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Zero-Net Emissions by 2050: Climate Realities and Challenges

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ZERO-NET EMISSIONS BY 2050: CLIMATE REALITIES AND CHALLENGES

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SEPTEMBER 2019



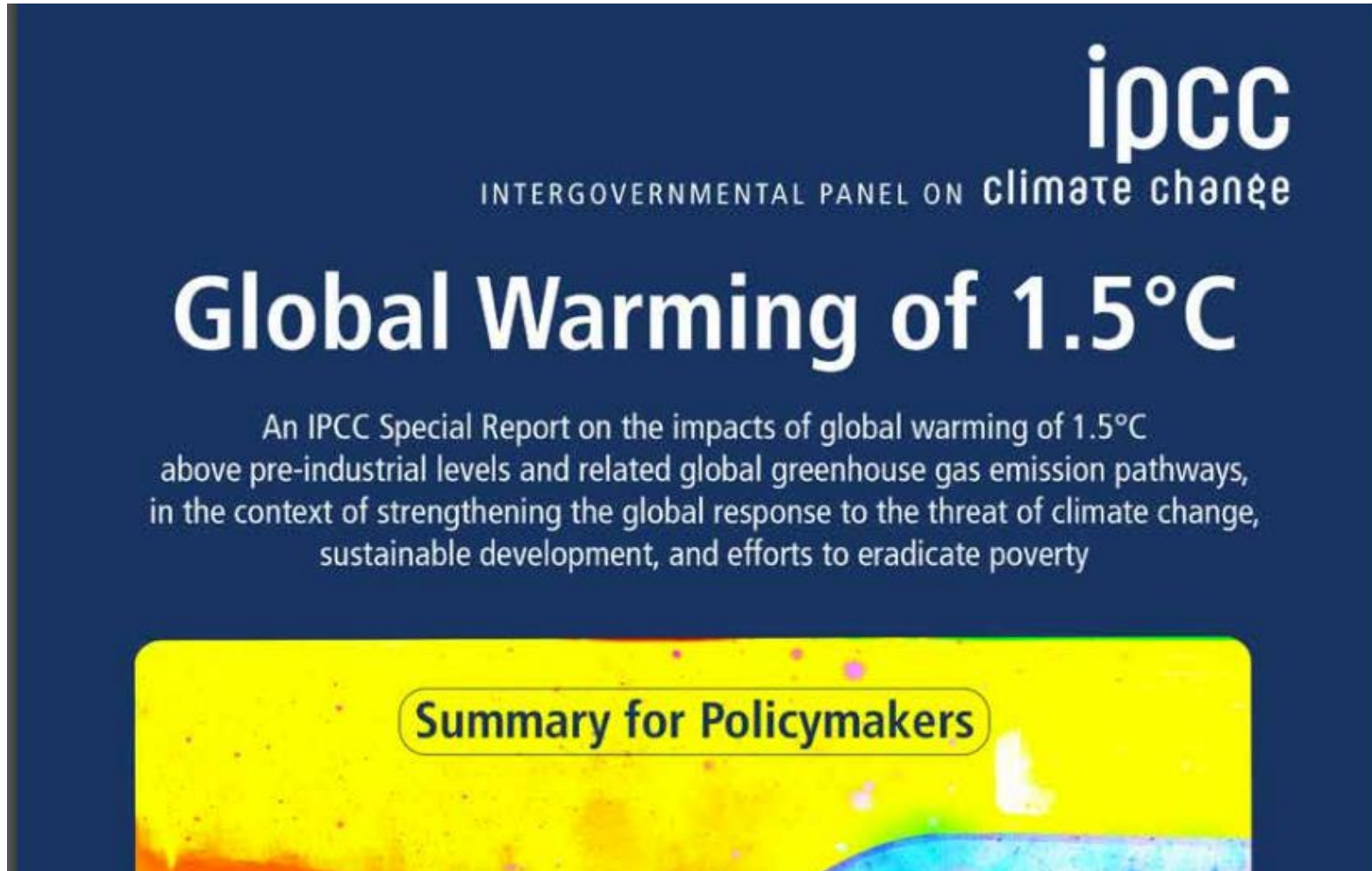
OUTLINE

- The mitigation challenge: the IPCC perspective
- Four strategies to reach zero net carbon
- The renewables revolution
 - how far can wind and solar take us?
- The need to “spread our chips”
 - roles for nuclear and CCS
- The imperative of carbon dioxide removal
- Key messages

