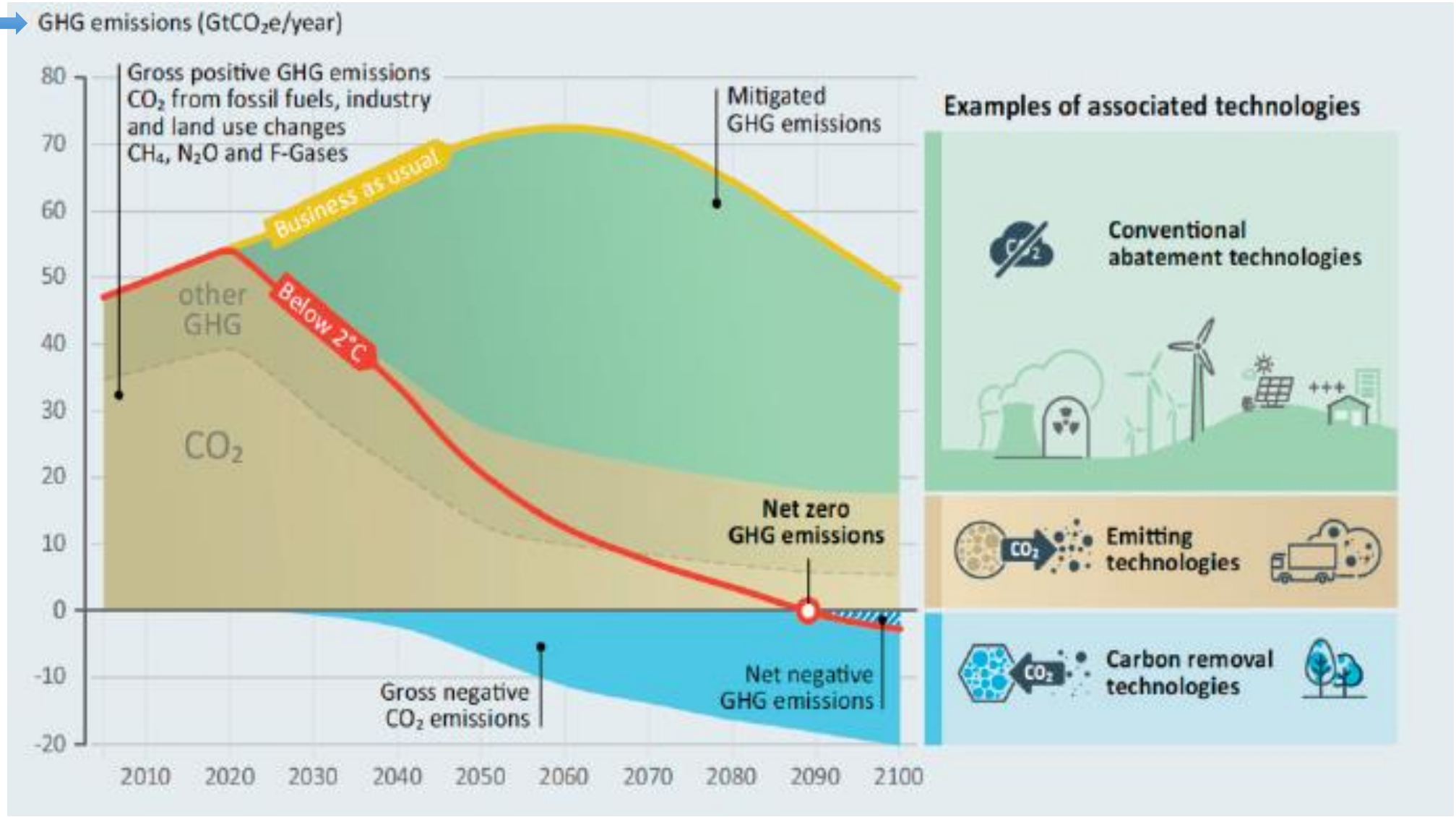
What We Oppose:

- Mandates, regulations, and taxes that hurt American working families and disadvantaged communities.
- Locking down our abundant energy and critical natural resources that will cost hundreds of thousands of good-paying jobs, and destabilize our energy supply chains.
- Wholesale destruction and restructuring of our economy and daily life based on exaggerated, apocalyptic projections of the pace of climate change.
- Policies that increase the influence of our geopolitical rivals, particularly China and Russia.
- Viewing policies through the myopic lens of only reducing U.S. emissions.
- Policies that result in importing more energy and energy products, including critical minerals and renewable energy technologies, from adversaries like China and Russia.
- Policies that empower countries that produce energy and critical minerals with weak to non-existent environmental and labor standards, and human rights records.

