The Future of Energy
Or
What The Energy Future Ought To Be

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2023 SPEE Annual Meeting

Newport, RI

June 19, 2023

Opening Thoughts

- **More energy but less carbon – we need both**
- **Electrons and molecules – not OR but AND**
- **The developed, and the developing, world are different**
- **And tradeoffs. It's all about tradeoffs to make progress**

Tradeoffs between what

- **Affordability**
- **Reliability**
- **Security**
- **Sustainability**
- **Accessibility**
- **Energy Poverty**
- **Decarbonization/net zero**
- **Agendas**

History of energy consumption in the United States, 1775–2009

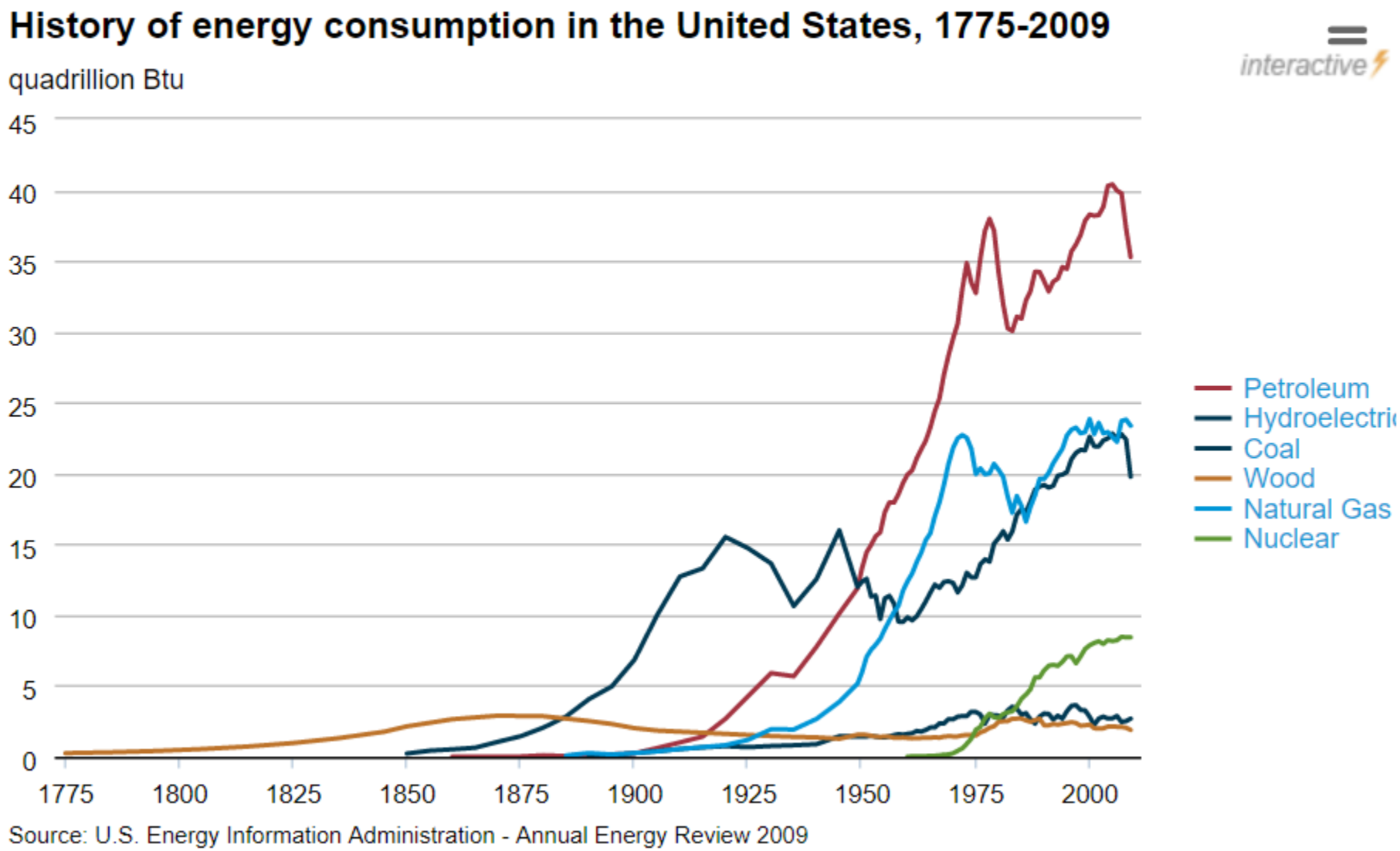


Figure 1.2 Primary Energy Production
(Quadrillion Btu)

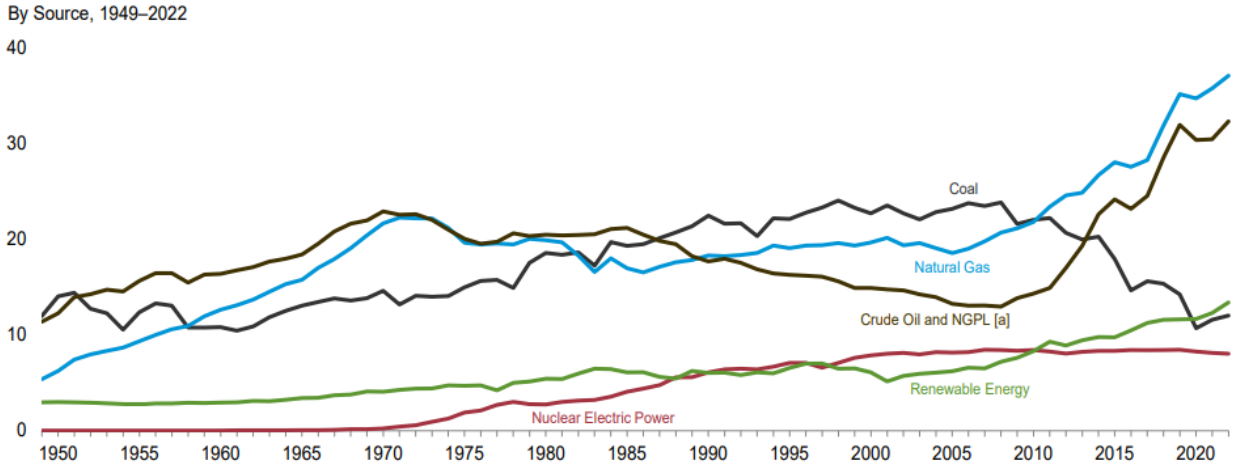


Figure 1.3 Primary Energy Consumption
(Quadrillion Btu)

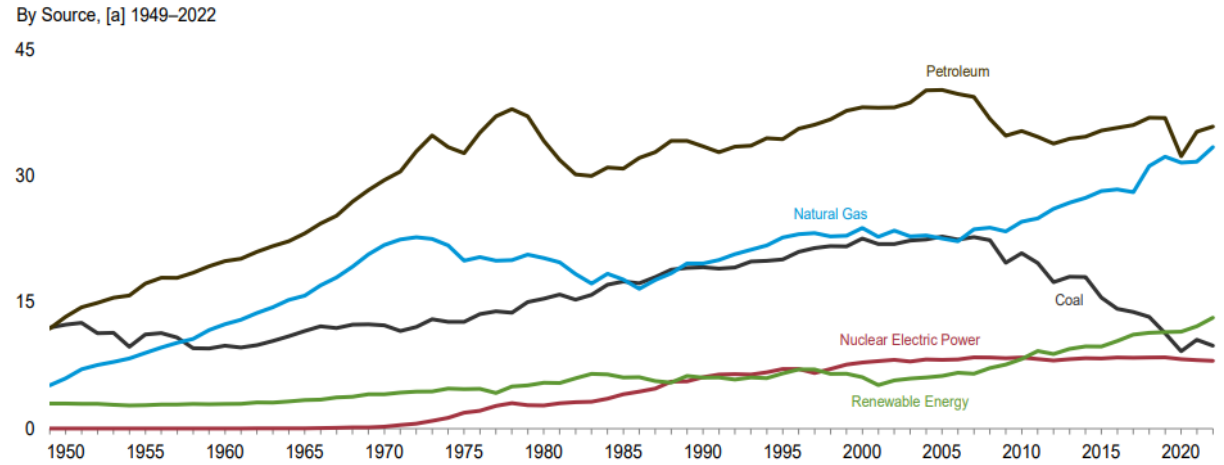
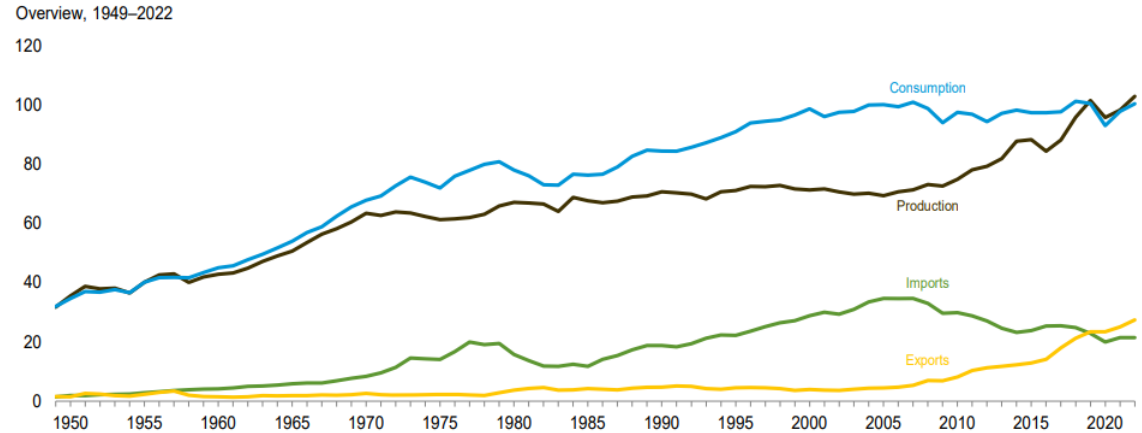
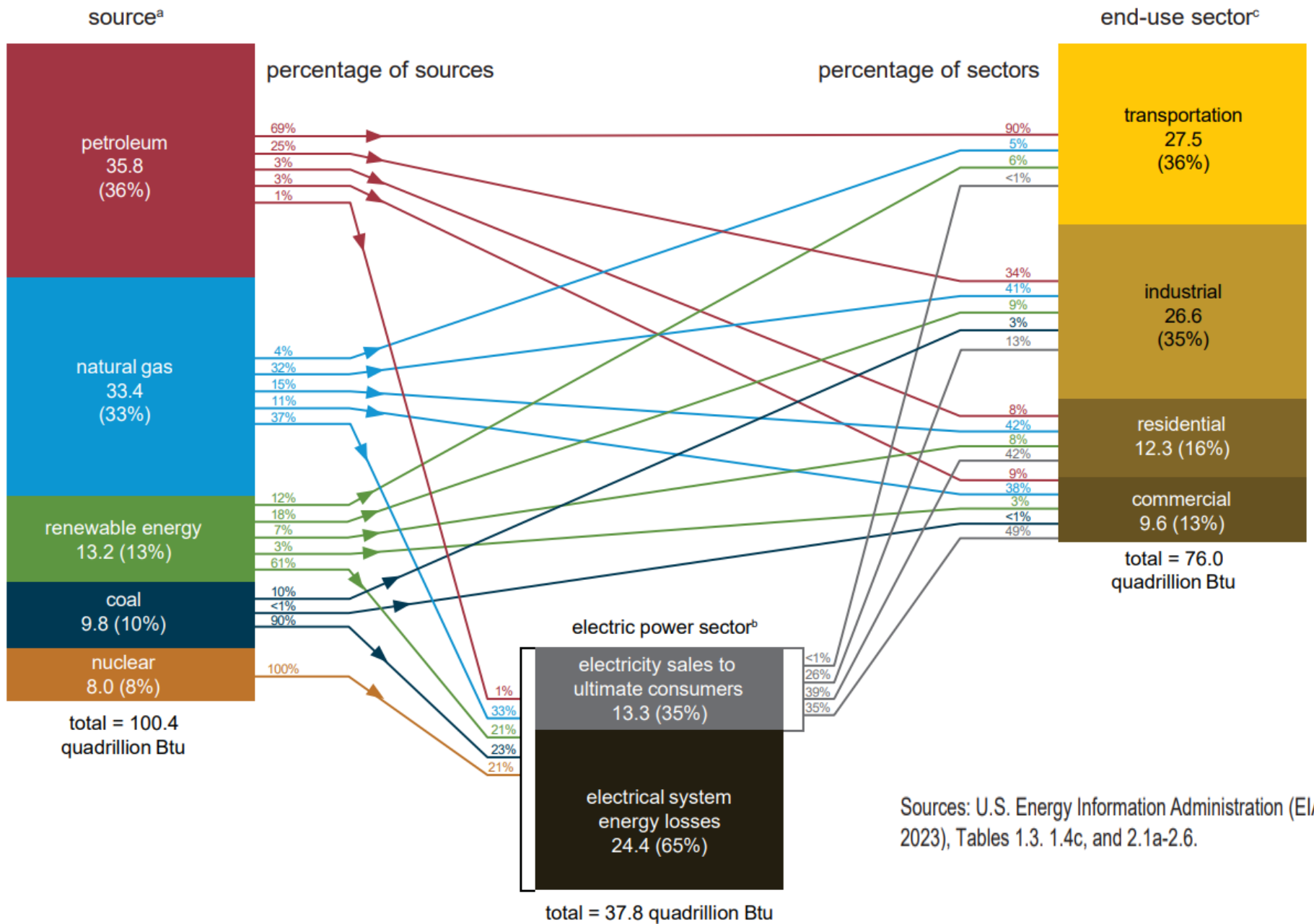


Figure 1.1 Primary Energy Overview
(Quadrillion Btu)



U.S. energy consumption by source and sector, 2022

quadrillion British thermal units (Btu)

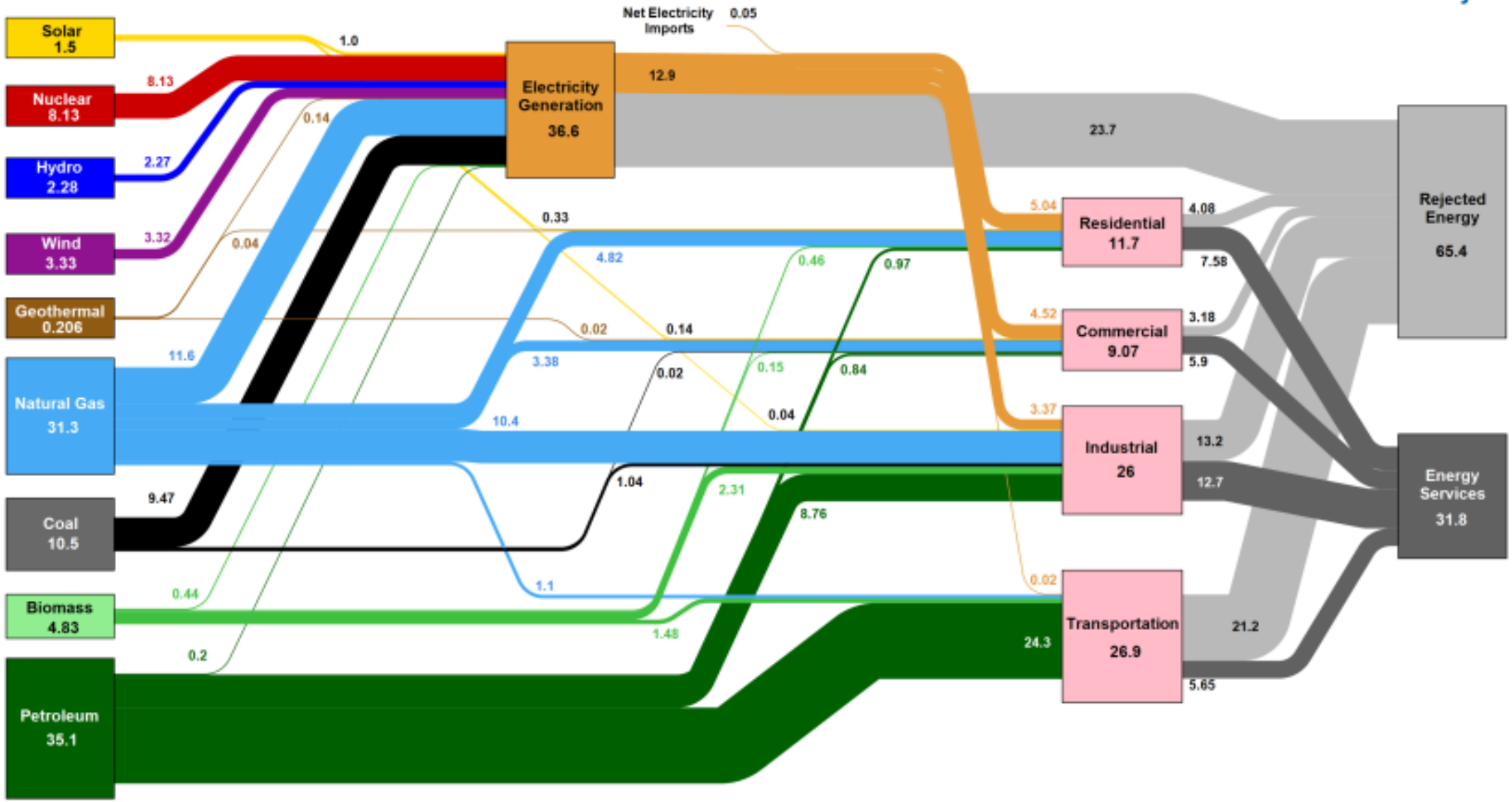


Sources: U.S. Energy Information Administration (EIA), *Monthly Energy Review* (April 2023), Tables 1.3. 1.4c, and 2.1a-2.6.