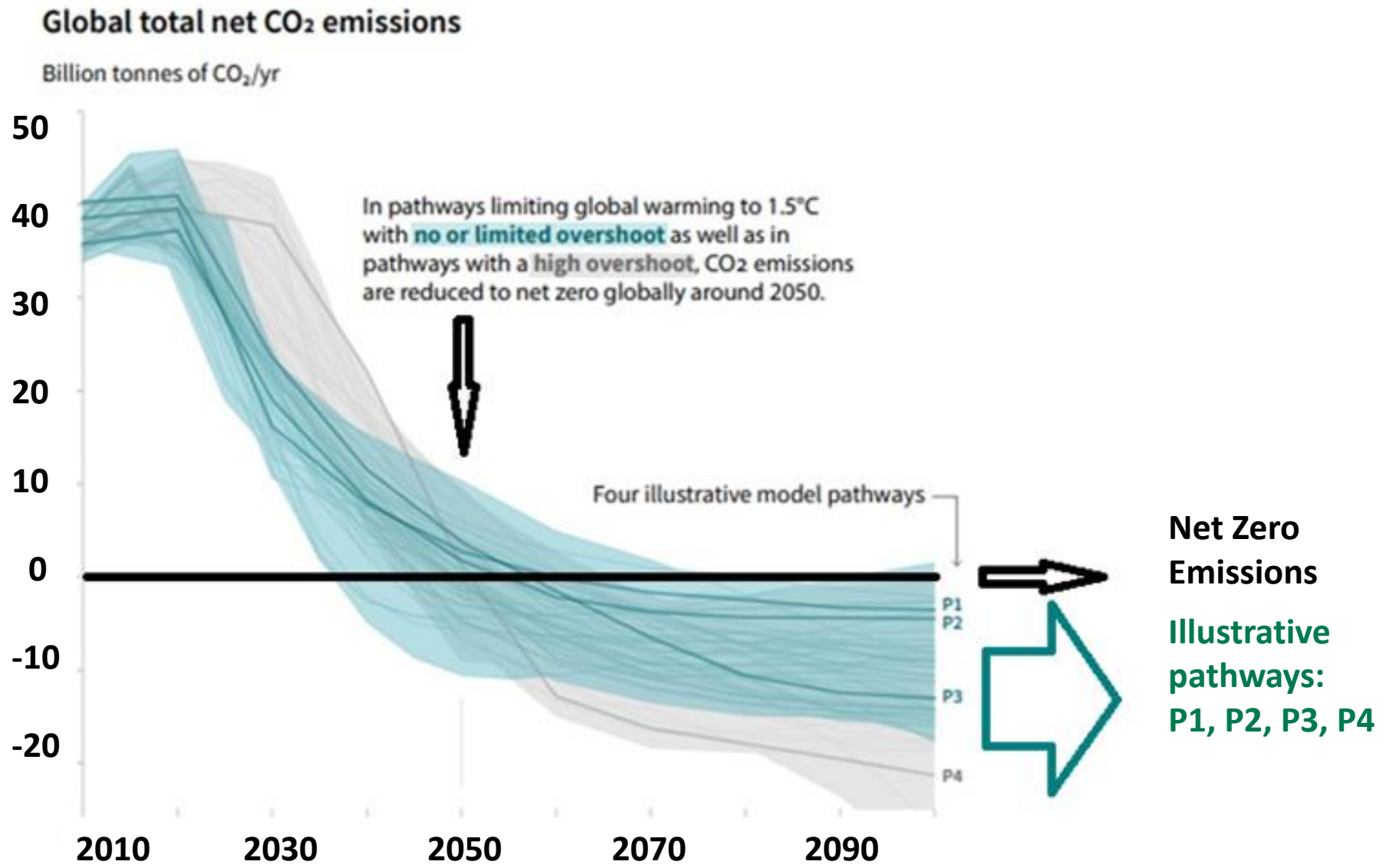
- *Speed limit, weblinks, Q&A*



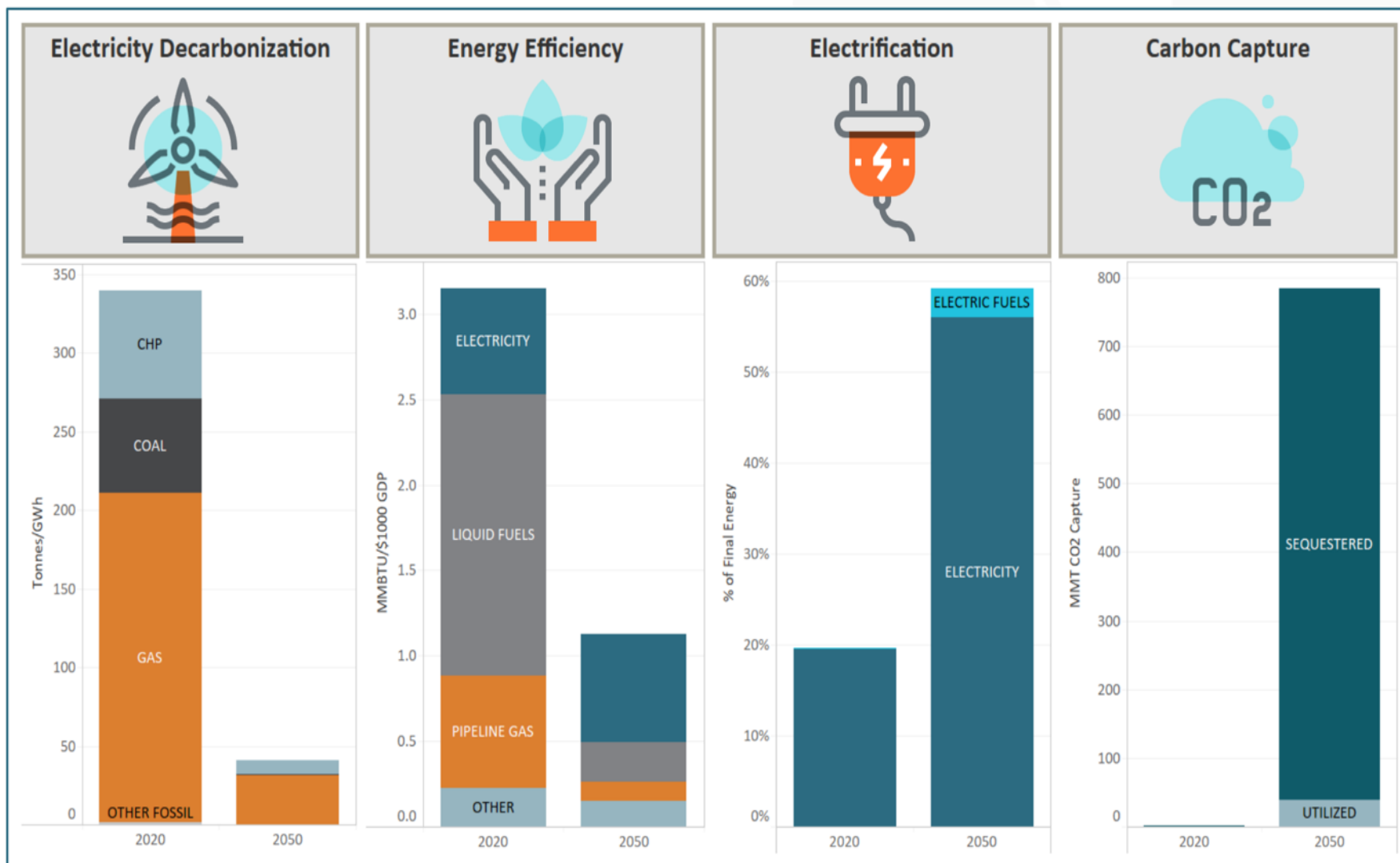
IPCC REPORT RELEASED IN OCT. 2018 LAYS OUT GLOBAL PATHWAYS TO A SAFE CLIMATE