U.S. Senators **Dan Sullivan** (R-Alaska), **Kevin Cramer** (R-N.D.) and **Cynthia Lummis** (R-Wyo.)

[April 22, 2021 - FACT SHEET: President Biden Sets 2030 Greenhouse Gas Pollution Reduction Target Aimed at Creating Good-Paying Union Jobs and Securing U.S. Leadership on Clean Energy Technologies]

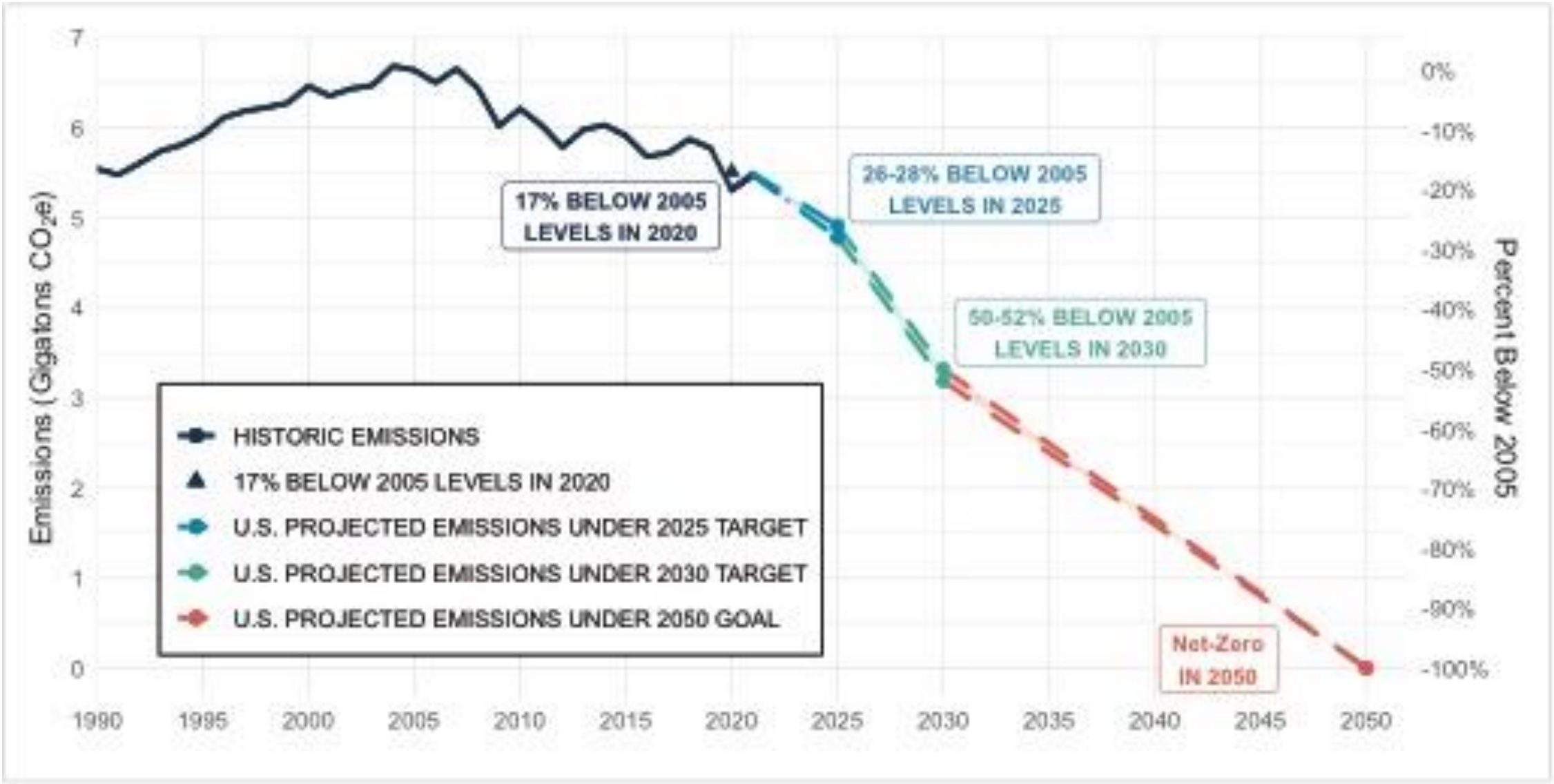
Reducing emissions across generation and use plus adding capture and removal is needed be needed to meet the ambitious goals.