eia

Estimated U.S. Energy Consumption in 2021: 97.3 Quads

Lawrence Livermore National Laboratory

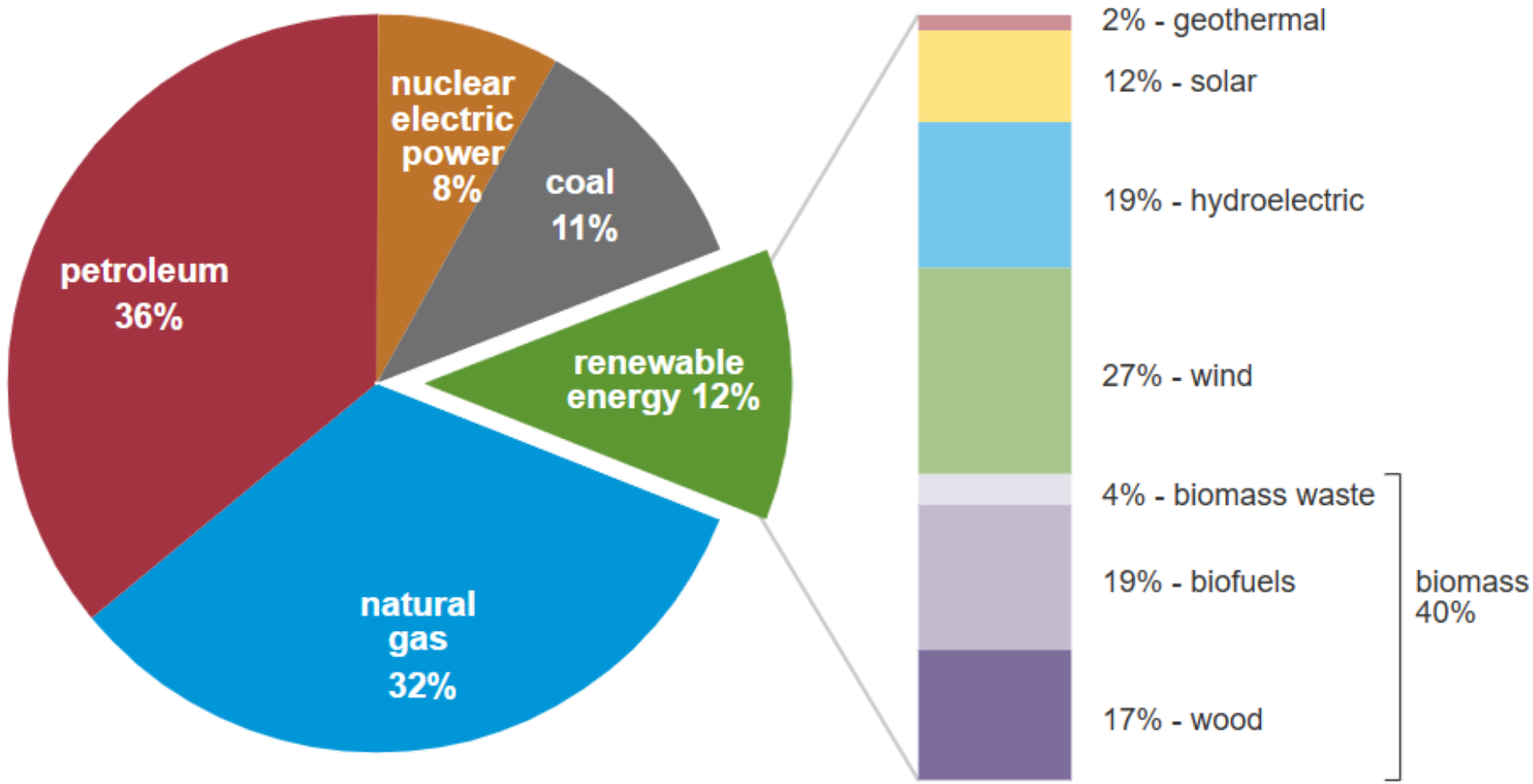


Source: LLNL March, 2022. Data is based on DOE/EIA MER (2021). If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports consumption of renewable resources (i.e., hydro, wind, geothermal and solar) for electricity is 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

U.S. primary energy consumption by energy source, 2021

total = 97.33 quadrillion British thermal units (Btu)

total = 12.16 quadrillion Btu

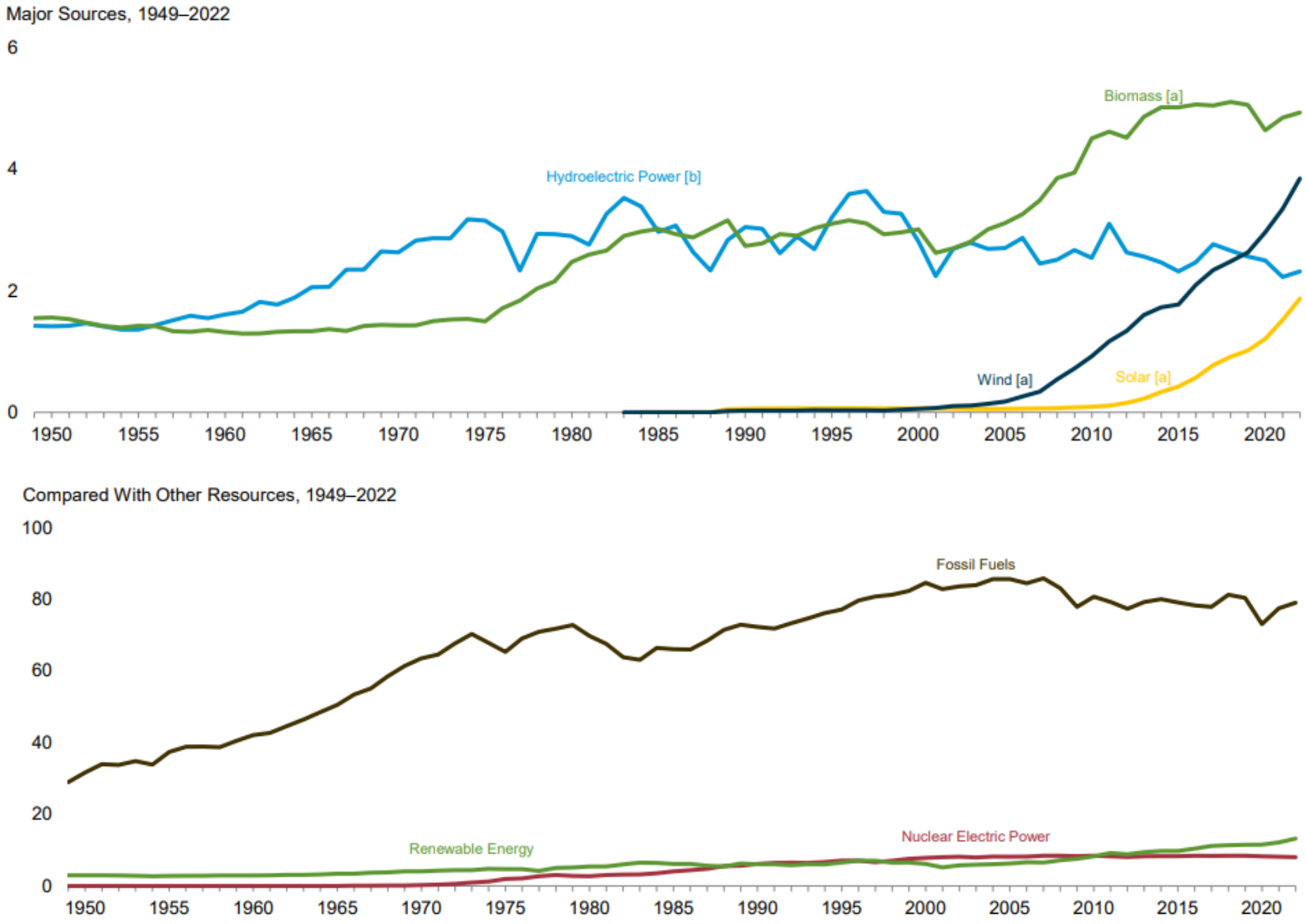


Data source: U.S. Energy Information Administration, *Monthly Energy Review*, Table 1.3 and 10.1, April 2022, preliminary data

Note: Sum of components may not equal 100% because of independent rounding.

Figure 10.1 Renewable Energy Consumption

(Quadrillion Btu)

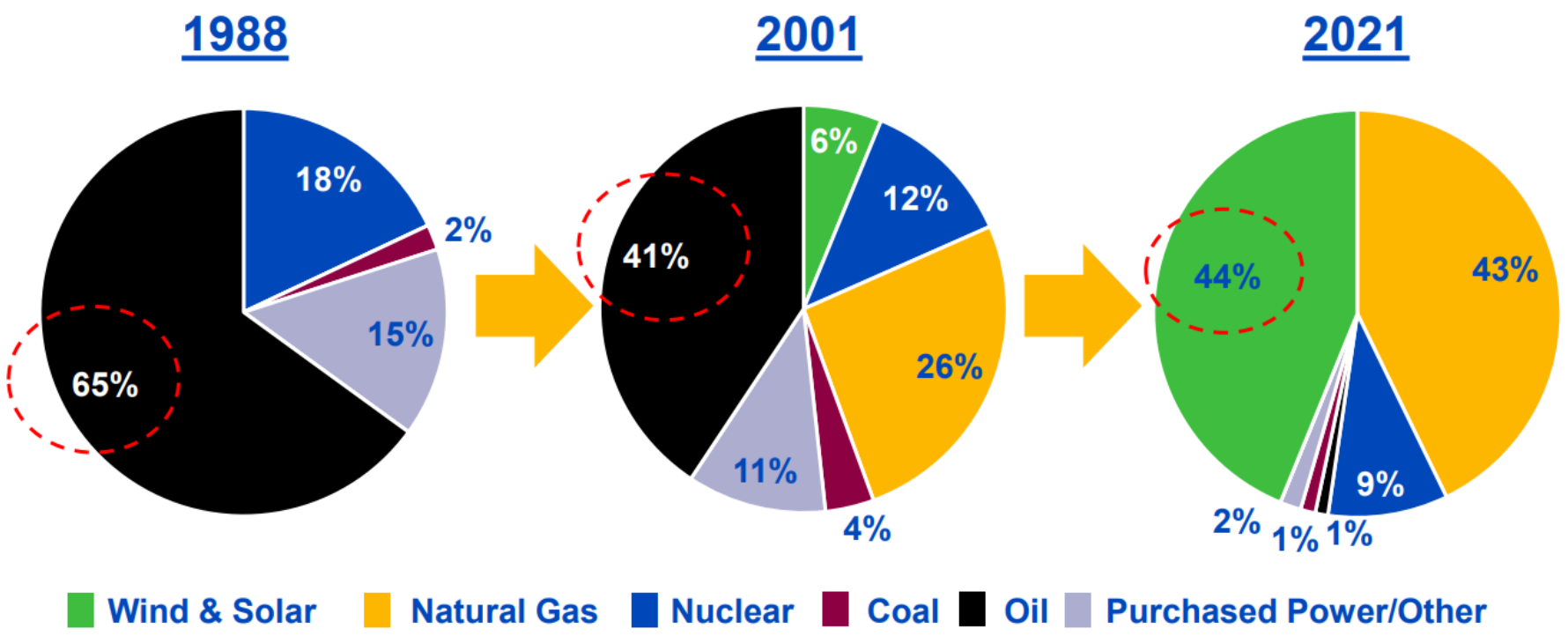


[a] See Table 10.1 for definition.
[b] Conventional hydroelectric power.

Web Page: http://www.eia.gov/totalenergy/data/monthly/#renewable.
Sources: Tables 1.3 and 10.1–10.2c.

NextEra Energy has already demonstrated an ability to cost effectively transform its generation profile

NextEra Energy Electricity Capacity by Fuel Type(1)

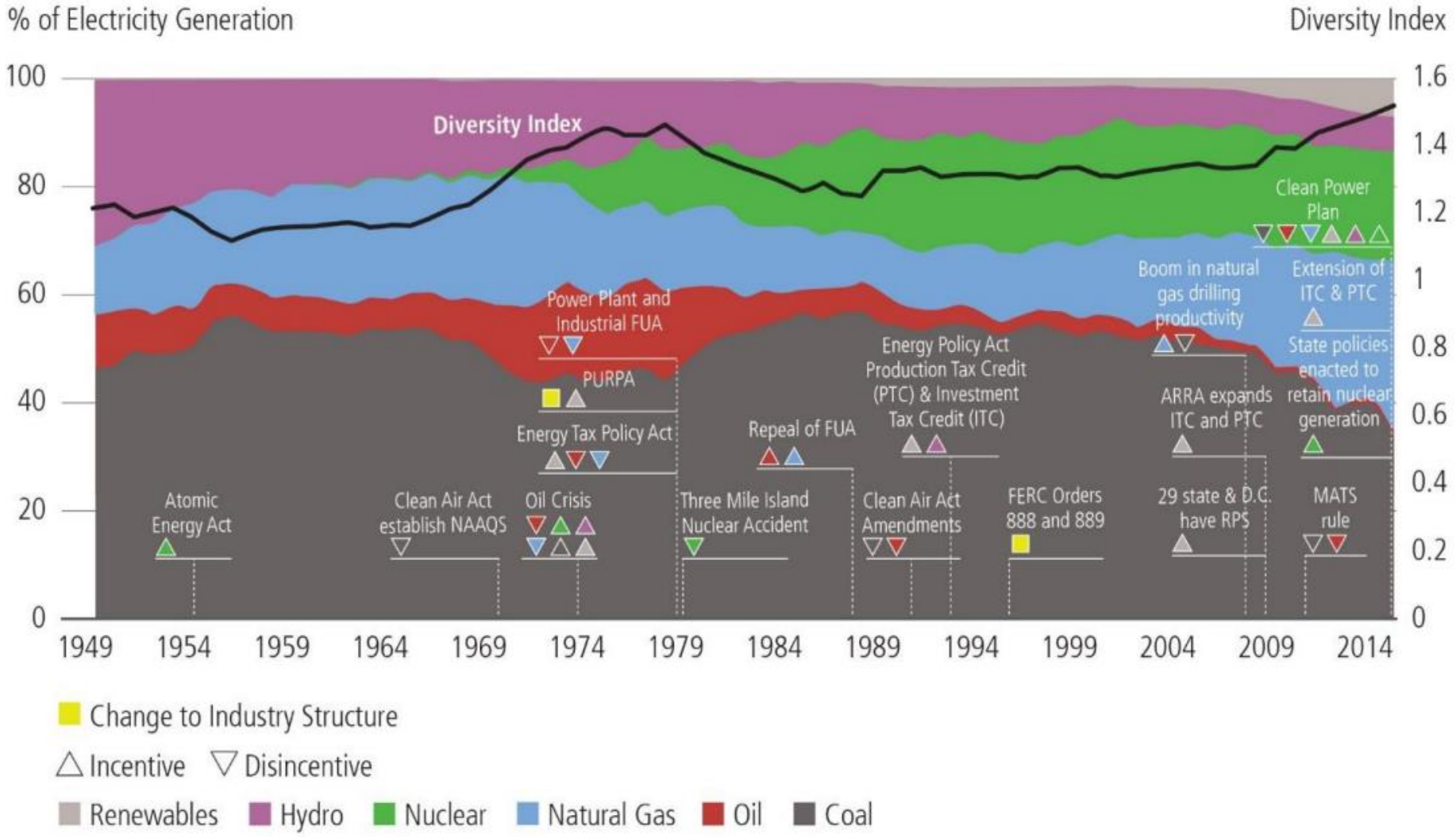


We believe NextEra Energy is uniquely qualified to execute on its Real Zero carbon emissions goal to transform its generation portfolio

1) 2021 megawatts shown includes assets operated by Energy Resources, including those owned by NextEra Energy Partners

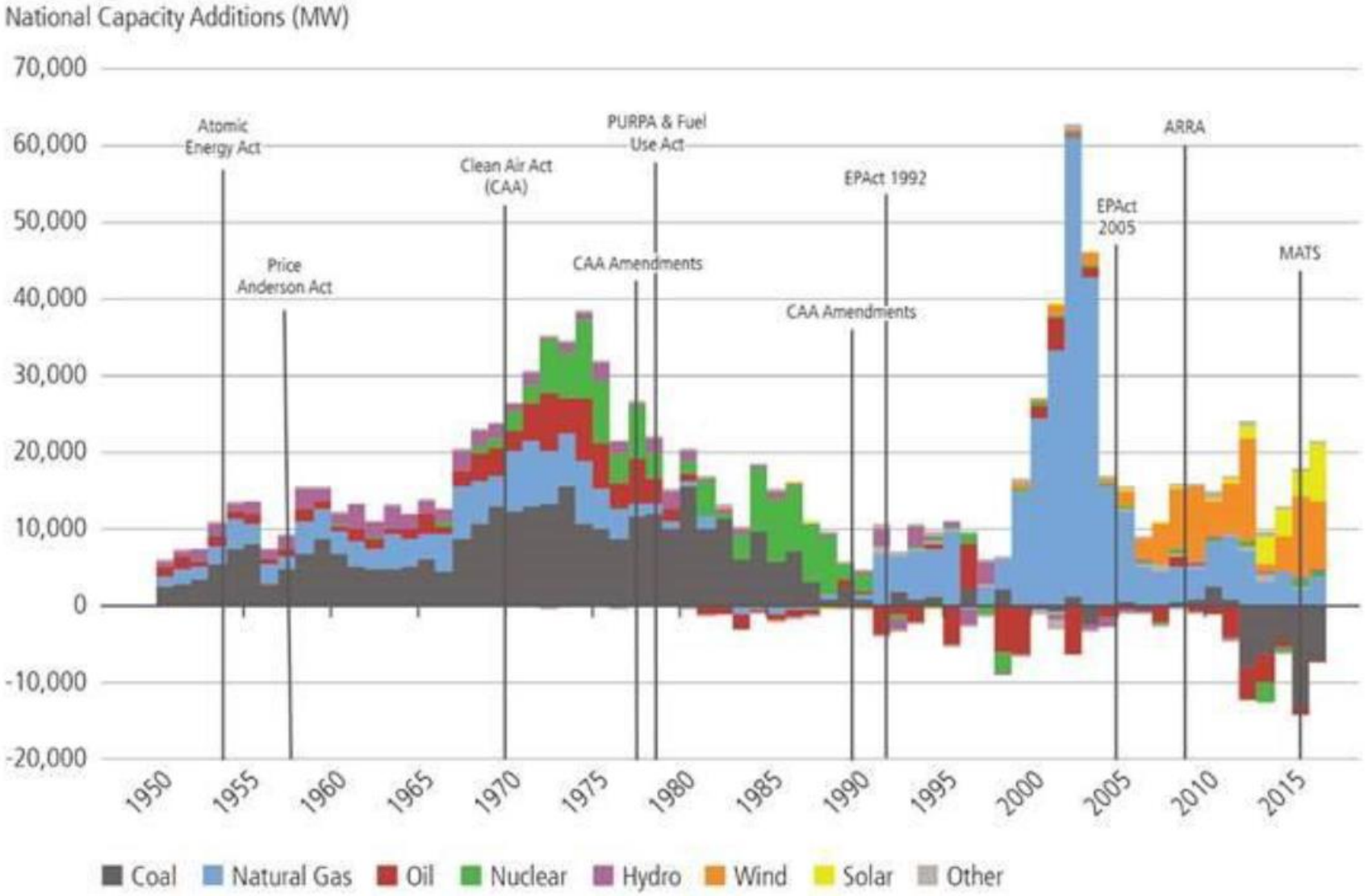
Policies Matter

Generation Mix and Various Economic and Policy Drivers Since 1949, Including Diversity Index