1.5°C PATHWAYS REQUIRE NET-ZERO BY MID-CENTURY



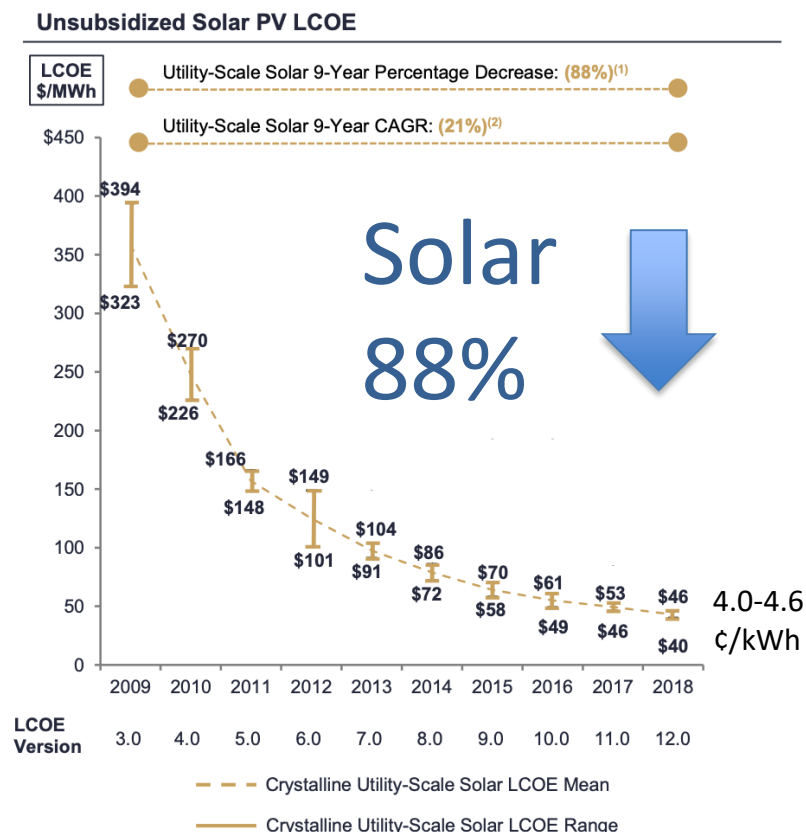
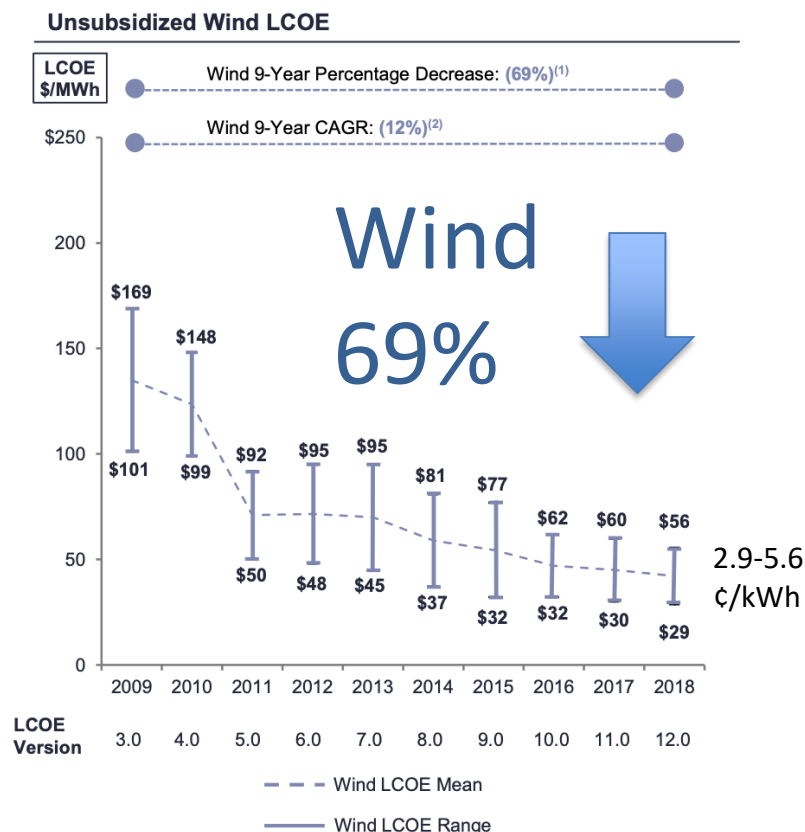
FOUR STRATEGIES TO TRANSFORM THE ENERGY SYSTEM TO ZERO-CARBON



THE RENEWABLES REVOLUTION

Dramatic cost decreases in wind and solar PV over the past 10 years

LCOE: Wind: 3 – 6 cents/kWh. Solar PV: 4 – 5 cents/kWh (Utility-Scale).