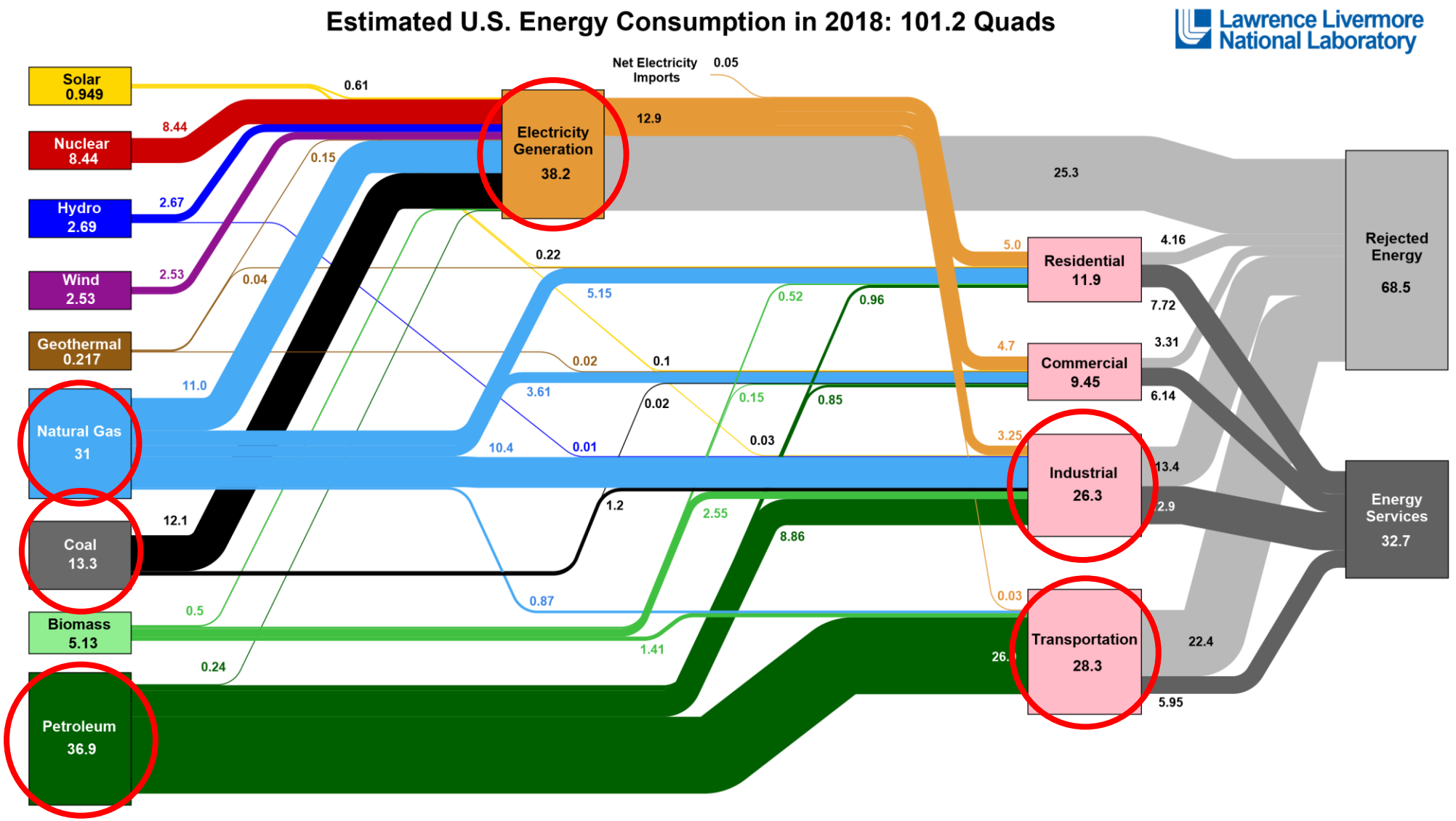
National Academies of Sciences, Engineering, and Medicine 2019. *Negative Emissions Technologies and Reliable Sequestration: A Research Agenda.* Washington, DC: The National Academies Press. https://doi.org/10.17226/25259. page 3.