Source: USDOE Staff Report to the Secretary on Electricity Markets and Reliability Figure 4.16 August 2017

Net Generation Capacity Additions and Retirements

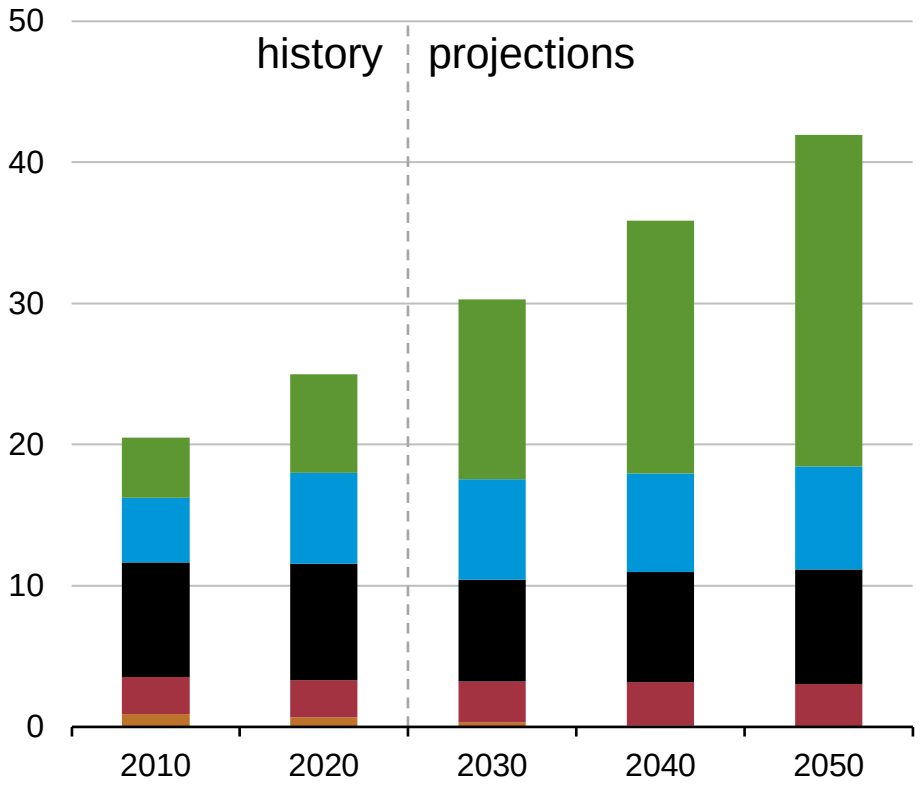


USDOE Staff Report on Electricity Markets and Reliability August 2017 Figure 3.2

World net electricity generation shares by fuel

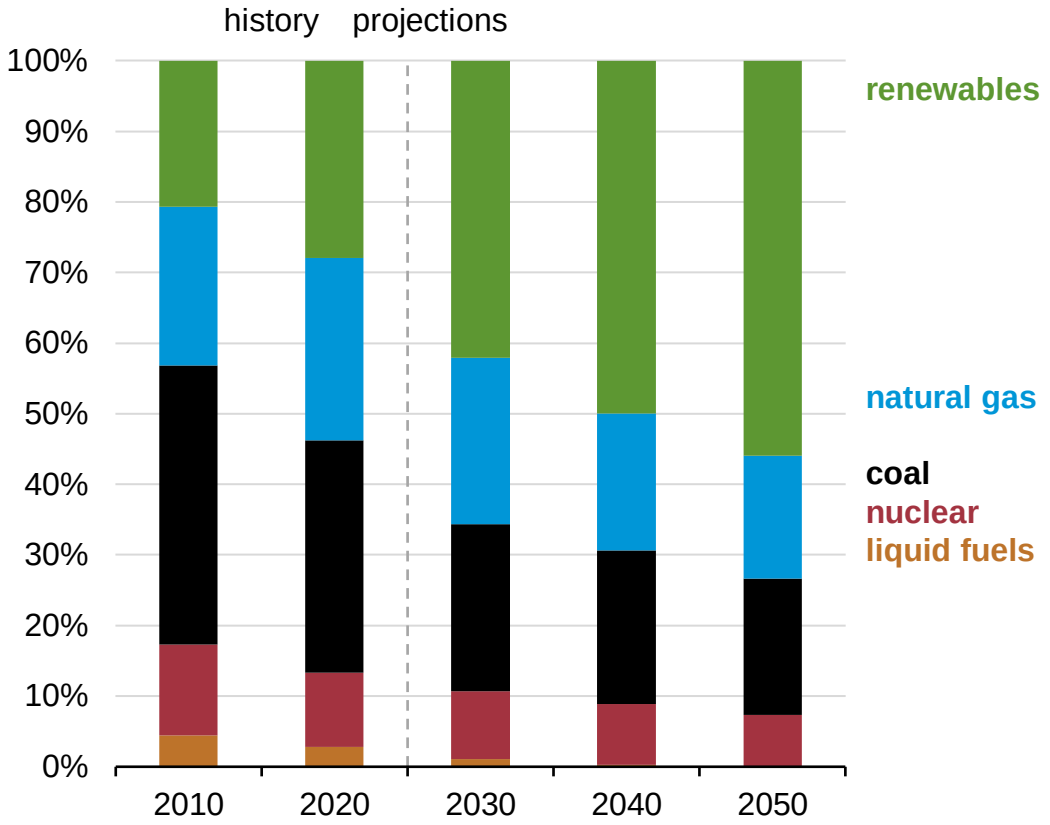
World net electricity generation by source

trillion kilowatthours



Share of net electricity generation

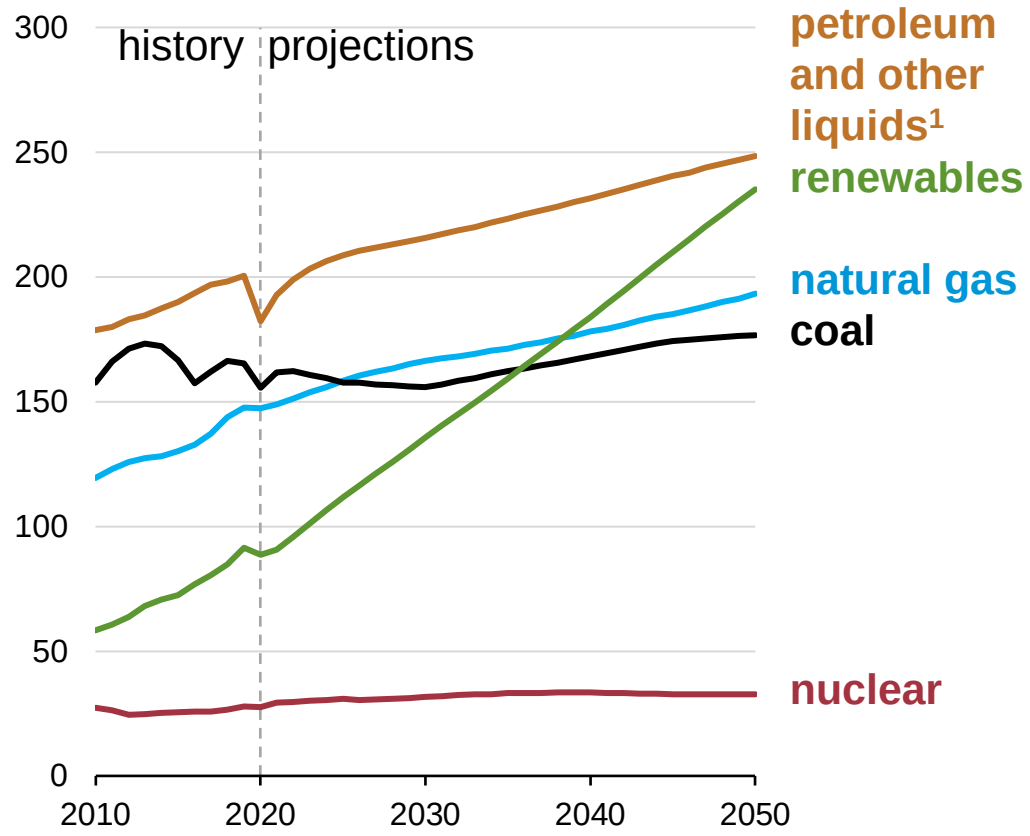
percentage



Primary energy consumption by energy source

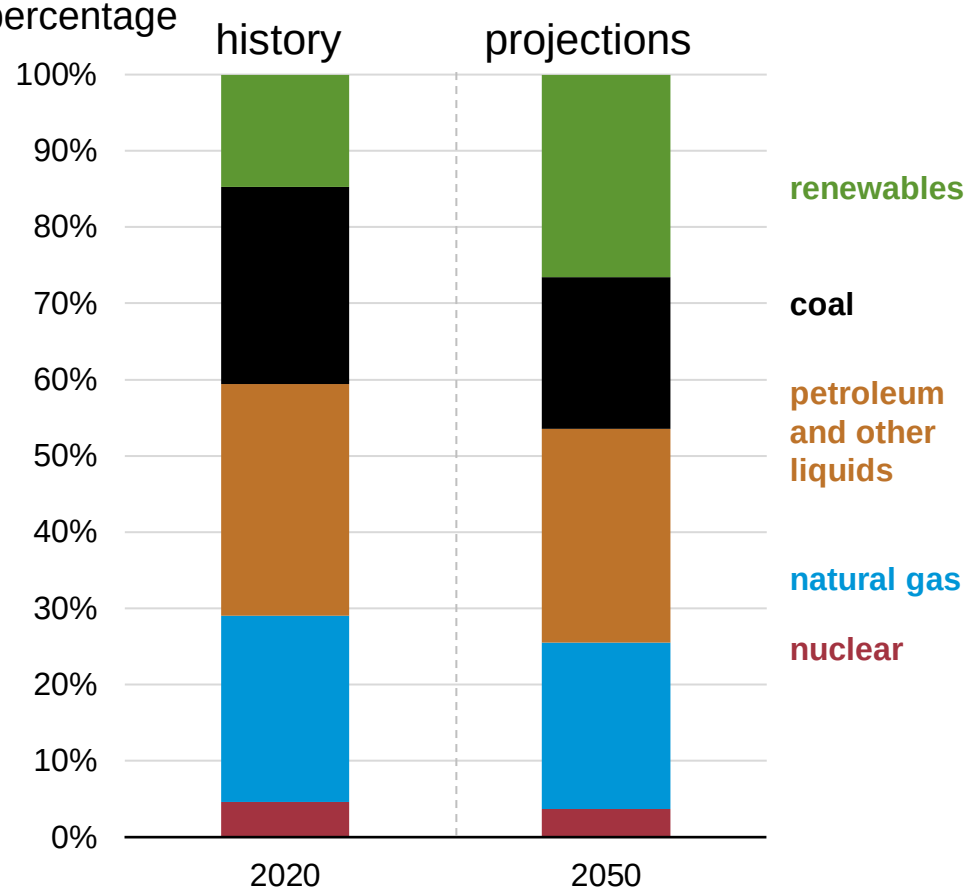
Primary energy consumption by energy source, world

quadrillion British thermal units



Share of primary energy consumption by source, world

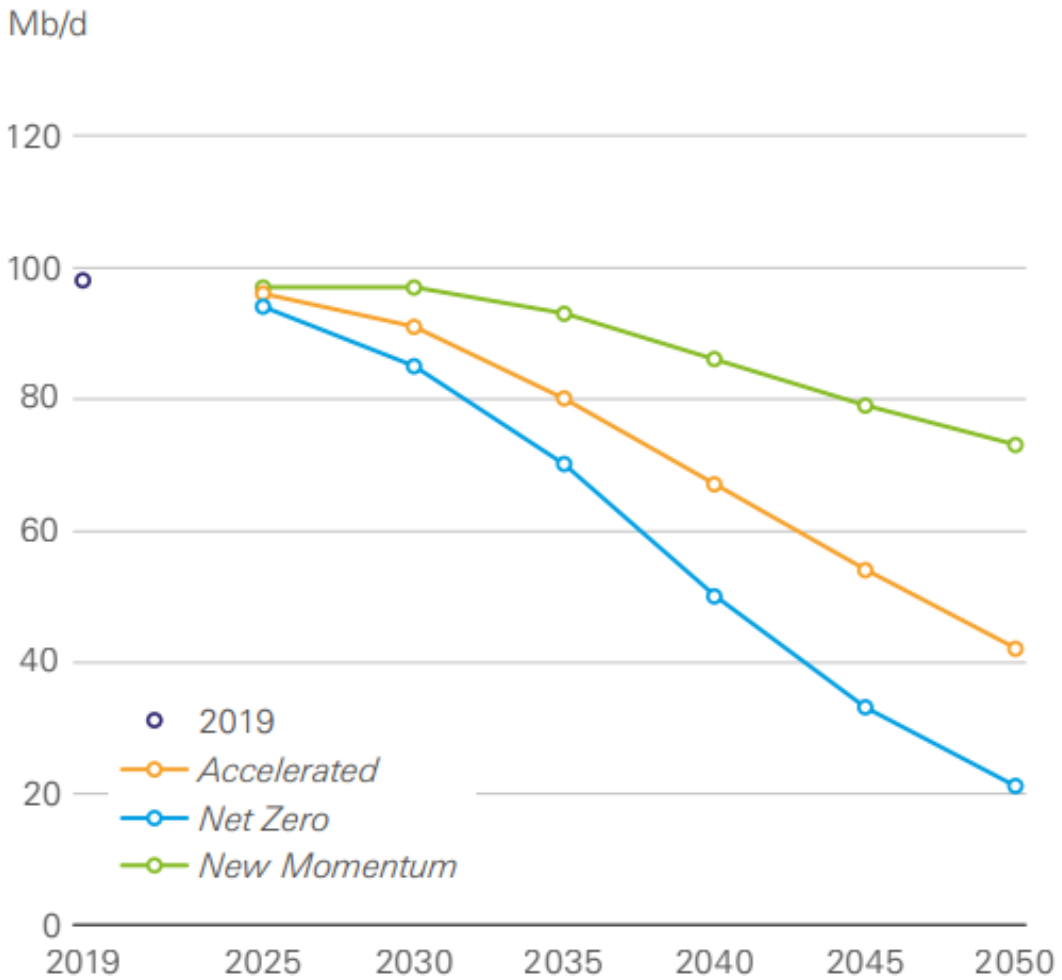
percentage



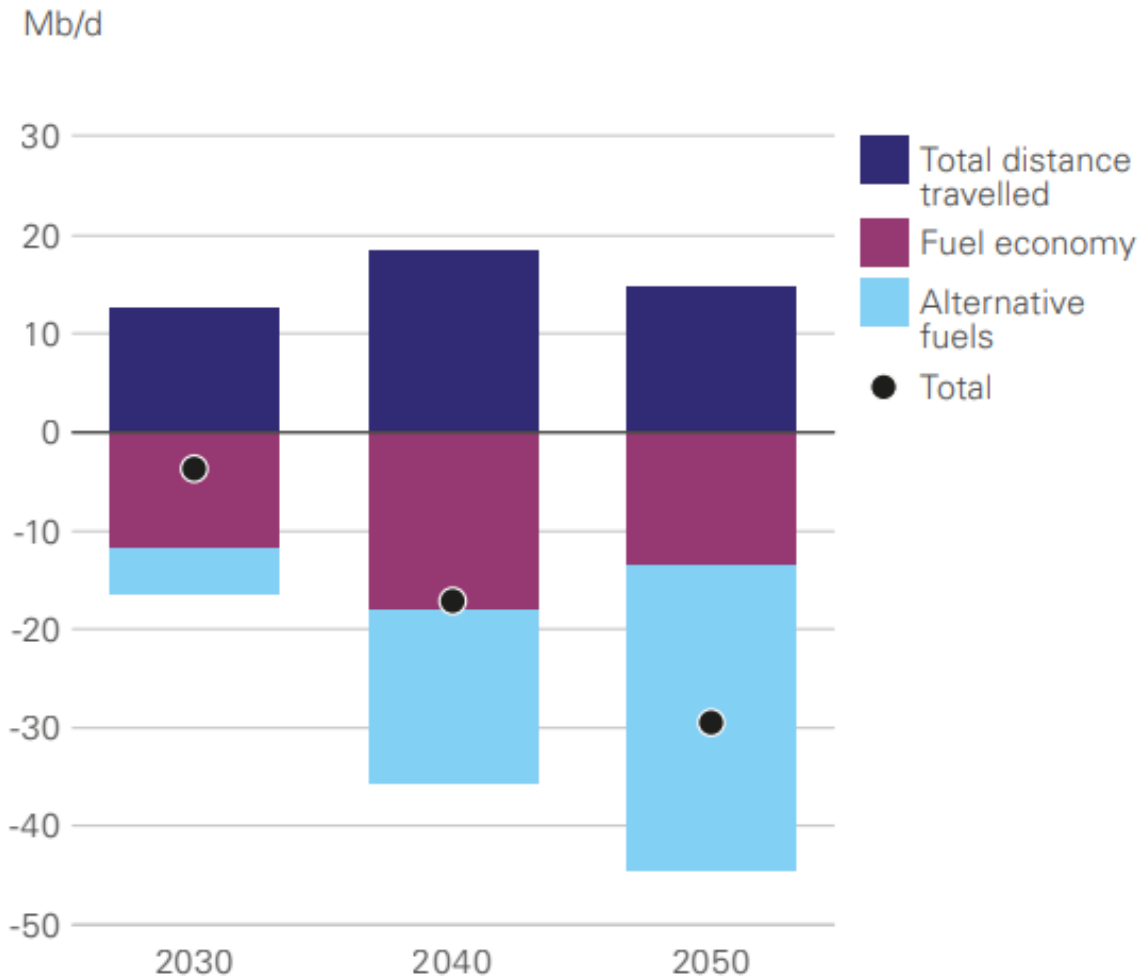
[1] includes biofuels

Oil demand falls over the outlook as use in road transportation declines

Oil demand



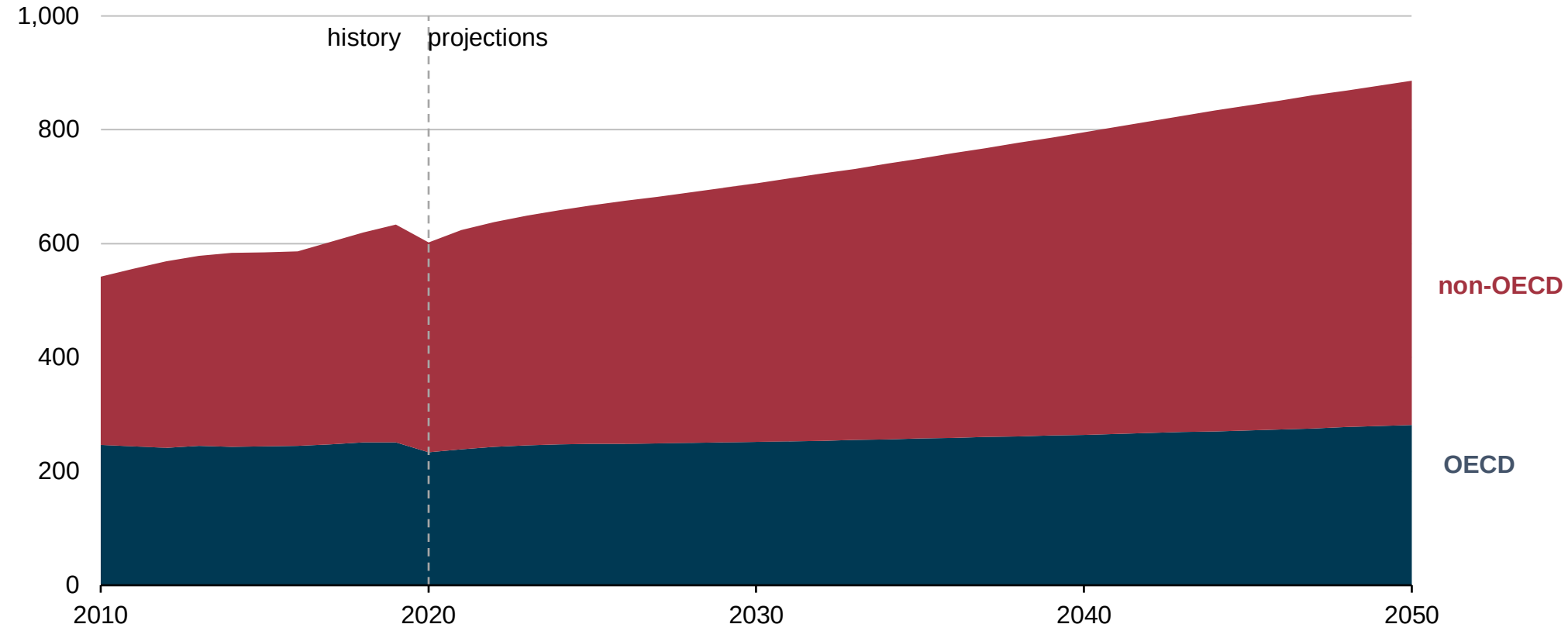
Change in oil demand in road transport versus 2019 in *Accelerated*