LAZARD
Copyright 2018 Lazard

Source: Lazard estimates.

- (1) Represents the average percentage decrease of the high end and low end of the LCOE range.
 (2) Represents the average compounded annual rate of decline of the high end and low end of the LCOE range.

EMBRACING 100% RENEWABLES



Sven Teske *Editor*

Achieving the Paris Climate Agreement Goals

Global and Regional 100% Renewable Energy Scenarios with Non-energy GHG Pathways for +1.5°C and +2°C

EXTRAS ONLINE

Springer Open

100% IN 139 COUNTRIES

Transition to 100% wind, water, and solar (WWS) for all purposes (electricity, transportation, heating/cooling, industry)

2050

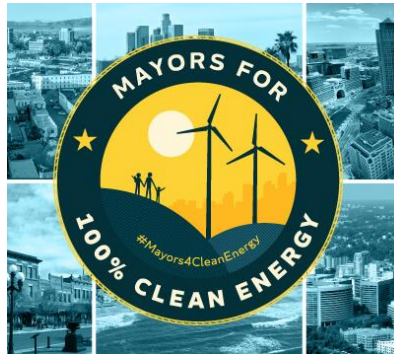
PROJECTED ENERGY MIX



A Study by LUT University ENERGYWATCHGROUP

NEW STUDY

Energy Transition to 100% Renewable in Europe Across Power, Heat, Transport and Desalination Sectors



RE100 - 100% Renewable Power

114 Companies committed

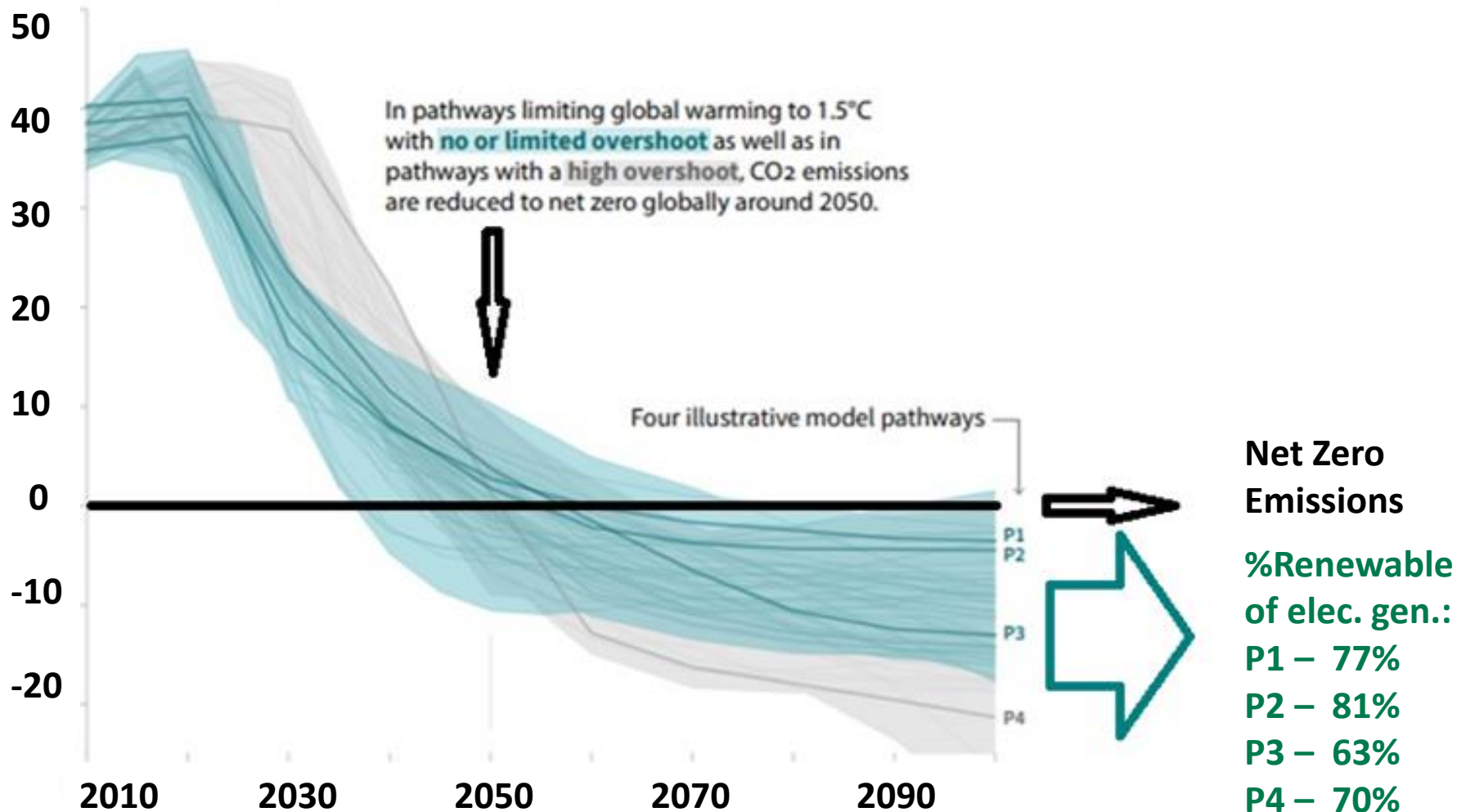
[See Companies](#)