U.S. 2030 Nationally Determined Contribution: 50-52% Reductions and Path to 2050 economy wide decarbonization.

https://www.whitehouse.gov/wp-content/uploads/2021/10/US-Long-Term-Strategy.pdf

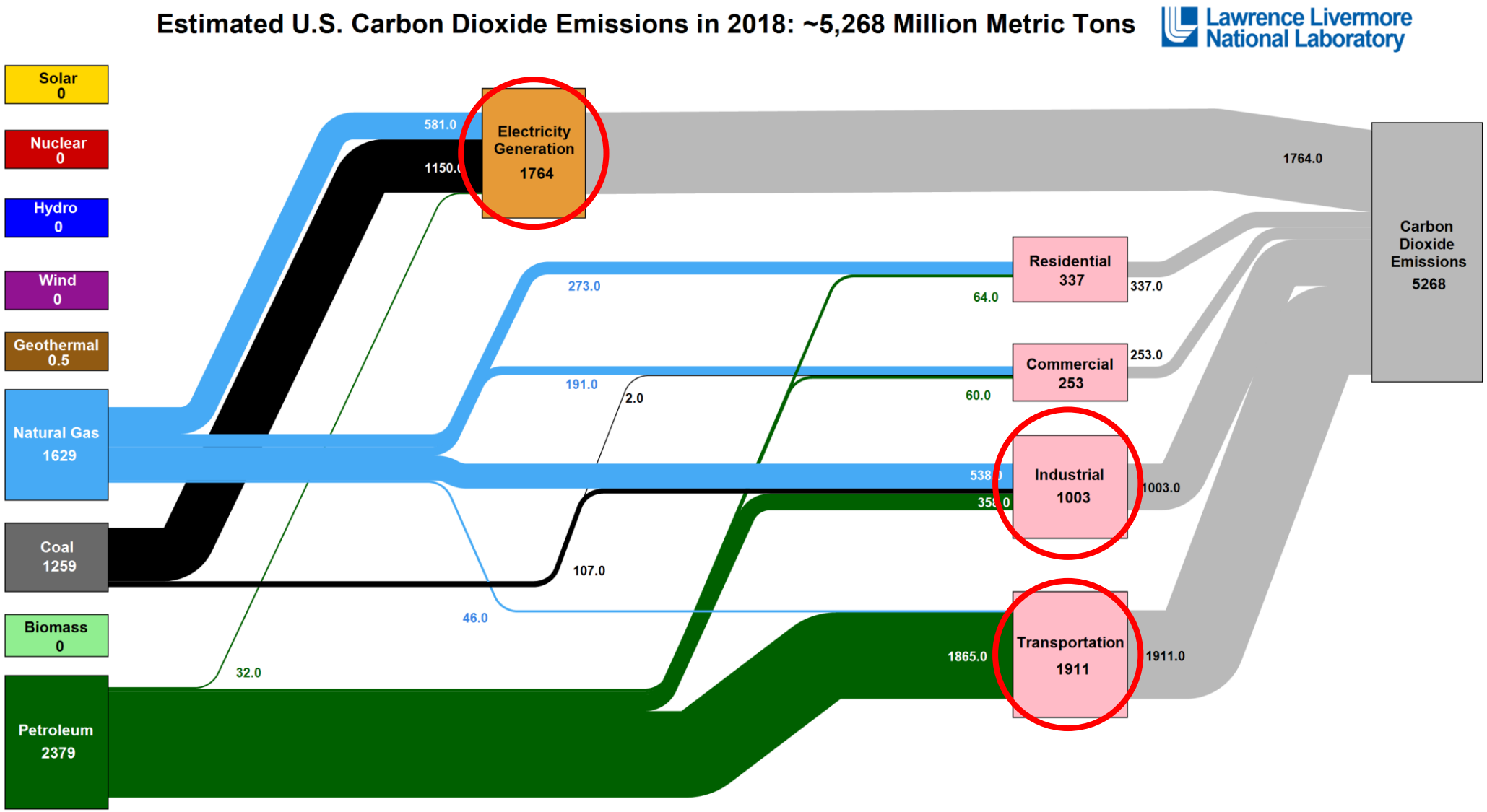


Over 80% of U.S. energy consumption results in GHG emission (natural gas, coal, petroleum – 80+ quads)