World energy consumption

World energy consumption

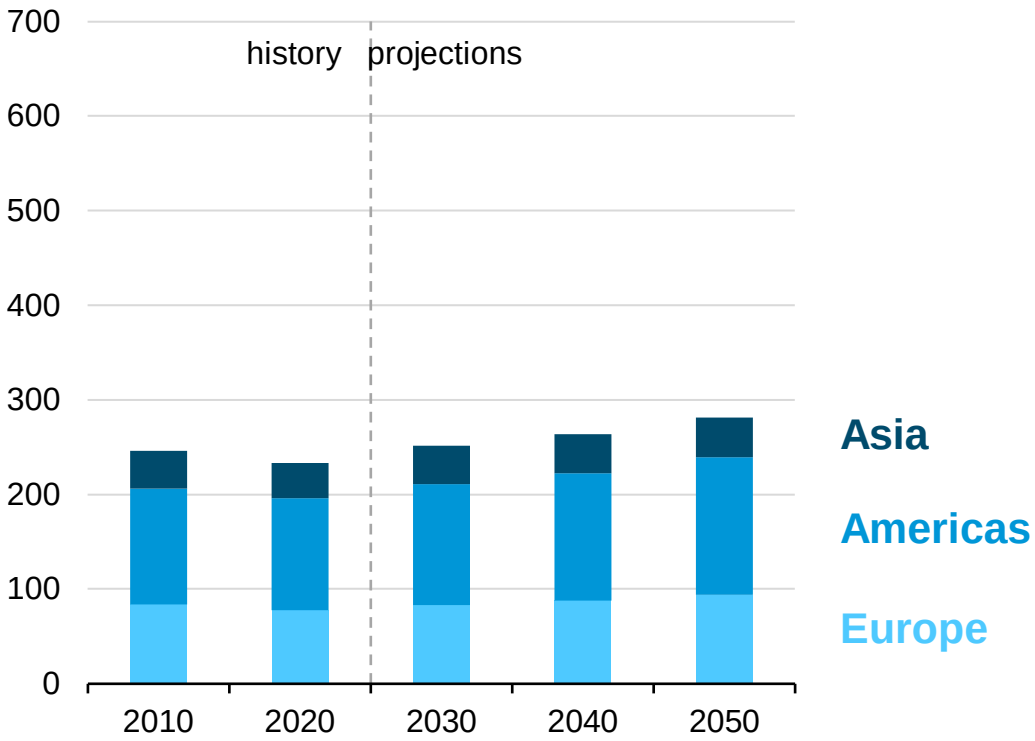
quadrillion British thermal units



Energy consumption by region

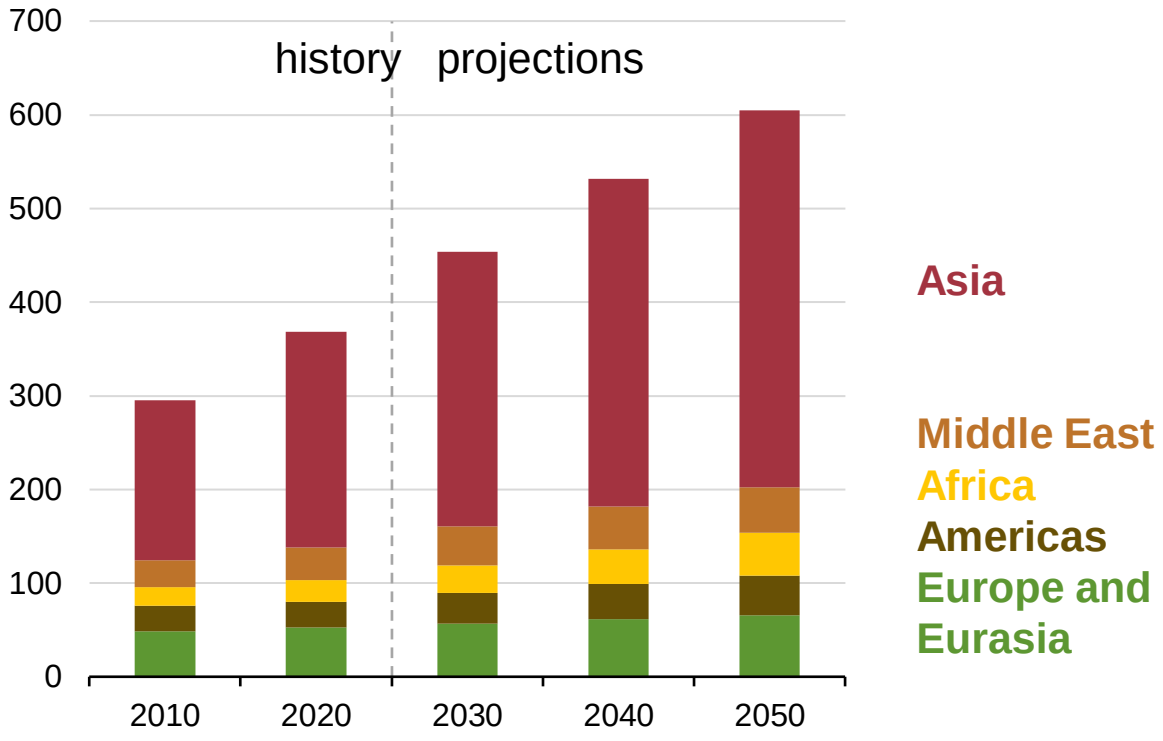
OECD energy consumption by region

quadrillion British thermal units

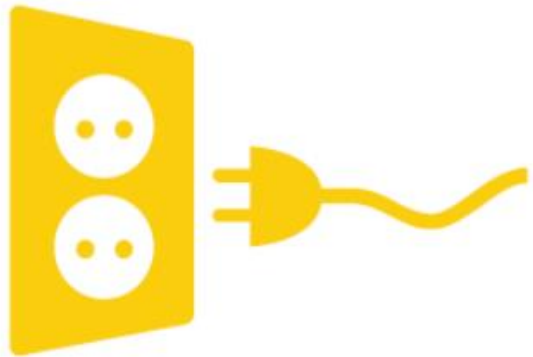


Non-OECD energy consumption by region

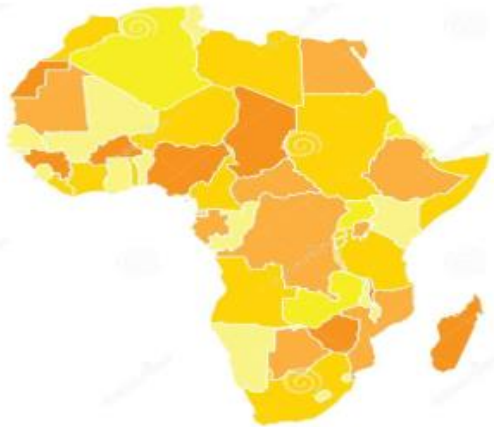
quadrillion British thermal units



THE REALITY: ENERGY POVERTY



1.2 billion people do not have access to electricity ~16% of world's population



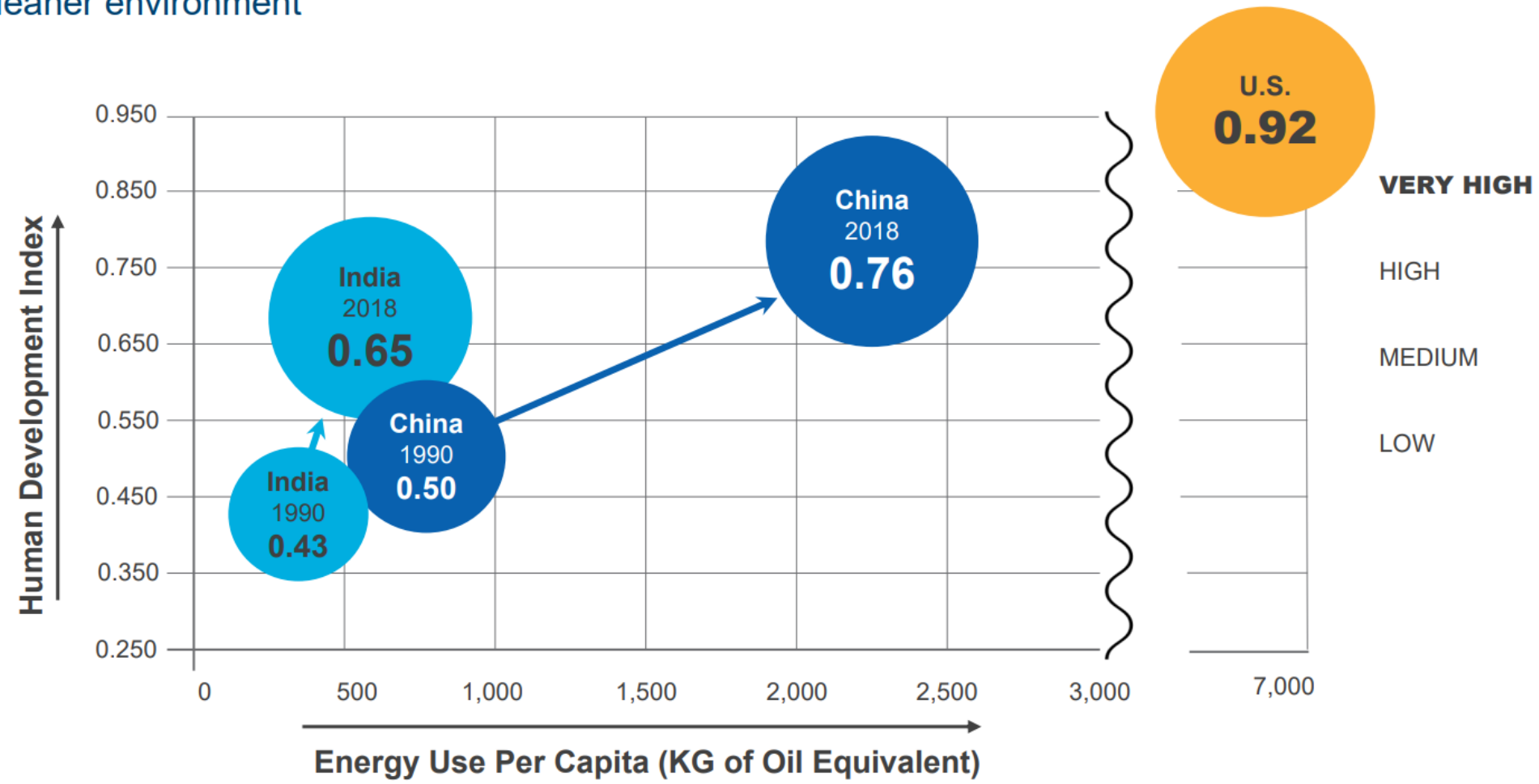
Over 50% of the1.2 billion people live in Sub-Saharan Africa

Nigeria: 2nd largest population without access to Electricity – 98 million people
(8.3% of global population without access to electricity)

Source: IEA, World Energy Outlook 2016

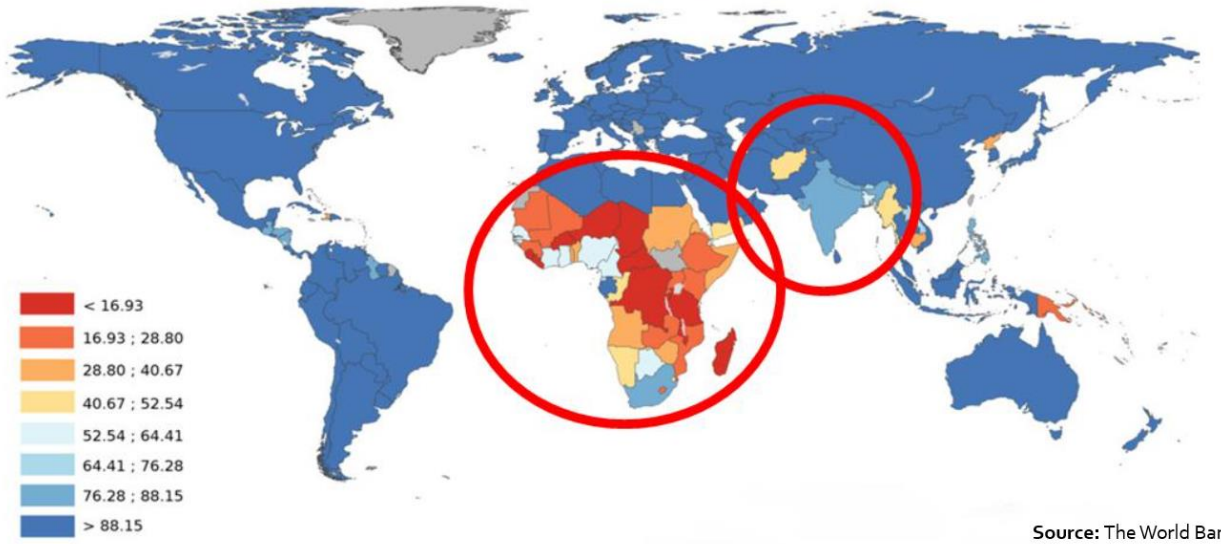
Society's Progress is Intrinsically Linked to Reliable Energy Access

- Access to reliable, affordable, low-carbon energy is a critical enabler of higher living standards, including a longer life and cleaner environment



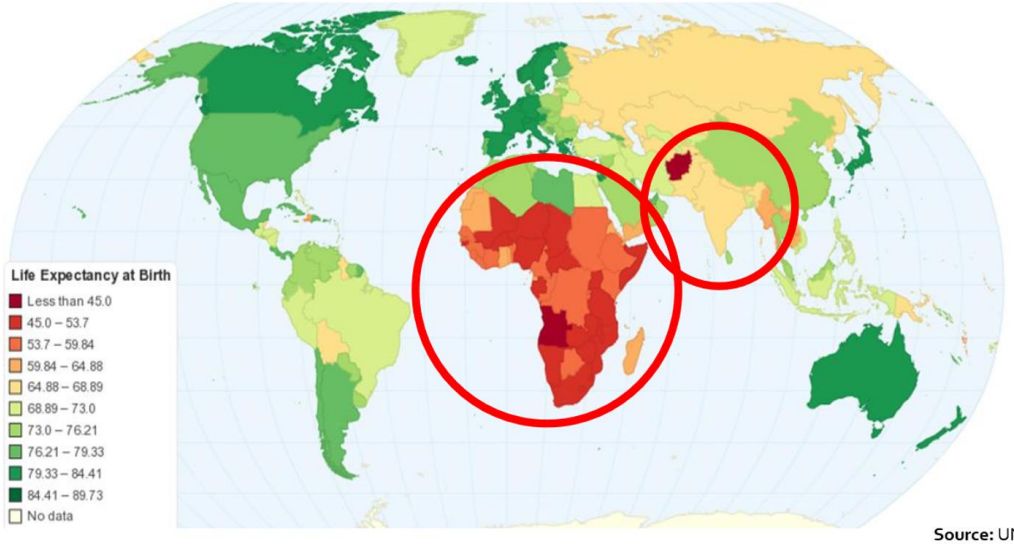
Source: World Bank and United Nations Development Programme 2018