1.5°C PATHWAYS INDICATE RENEWABLE SHARE OF ELECTRICITY GENERATION OF 63-81 PERCENT

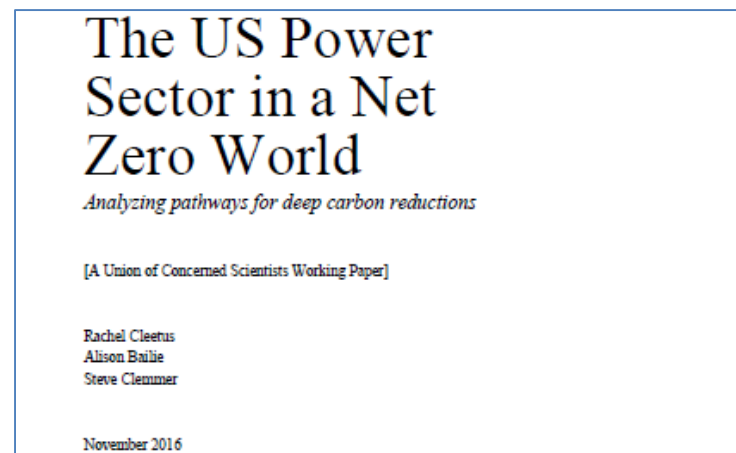
Global total net CO₂ emissions

Billion tonnes of CO₂/yr



MODELING OF U.S. IN 2050: RENEWABLES BECOME LARGEST ELECTRICITY SOURCE (50-80%)

CAVEAT “BEYOND XX% RENEWABLES, SYSTEM COSTS INCREASE SHARPLY”