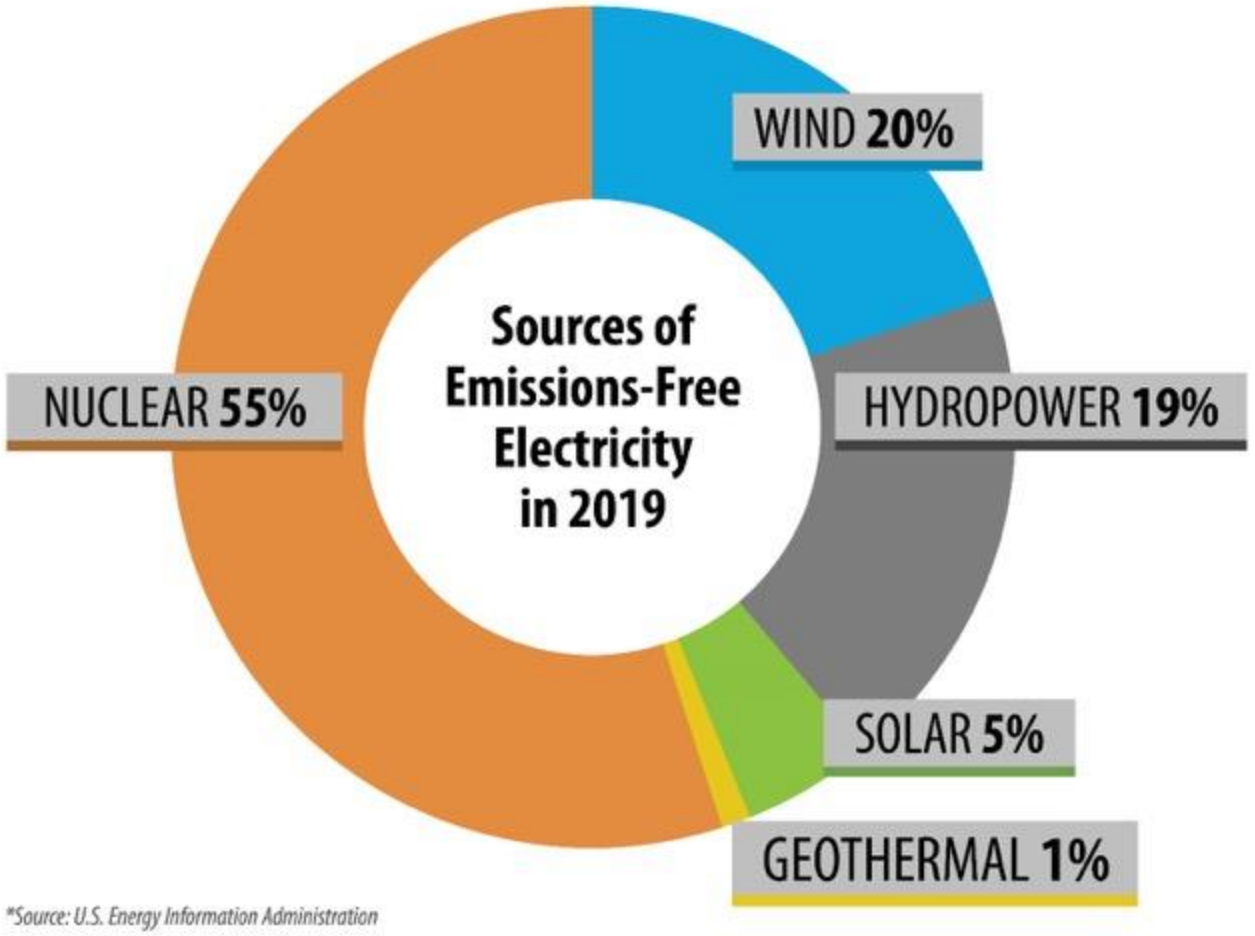
Source: LLNL March, 2019. Data is based on DOE/EIA MER (2018). If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports consumption of renewable resources (i.e., hydro, wind, geothermal and solar) for electricity in BTU-equivalent values by assuming a typical fossil fuel plant heat rate. The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 65% for the residential sector, 65% for the commercial sector, 21% for the transportation sector and 49% for the industrial sector, which was updated in 2017 to reflect DOE's analysis of manufacturing. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527