Percent of Population with Access to Electricity



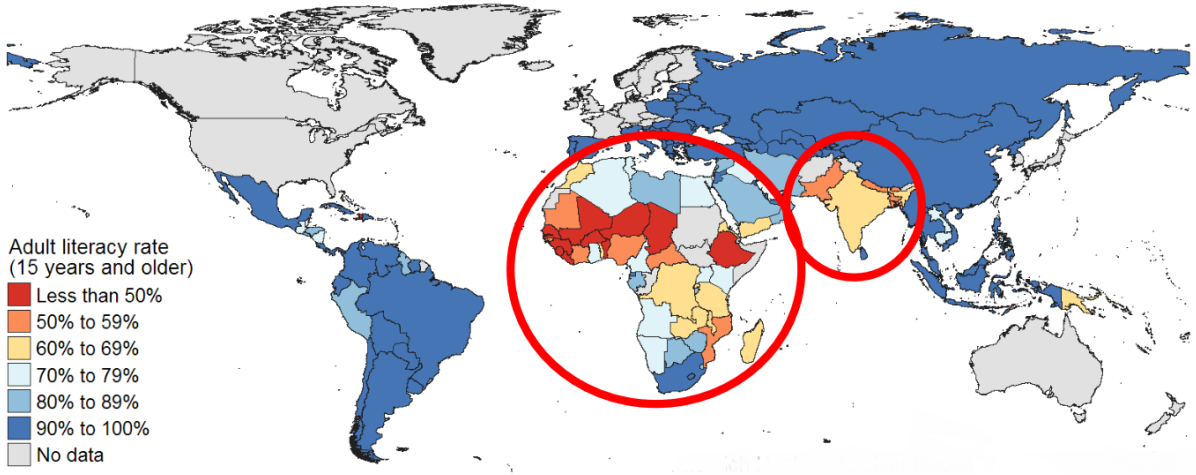
Source: The World Bank

Life Expectancy by Country

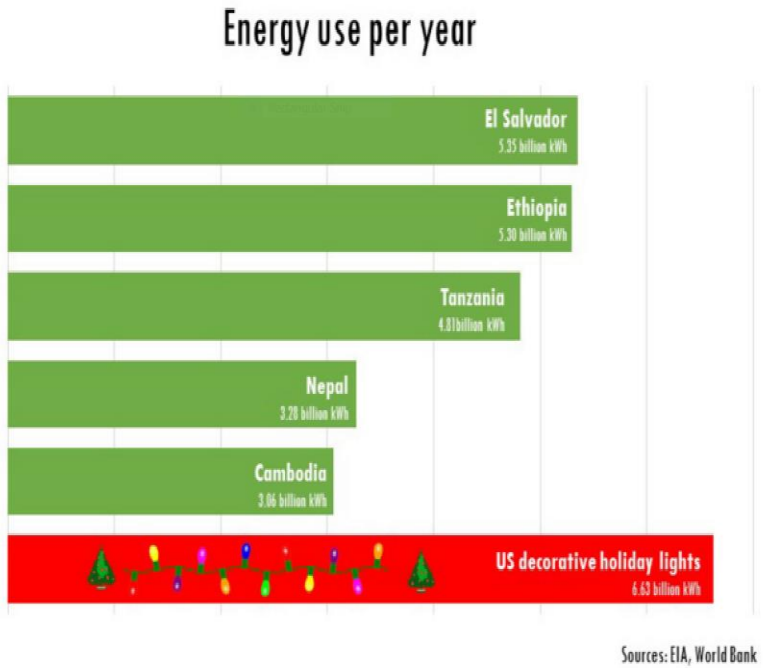


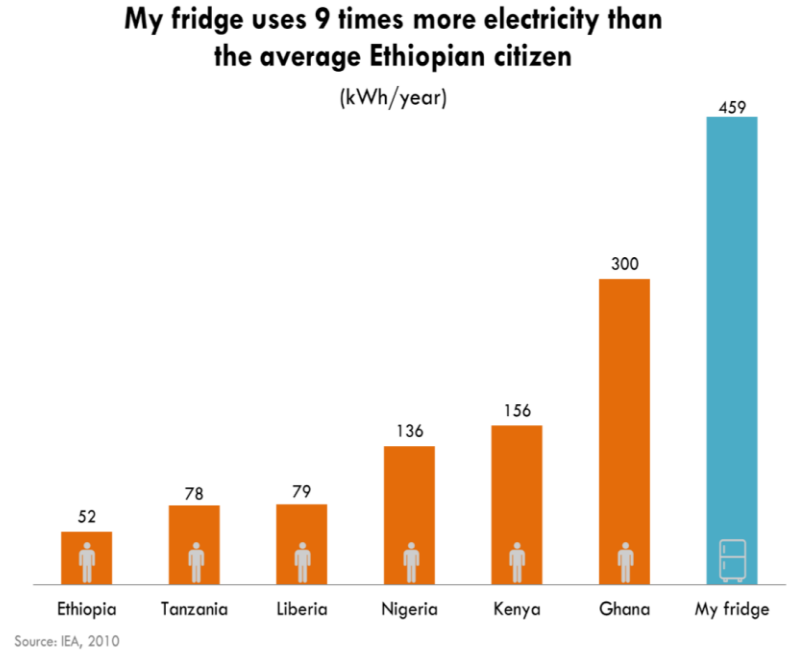
Source: UN World Population Prospects

Literacy Rates by Country



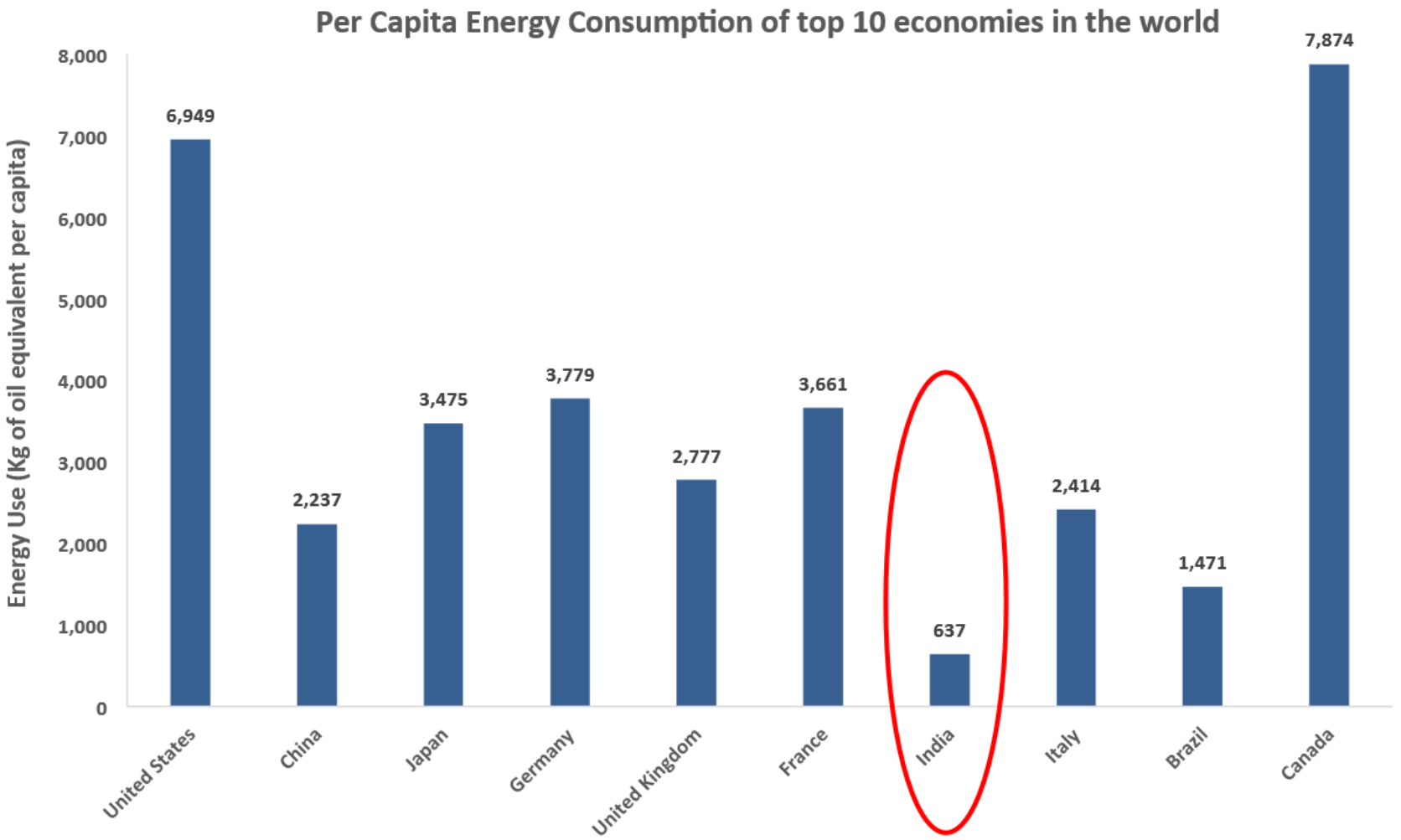
Source: International Education Statistics





Stanford Natural Gas Initiative - 2017 Energy Poverty Symposium
Todd Moss

Energy poverty divide



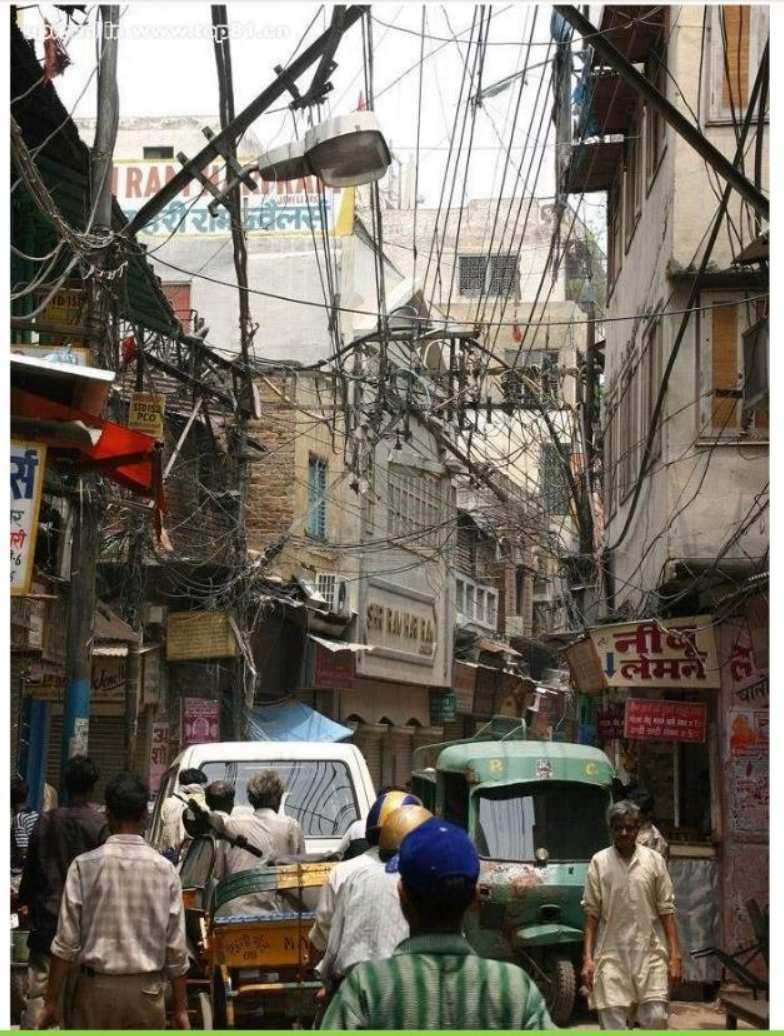
Source: World Bank data 2014

Stanford Natural Gas Initiative - 2017 Energy Poverty Symposium

India's per capita energy consumption lowest among the top economies

Electrifying India: Power for all

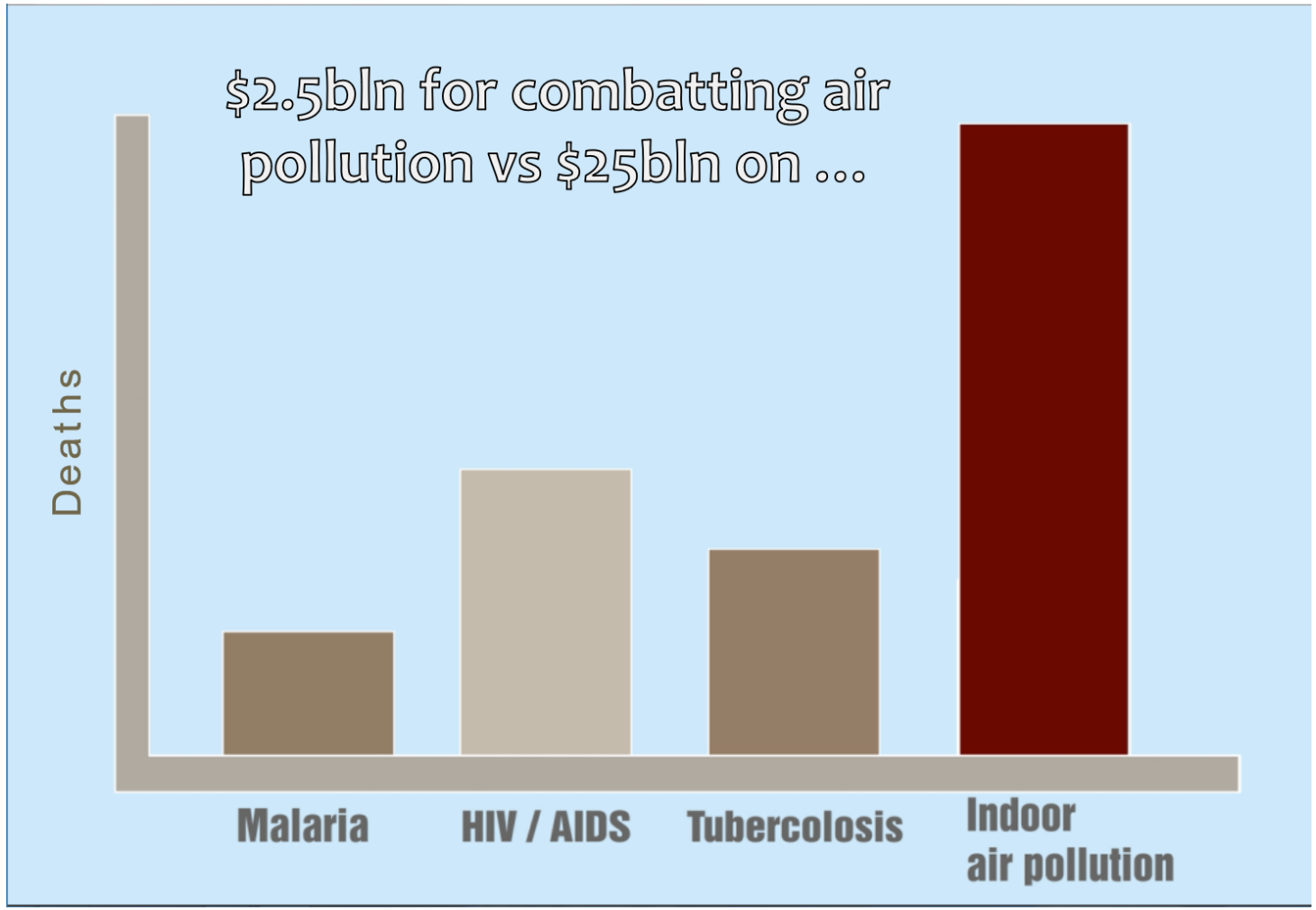
- The world's largest un-electrified population
- Available 1100 TW translates to a 90 watts per capita
- EU 700 watts, US 1500 watts
- 250 watts can hardly be too ambitious for India
- 100% villages by May 2018
- Pricing reforms will need to occur across the energy chain



Stanford Natural Gas Initiative -
2017 Energy Poverty Symposium

DNEP 2016 targets 2132 TWh by 2026-27
By 2030 India generation increases 3 times to 3600 TWh.

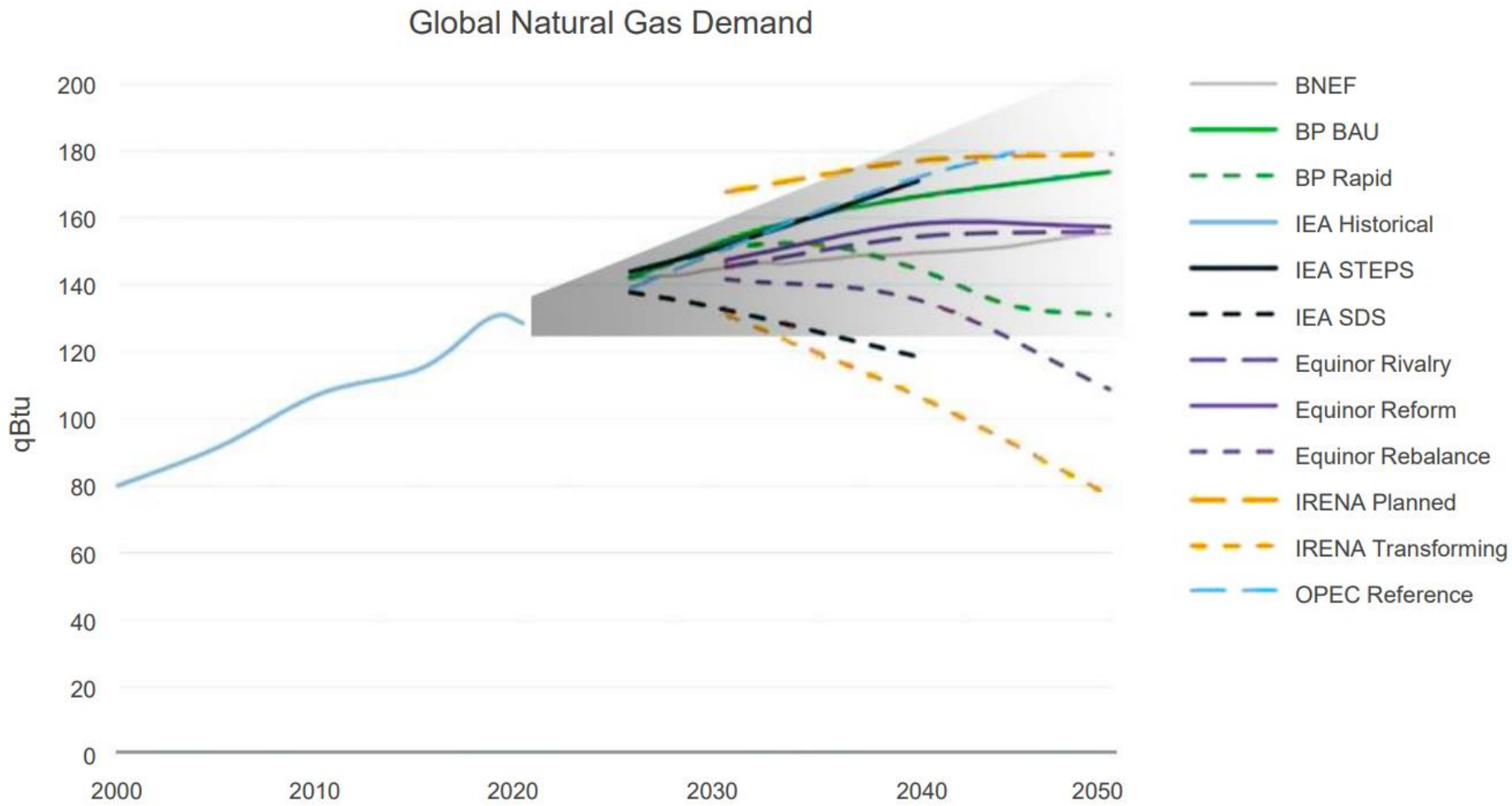
The Value of, and the Need for, Cleaner Thermal Fuels