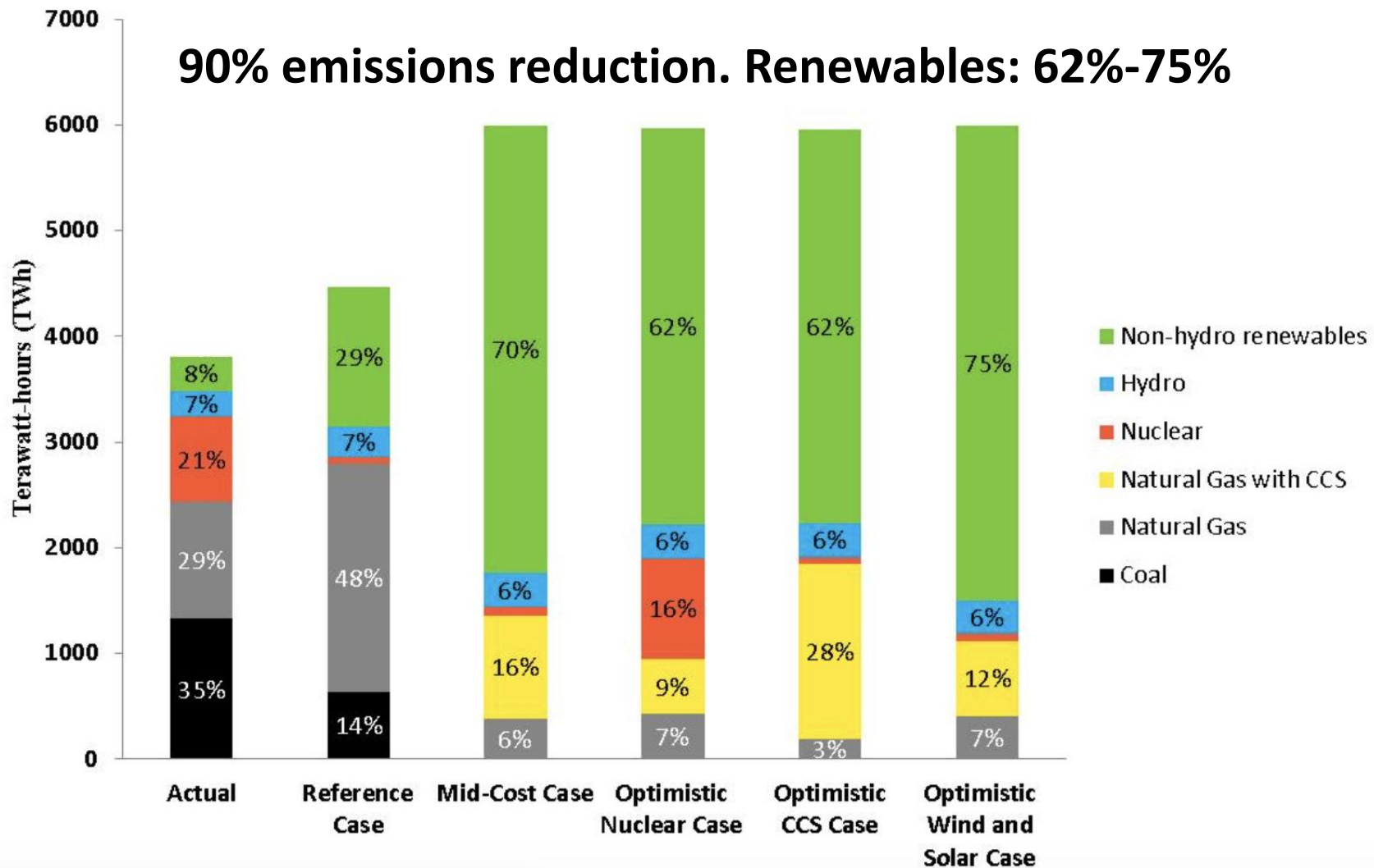
https://unfccc.int/files/focus/long-term_strategies/application/pdf/mid_century_strategy_report-final_red.pdf