Need to decarbonize electricity generation, industrial manufacturing, and transportation



Source: LLNL July, 2019. Data is based on DOE/EIA MER (2018). If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Carbon emissions are attributed to their physical source, and are not allocated to end use for electricity consumption in the residental, commercial, industrial and transportation sectors. Petroleum consumption in the electric power sector includes the non-renewable portion of municipal solid waste. Combustion of biologically derived fuels is assumed to have zero net carbon emissions - the lifecycle emissions associated with producing biofuels are included in commercial and industrial emissions. Totals may not equal sum of components due to indepedent rounding errors. LLNL-MI-410527

Carbon Free Power – Nuclear!



REACTOR

CO2 / Carbon Sources

Thermal Storage

Peaking Generator

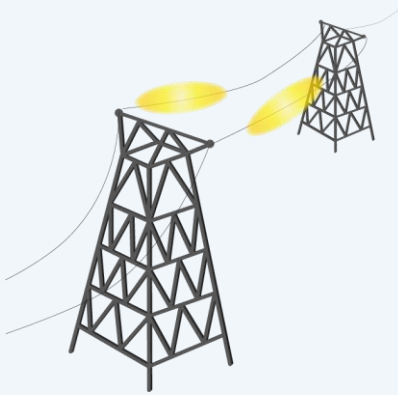
Primary Generator

Industrial/Chemical Plant

Hydrogen Production

Battery

Firm, Flexible, Zero-Carbon Grid Capacity



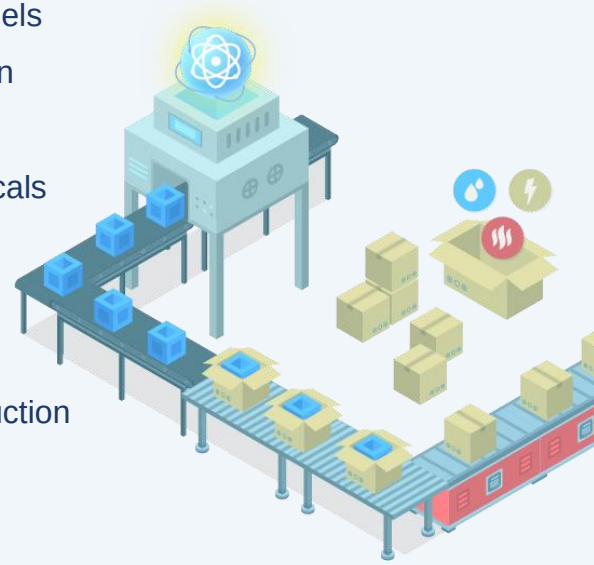
Transportation Fuels

Steel Production

Fertilizer

Polymers/ Chemicals

Hydrogen



Refineries/Oil Production

Minerals

Cement

Wood/Paper plants

District Heating

Office of Nuclear Energy - What We Do

Mission

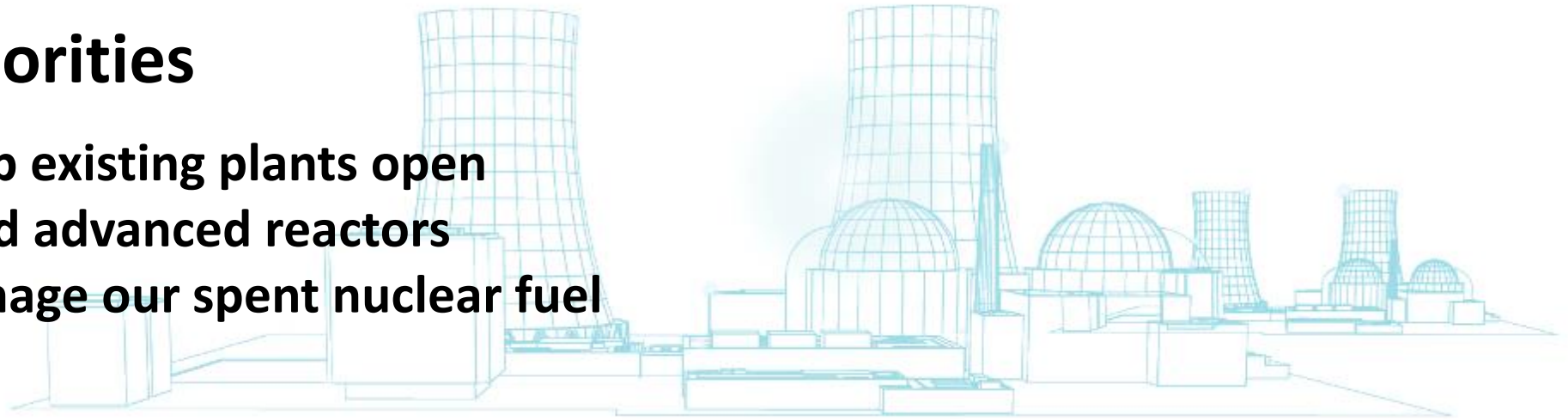