Stanford Natural Gas Initiative - 2017 Energy Poverty Symposium
James Rockall WLPGA

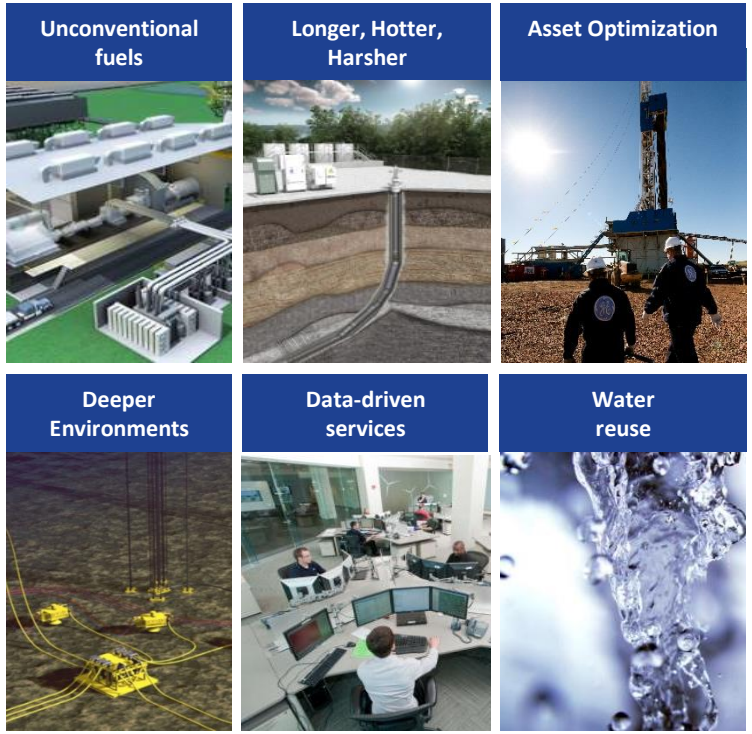
Experts Generally Agree

Global Demand for Natural Gas Must Grow to Meet Ambitions of the Paris Climate Accord

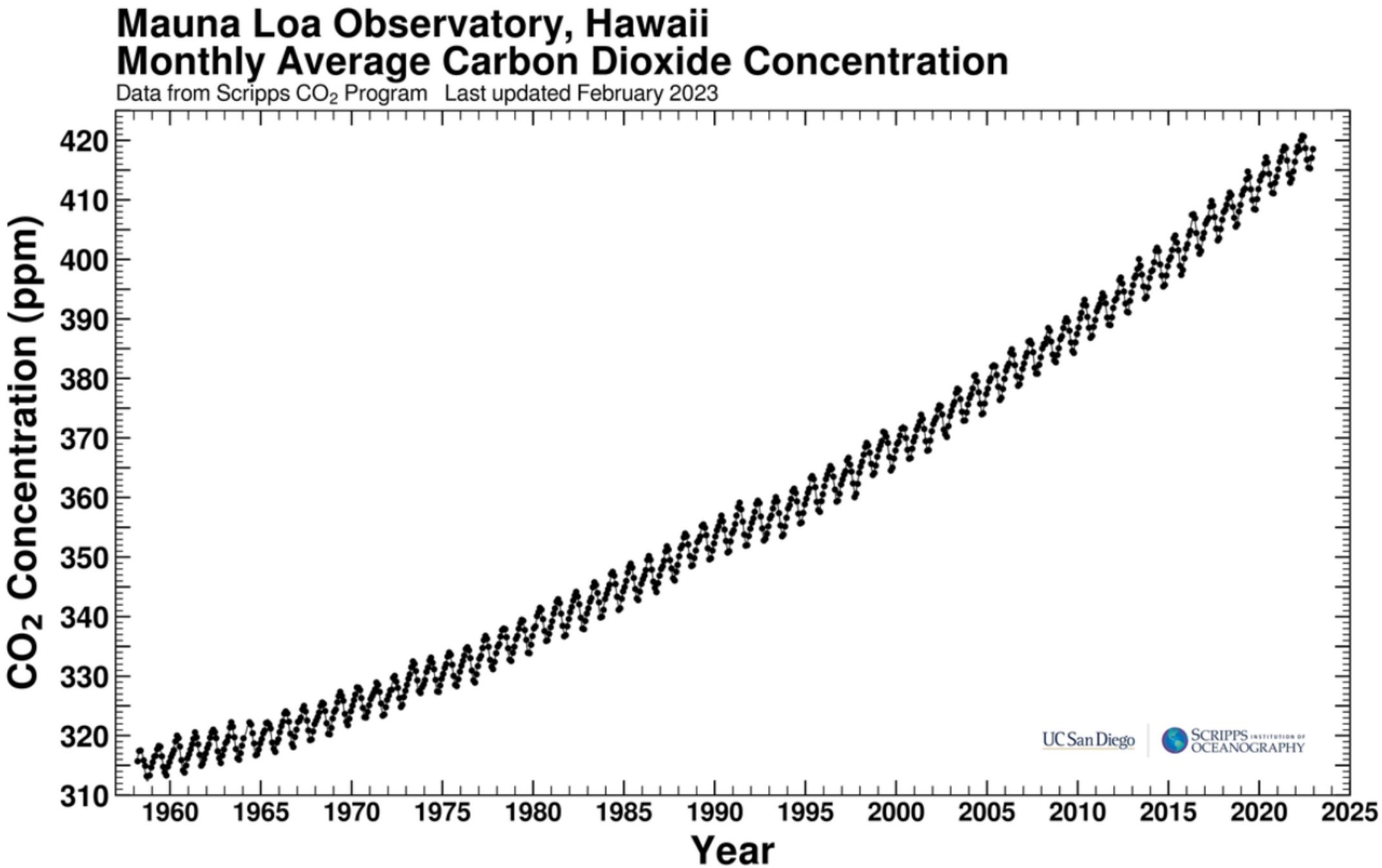


Developing a New Generation of Resources

- Better
- Smarter
- Safer
- Faster
- Cleaner
- More Efficient



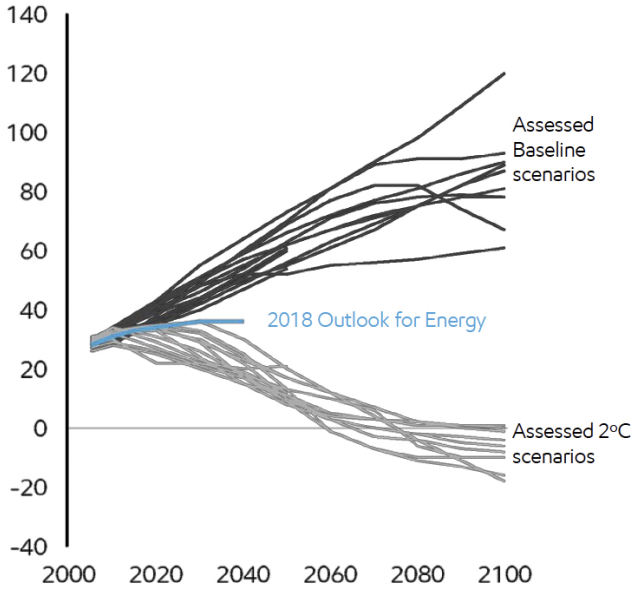
Producing these new resources the Right Way


Mauna Loa Observatory, Hawaii
Monthly Average Carbon Dioxide Concentration
Data from Scripps CO_2 Program Last updated February 2023
CO_2 Concentration (ppm)
420
410
400
390
380
370
360
350
340
330
320
310
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
Year
UC San Diego
SCRIPPS INSTITUTION OF OCEANOGRAPHY

Oil and gas required in 2°C scenarios

Global energy-related CO_2 emissions

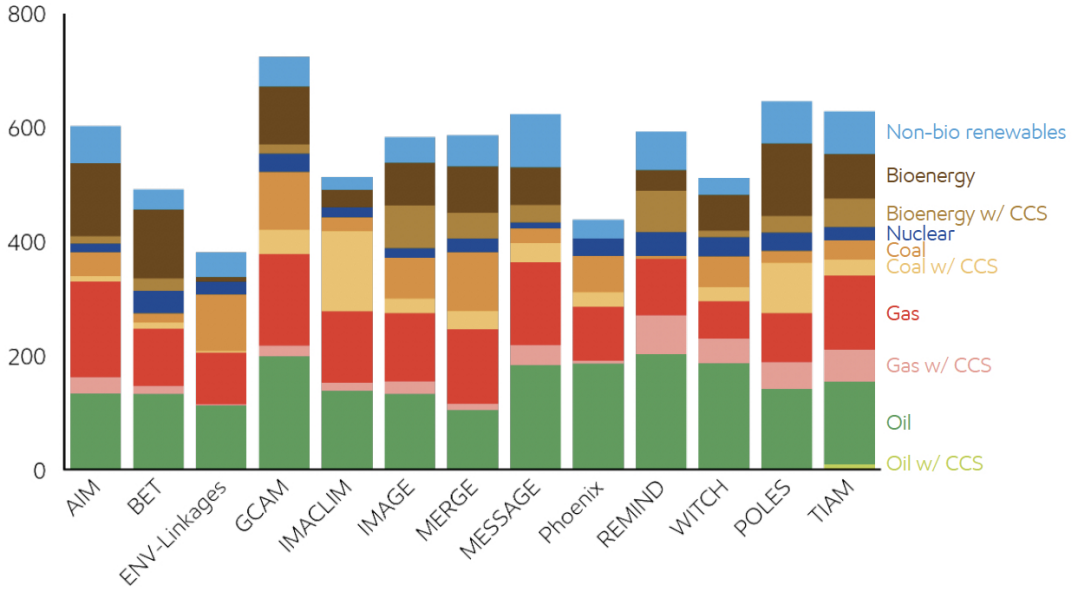
Billion tonnes



Baseline and 2°C scenarios based on Stanford EMF27 full technology scenarios
EMF27-FT cases include CO_2 emissions from energy and industrial processes

2040 Global demand by model and energy type

Exajoules



13 Scenario's from
Stanford Energy Modeling Forum
Professor John Weyant

Industry Response to Climate Questions

HOW IT STARTED…

"It's not our fault…"

"It doesn't matter, you need us anyway."

HOW IT'S GOING…

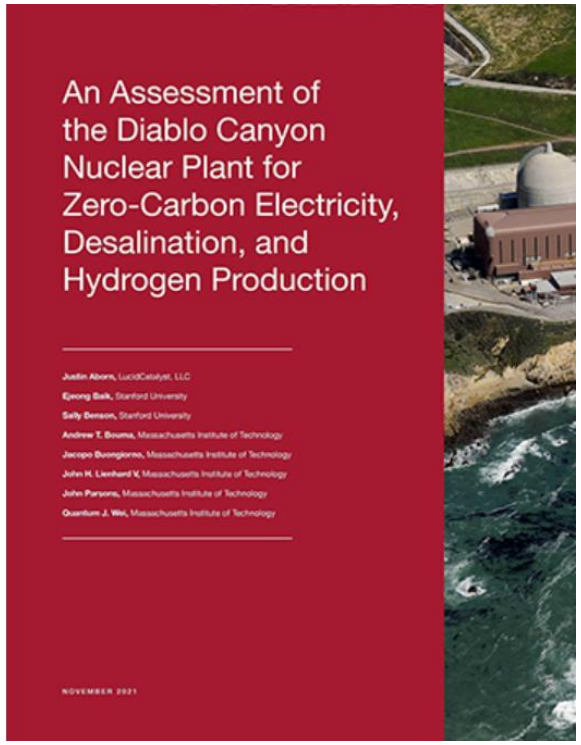
"Politics aside, we can reduce our carbon footprint. Materially."

Photos source: National Football League

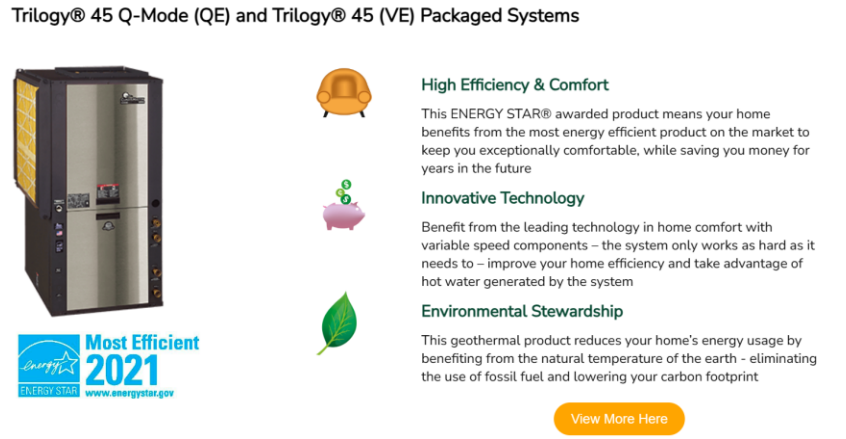
Today's Toolbox

Mobility

Preserving & Enhancing Options



My Home

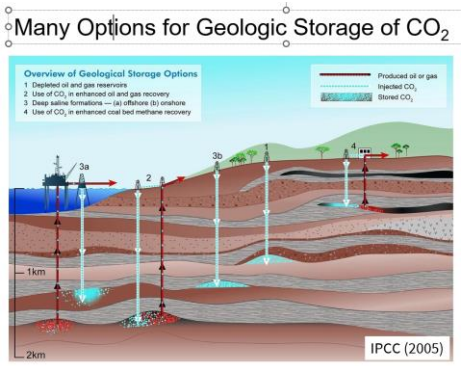


Model Y	Model 3	Model 3
$50,490	$47,240	$40,240
330 miles (EPA est.)	333 miles (EPA est.)	272 miles (EPA est.)
7 seats	5 seats	5 seats
76 cu ft	23 cu ft	23 cu ft
AWD Dual Motor	AWD Dual Motor	RWD

2023 Ford Explorer® Hybrid SUV

The 2023 Explorer® Hybrid SUV comes well-equipped in both Limited and Platinum models. Combined with road trip-ready range, impressive towing and confidence-inspiring off-road capability — it gives you the best of all worlds while you're out discovering this one.

Power Generation & Industry



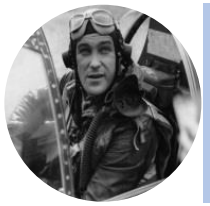
Hybrid Synergies

+

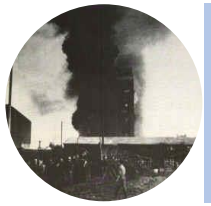
+

+

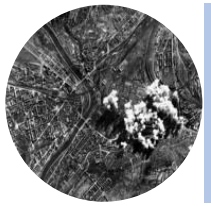
Getting The Bigger Picture: Ball Bearings



It’s



All

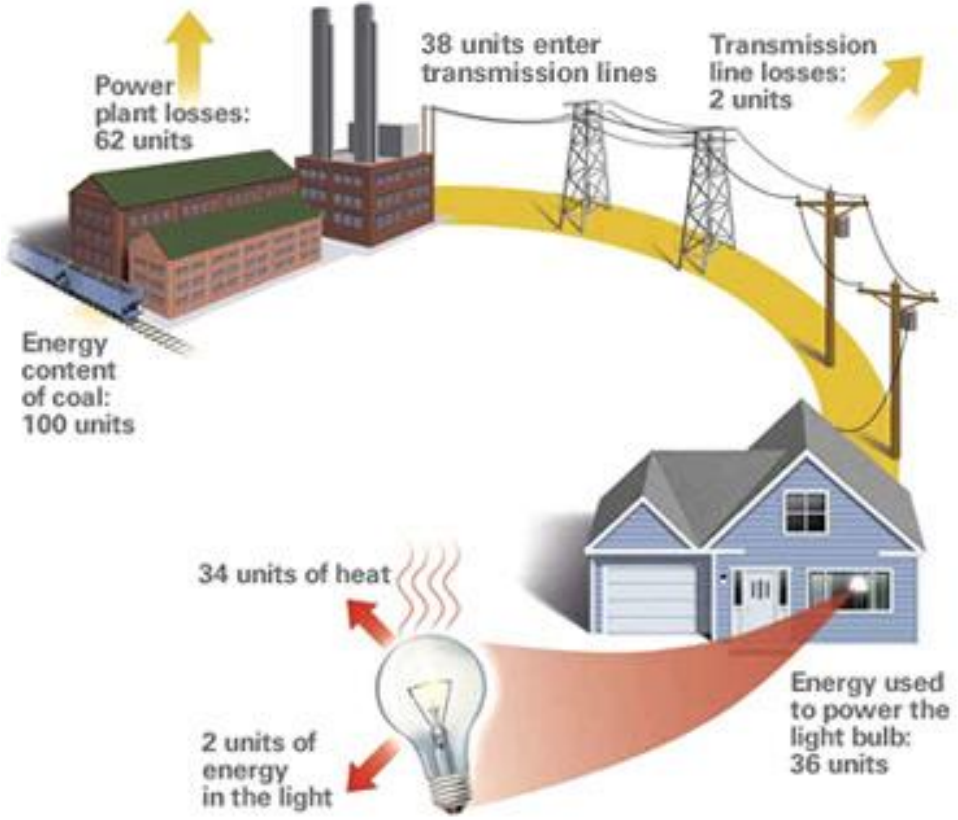


About

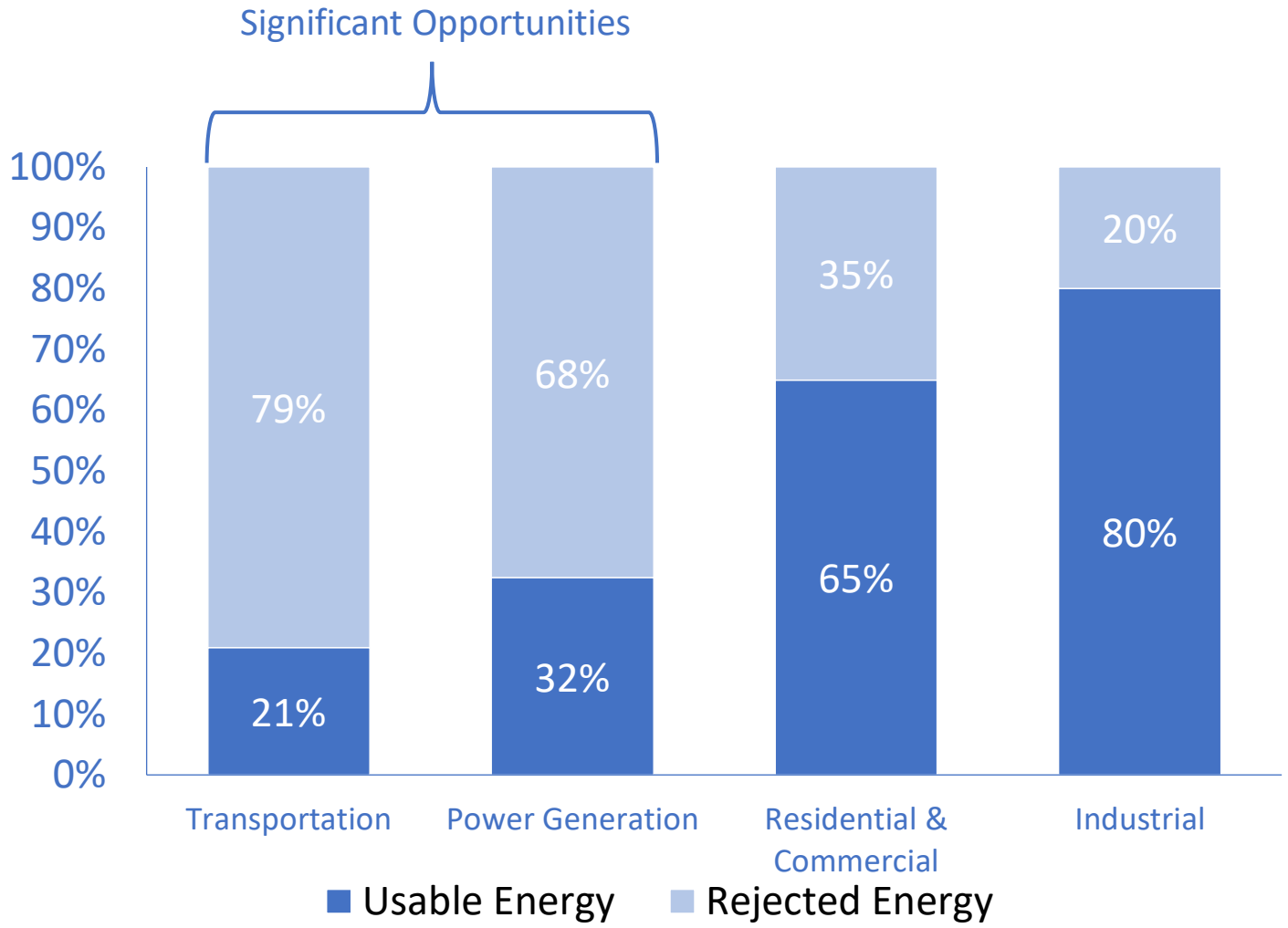
Optimizing

Components

Optimizing Any Component Can Improve the Entire System

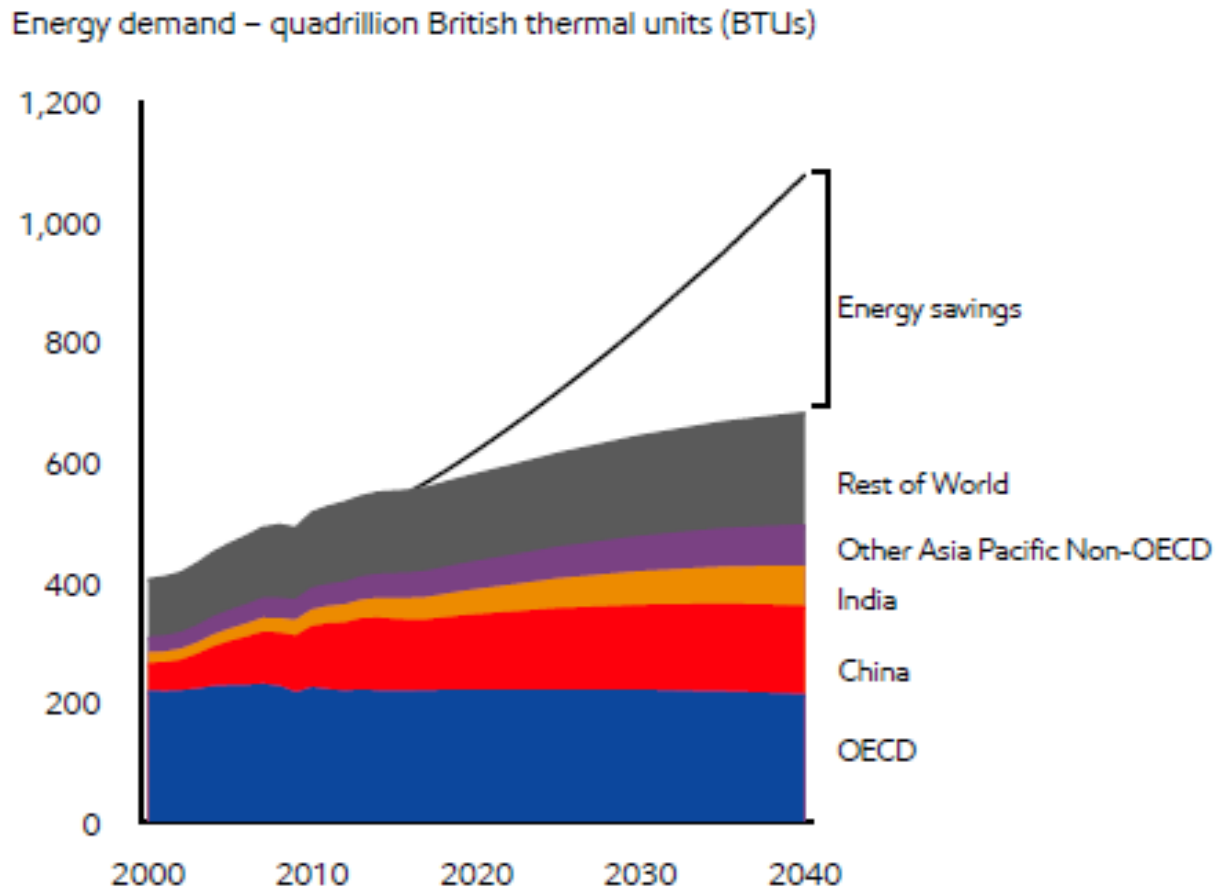


2013 US Efficiency by Sector



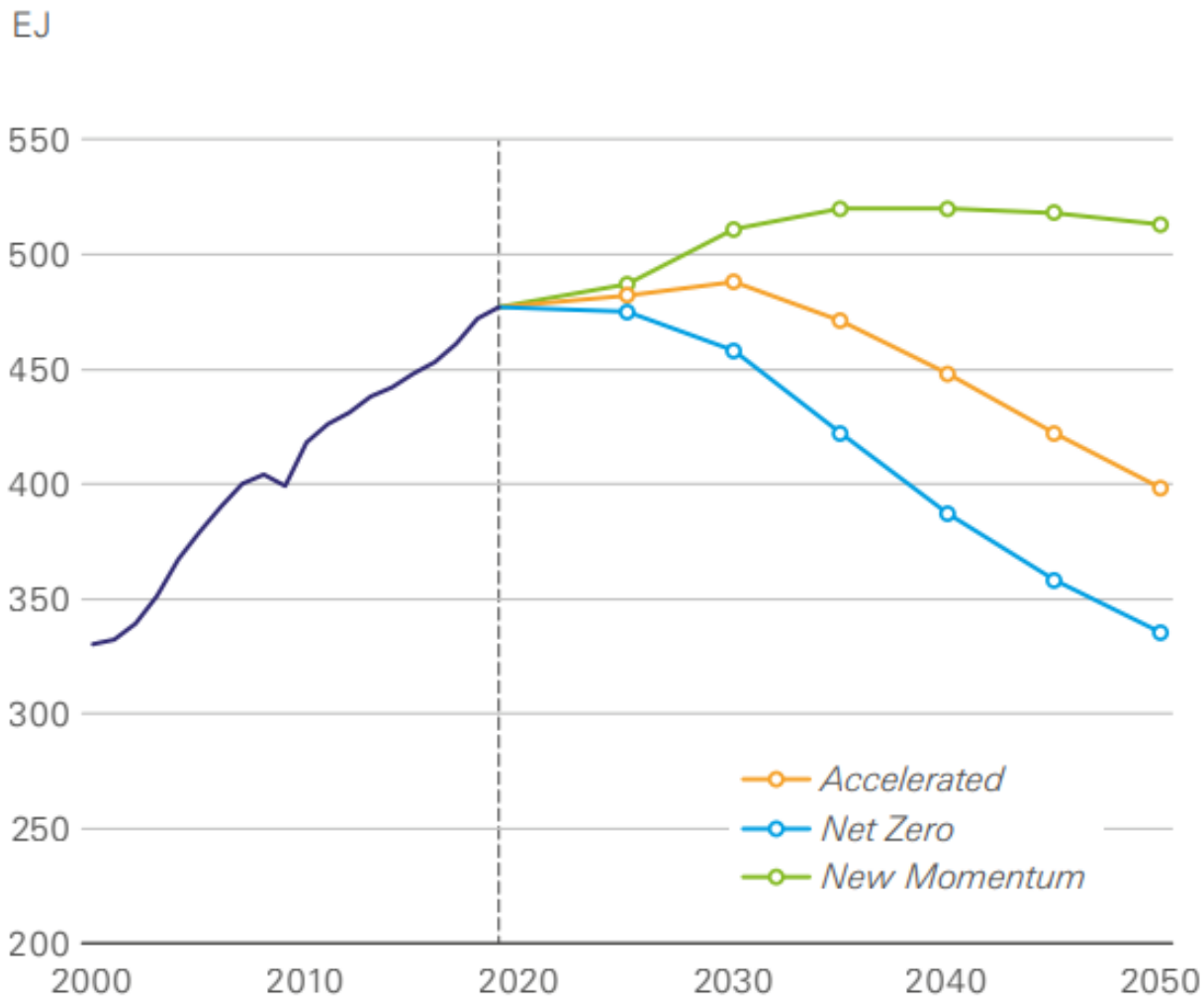
Data : Lawrence Livermore National Laboratory (2014), based on US DOE/EIA-0035(2014-03), March 2014.

Global efficiency limits demand growth

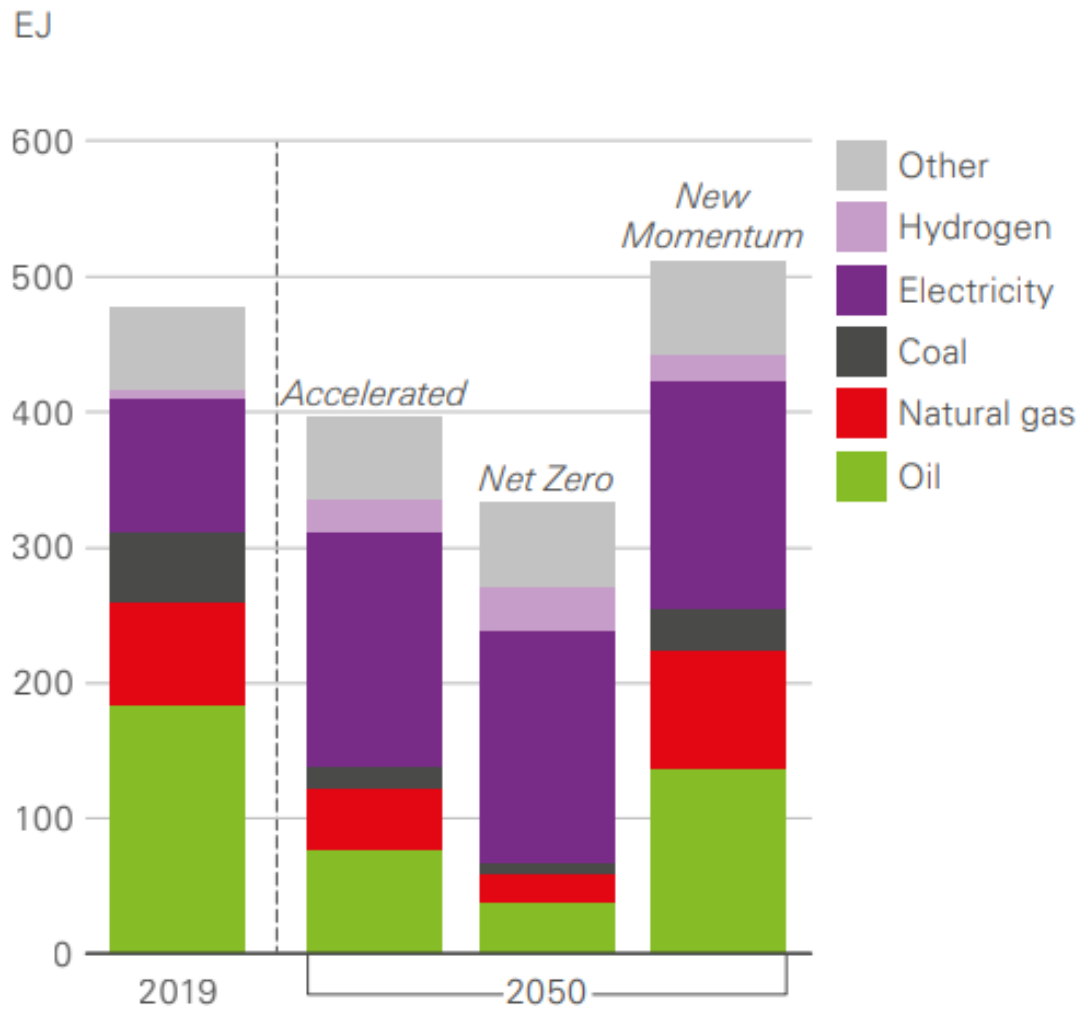


Final energy demand peaks in all three scenarios as gains in energy efficiency accelerate

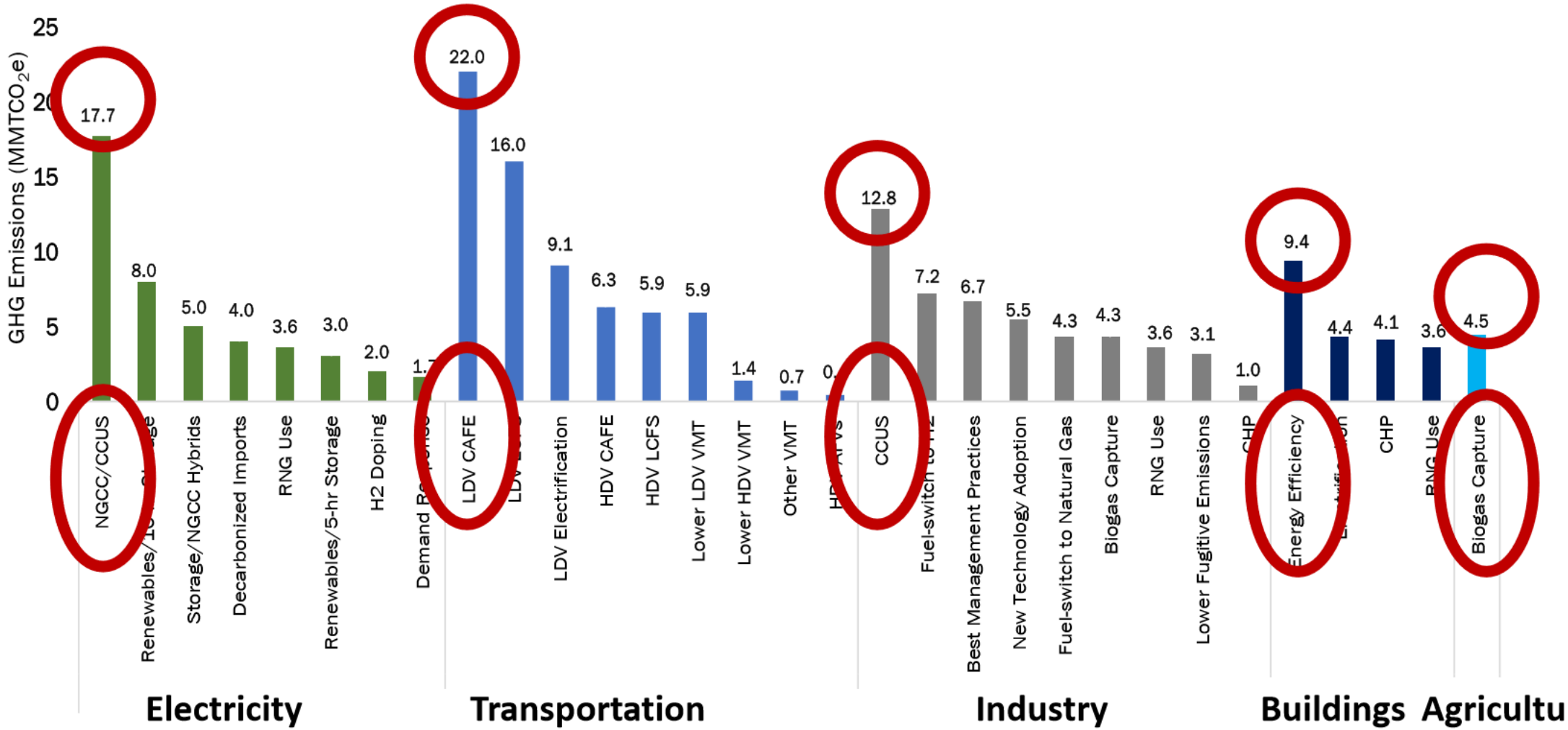
Total final consumption



Total final consumption by fuel



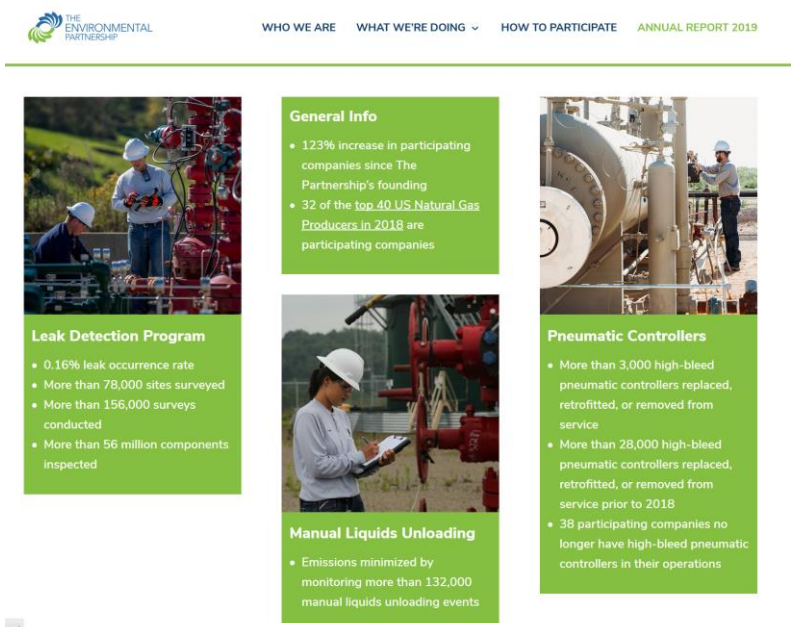
Identified Emissions Reduction Potential of Sector-Specific Pathways for Meeting the 2030 Targets