To advance nuclear science and technology to meet U.S. **energy, environmental, and economic needs**.

Our Work

Solve challenges related to technology, cost, safety, security, and proliferation resistance through early-stage research, development, and demonstration.

Top Priorities

1. **Keep existing plants open**
2. **Build advanced reactors**
3. **Manage our spent nuclear fuel**



Top Priorities: Keep Existing Plants Open

Enhance Performance and Reduce Operating Costs

- Develop advanced digital technologies
- Apply risk-informed systems analysis
- Provide technical analysis for continued long-term operation
- Commercialize Accident Tolerant Fuels
- Demonstrate hydrogen production

Exelon: Dresden Generating Station

Top Priorities: Build Advanced Reactors

Top Priorities: Manage our Spent Nuclear Fuel

Spent Nuclear Fuel Management

- Revamp DOE's overall integrated waste management strategy
- Update and restart a consent-based siting approach to building a federal interim storage facility
- Develop high-tech railcars to transport spent nuclear fuel
- Perform R&D on high-burnup fuel

Idaho Nuclear Technology & Engineering Center

What about the waste?

Connecticut Yankee Nuclear Power Plant

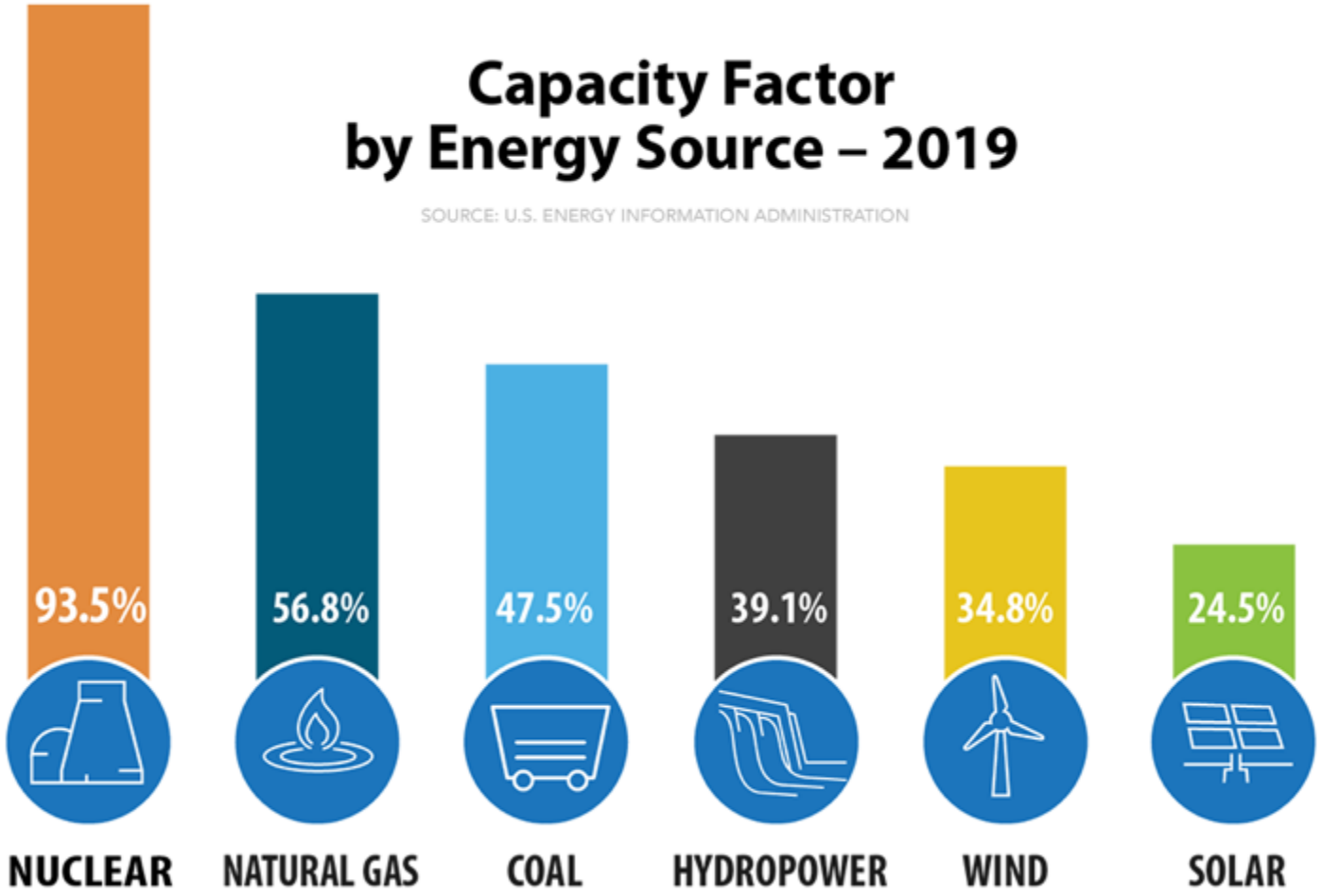
- 582 MWe
- Operated for 30 years
- Spent Fuel stored in 43 steel lined concrete storage vaults (all pictured here)

How close to a nuclear power plant are you?

Boston, MA

- Seabrook Nuclear Power Station (45 miles)
- Millstone Nuclear Power Station (117 miles)

Nuclear has the Highest Capacity Factor operating 24/7/365



Typically, a U.S. nuclear reactor performs a 2- to 4-week outage every 12 or 18 months

Current Legislative Actions to Watch

Bipartisan Infrastructure Bill (IIJA – Infrastructure Investment and Jobs Act) – Passed to the President for signature - November 6, 2021

- CNC – Commercial Nuclear Credit - $6B over 5 years to support nuclear power plants in danger of closure due to economic conditions.
- CEPP – Clean Energy Payment Program (now removed, but illustrative and may appear again)

  Increase clean energy production by 4 percent each year (and get $15/MWhr grant) — and penalizing utilities ($40/MWh) if they don't.

- Establish Regional Clean Hydrogen Hubs

Reconciliation (ie, the upcoming Build Back Better)

- Hydrogen production credit - $3 per kilogram tax credit for H2 production using renewables. A reduced credit would be available for non-renewable but clean production.
- ZERO-EMISSION NUCLEAR POWER PRODUCTION CREDIT (Cramer/Cardin Amendment)
  - $15B (~ over 5 years) to support all current nuclear power plants continue generation of clean electricity. 0.3 cents /kWhr, increasing to 1.5 cents /kWhr if meeting Fair Labor criteria = $15/MWhr.

Nov 4 – Senate Energy and Natural Resources (SENR) – Nonelectric applications of nuclear (https://www.energy.senate.gov/hearings/2021/11/full-committee-hearing-on-potential-non-electric-applications-of-civilian-nuclear-energy)

Policy Playbook

- Industry alignment and advocacy – make a plan and communicate it
- DOE and Congress are considering building programs that demonstrate the use of nuclear energy for non-electric applications. Help them define this.
  - SWNR – Senate Water and Natural Resources
  - SENR – Senate Energy and Natural Resources
  - HEWD – House Energy and Water
  - HSST – House Space, Science, and Technology
  - DOE NE - Office of Nuclear Energy
  - DOE EERE – Energy Efficiency and Renewable Energy

- How would you envision a demonstration of the use of nuclear energy taking place in your industry?

- How do you envision a nuclear power plant in your future?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