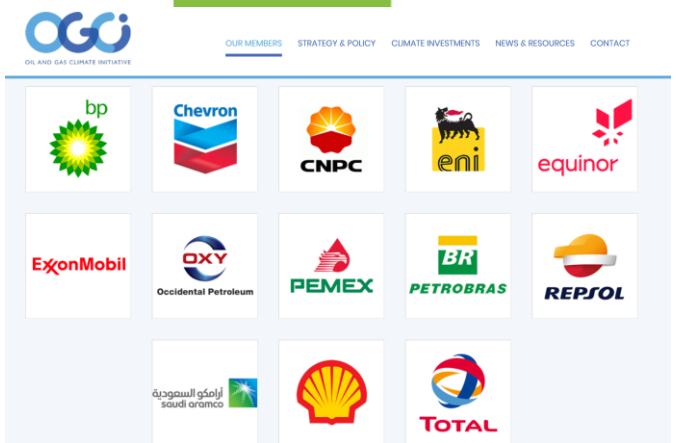


Source: EFI analysis

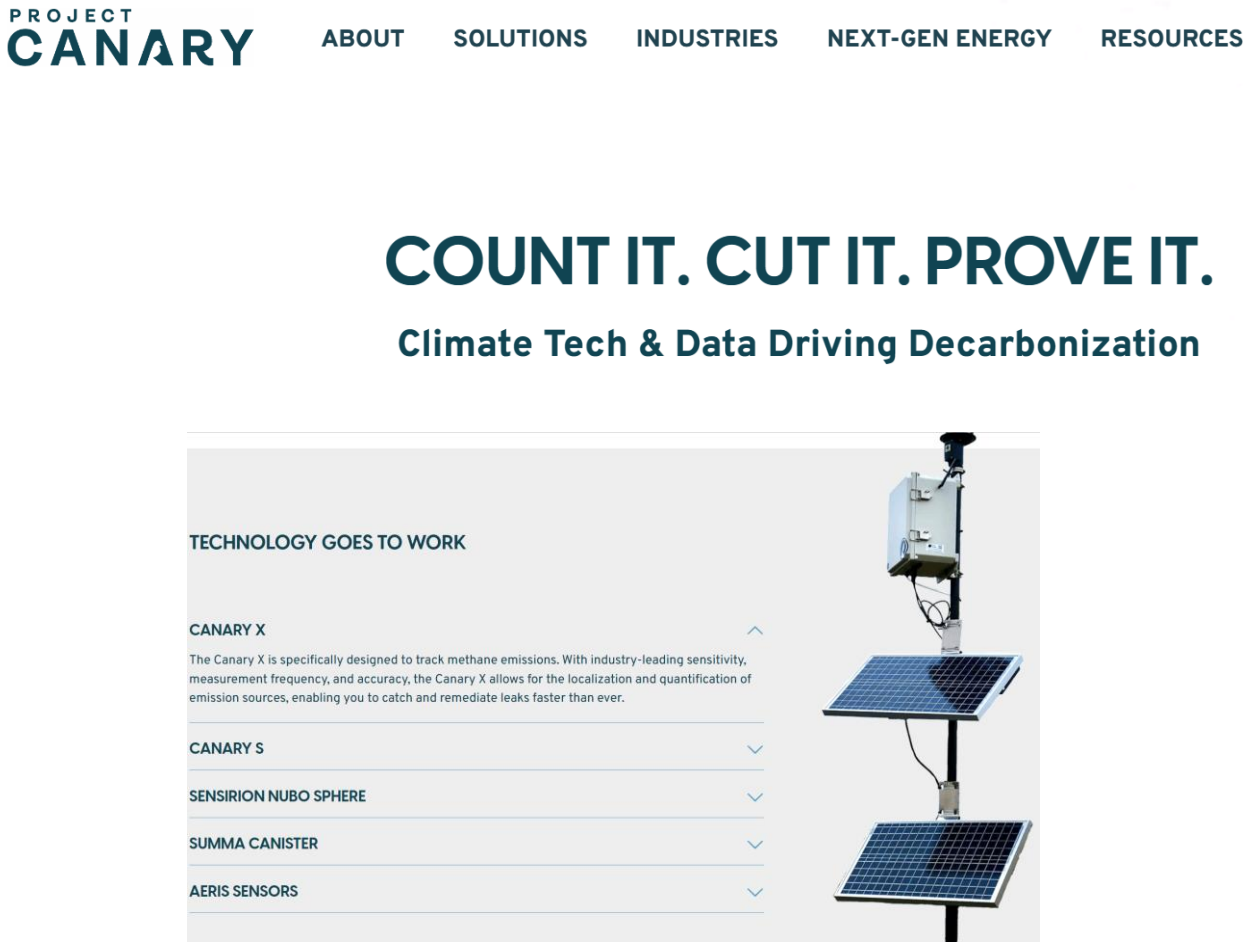
Fugitive Methane Emissions

Trade Association Efforts





A Burgeoning Industry



https://theenvironmentalpartnership.org/2019-annual-report/

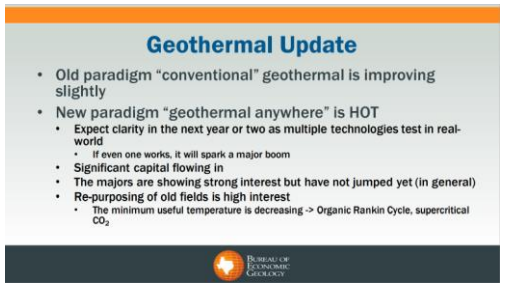
Tomorrow's Toolbox

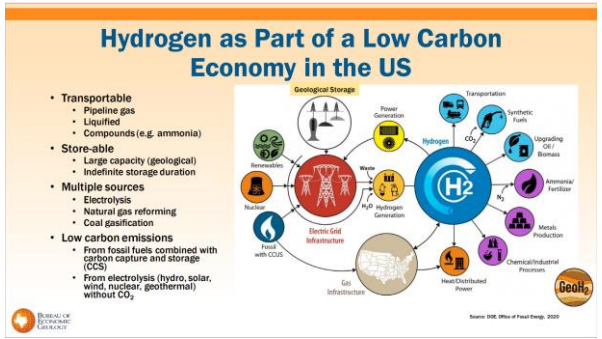
- Energy storage advances (not just batteries)
- Direct Air Capture (DAC) & Carbon Dioxide Removal (CDR)
- Battery technology past Lithium Ion – solid state, flow, etc.
- Hydrogen (H2) – brown, gray, blue, green, pink, white, yellow, turquoise. And Ammonia
- Fuel cells
- Renewable Natural Gas (RNG) & Responsibly Sourced Natural Gas (RSG)
- CCUS/CCS advancements (UCR EOR, methane pyrolysis solid carbon, etc.)
- System optimization advances – Electrification, efficiency, renewable firming, & better market design
- Plastic usage and regulations
- Nuclear – fusion and small scale fission
- Geothermal

Olive Creek

Monolith's Olive Creek 1 (OC1) commercial-scale facility is the first of its kind in the world and the first carbon black production facility to be constructed in the U.S. since the 1980s.

OC1
27077 SW 42nd Street
Hallam, NE 68368





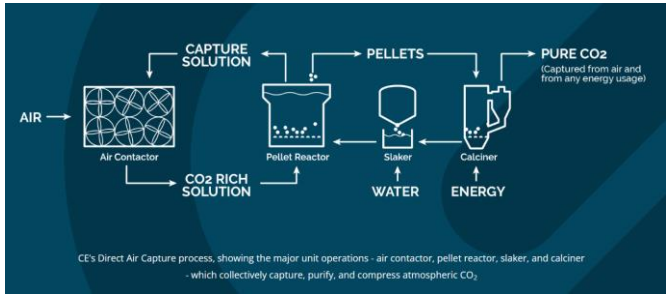
What a breakthrough in nuclear fusion technology means for the future of clean energy

Science Dec 14, 2022 12:10 PM EST

American scientists have announced what they have called a major breakthrough in a long-elusive goal of creating energy from nuclear fusion.

The U.S. Department of Energy said on Dec. 13, 2022, that for the first time – and after several decades of trying – scientists have managed to get more energy out of the process than they had to put in.

WATCH: Scientists announce fusion energy breakthrough, possible game-changer for climate

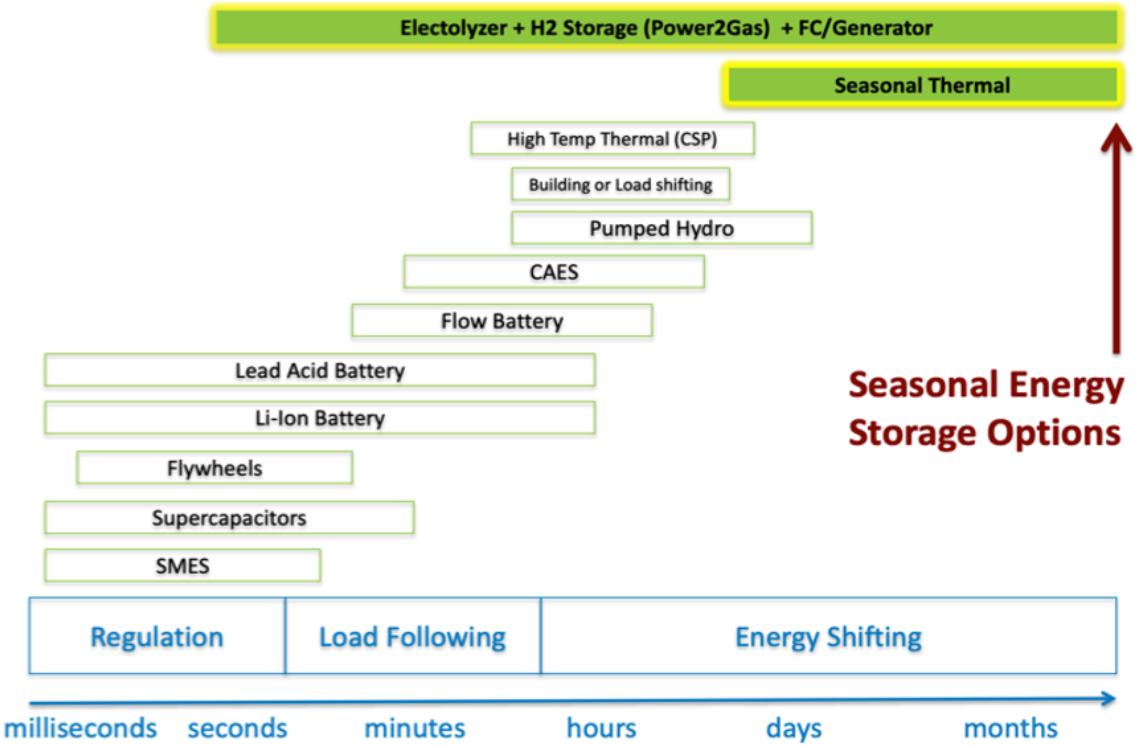


Breakthrough Technology Portfolio, Post-2030

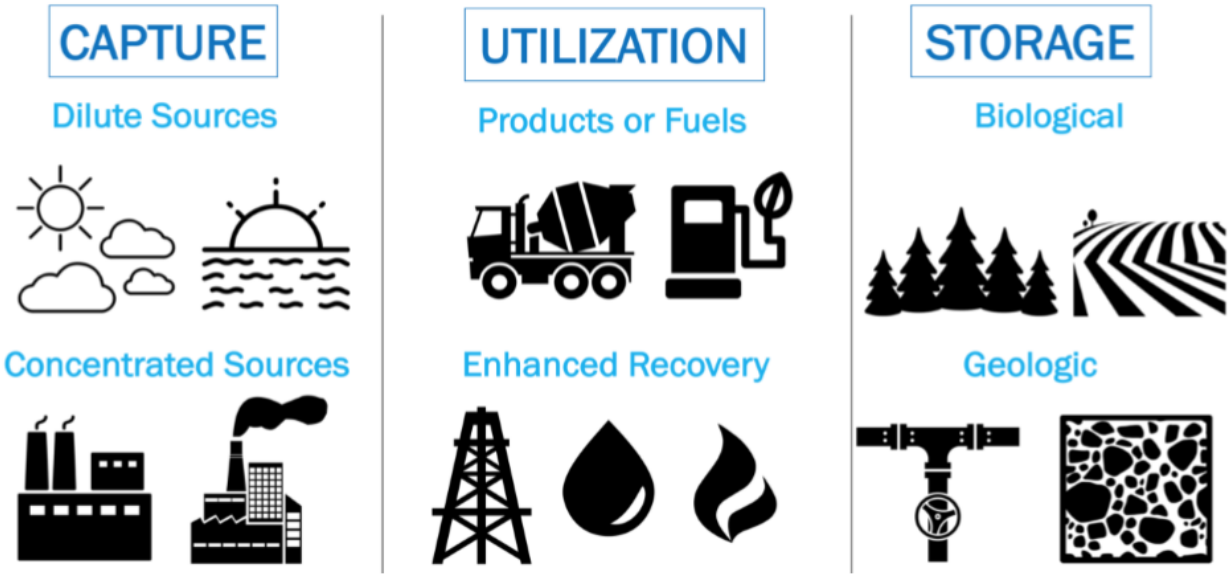
ENERGY FUTURES INITIATIVE

- Smart Cities
- Building Performance Technology
- Floating Offshore Wind
- Clean Cement
- Advanced Photovoltaics
- Hydrogen from Electrolysis
- Bioenergy
- Advanced Nuclear
- Li-ion Battery Recycling
- Direct Air Capture
- Seasonal Storage

Seasonal Storage



Direct Air Capture, Large Scale Carbon Management



Source: EFI Analysis, NREL

Hydrogen Supply

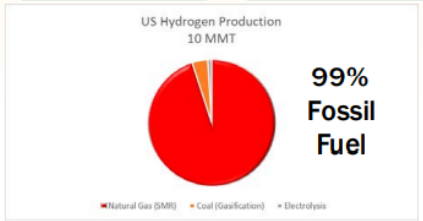
The Color Spectrum of Hydrogen Supply

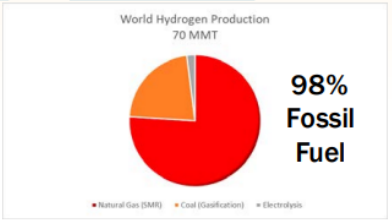
Higher H_2 Production Cost
$5.60 – 13.00/kg H_2

Lower H_2 Production Cost
$1.35 – 2.30/kg H_2

Renewable* (electrolysis)	Nuclear* (electrolysis)	"Grid" (electrolysis)	Natural Gas (pyrolysis)	Fossil Fuels/ Natural Gas (w/ CCS)	Natural Gas (steam reforming w/o CCS)	Coal (coal gasification w/o CCS)
Green	Pink	Yellow	Turquise	Blue	Grey	Brown
No direct CO_2 emissions		?	Solid carbon	Low CO_2	CO_2 emissions	

*
Biomass Gasification ~ $1.90/kg
Nuclear thermolysis ~$2.40/kg





GeoH$_2$

Source: Production & cost data from DOE, Office of Fossil Energy, 2020

Bureau of Economic Geology

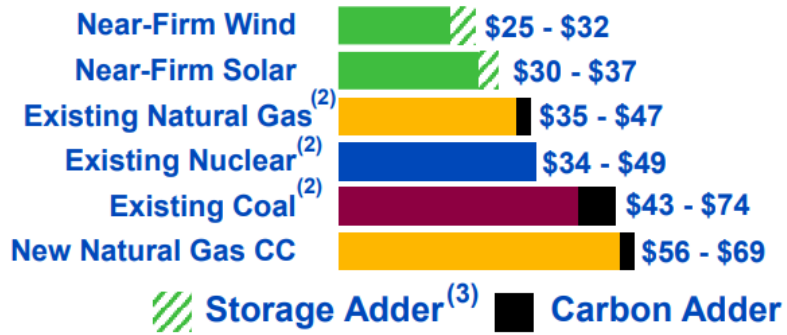
https://www.energy.gov/sites/prod/files/2020/07/f76/USDOE_FE_Hydrogen_Strategy_July2020.pdf

We believe decarbonization will be driven by the low cost of renewables and will require a set of core skills that have been two decades in the making at NextEra Energy

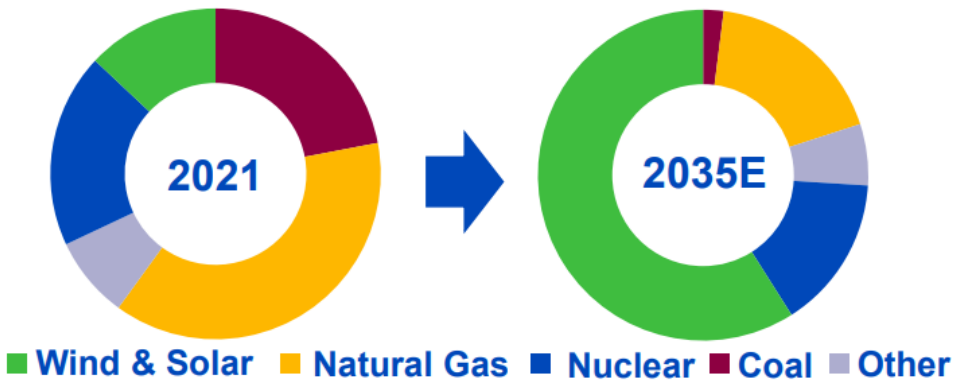
Economic Drivers and Core Skills Required

Potential Cost per MWh Late-2020s[1]

($/MWh)



U.S. Electricity Production by Fuel Type[4]



1) Energy Resources' estimate, based on current law
2) Represents all-in cash operating cost per MWh including fuel and ongoing capital expenditures
3) Near-firm assumes a 4-hour battery to achieve roughly equivalent reliability during peak hours for comparison with dispatchable generation sources
4) Source: U.S. EIA Annual Energy Outlook (2021); IHS 2021 Fast Transition Case (2035E)
5) Source: IHS North American Power Market Outlook (November 2021)

NEXTera ENERGY

Thank You!