www.riskybusiness.org/fromrisktoreturn/

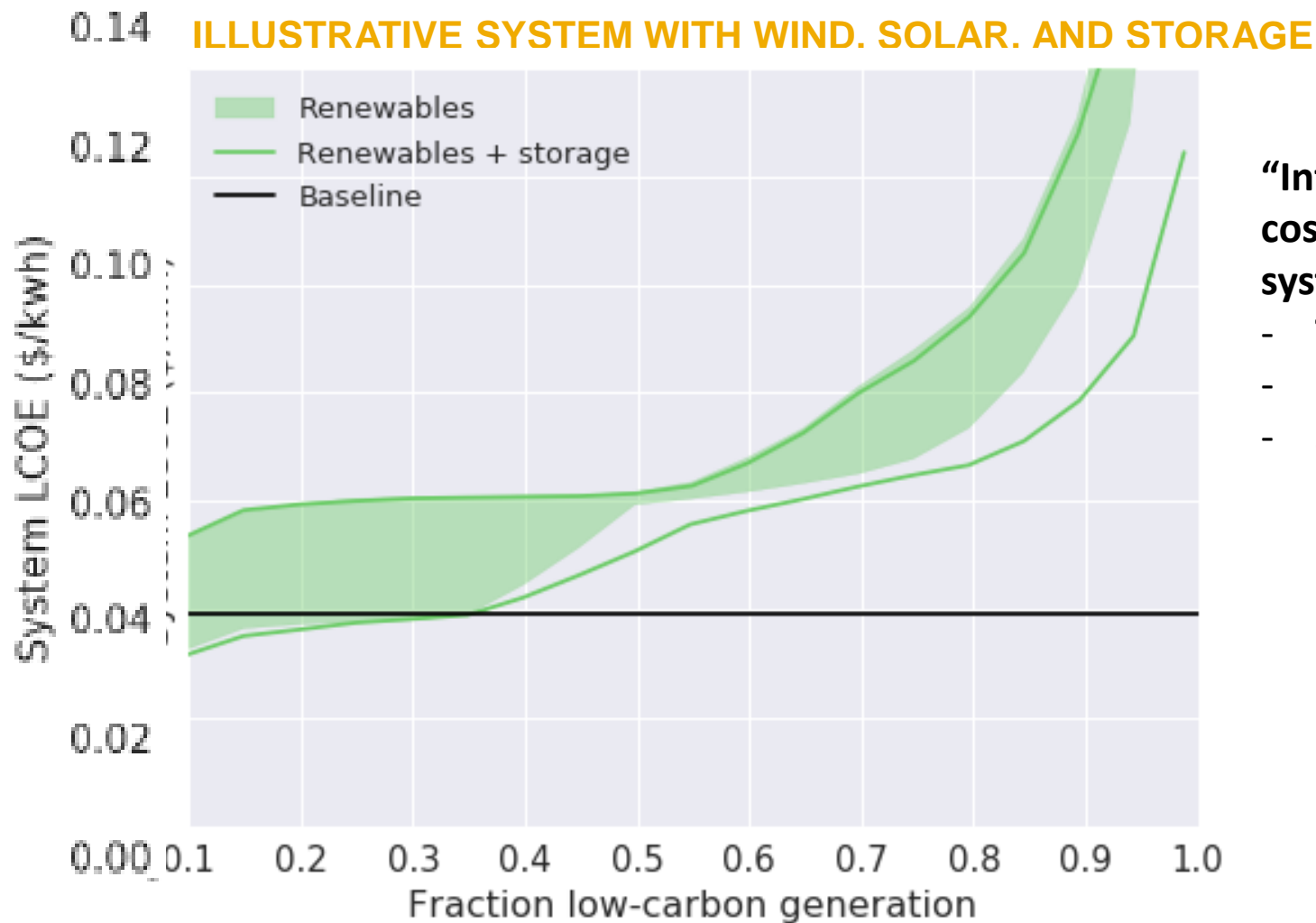
<https://www.nrdc.org/resources/americas-clean-energy-frontier-pathway-safer-climate-future>

https://www.ucsusa.org/sites/default/files/attach/2016/11/UCS-Deep-Decarbonization-working-paper.pdf?_ga=2.263568588.1974402731.1534852232-1981528426.1534852232

EXAMPLE OF A 2050 ELECTRICITY GENERATION MIX: FOUR SCENARIOS, UNION OF CONCERNED SCIENTISTS



“SYSTEM LCOE” INCREASES SHARPLY WITH HIGH RENEWABLE PENETRATION



“Integration” costs drive up system LCOE:

- Transmission
- Load shifting
- Storage
 - Daily
 - Seasonal
 - Weather flux

See also: Hausker (2019), <https://kleinmanenergy.upenn.edu/paper/betting-climate-solutions>

Frew et al (2016) , <https://web.stanford.edu/group/efmh/jacobson/Articles/Others/16-Frew-Energy.pdf>

Sepulveda, N., Jenkins, J.D., et al. (2018), “The role of firm low-carbon resources in deep decarbonization of electric power systems,” *Joule*

“SPREAD YOUR CHIPS”

UCS REPORT CITES VALUE OF EXISTING NUCLEAR PLANTS

- Without policies to replace retired nuclear power generation with low-carbon energy technologies, utilities could turn to natural gas and coal to fill the gap
 - could result in a 4 to 6 percent increase in US power sector emissions.

SMALL MODULAR REACTORS HOLD PROMISE



The Nuclear Power Dilemma

Declining Profits, Plant Closures, and the Threat of Rising Carbon Emissions

KEY FINDINGS

Over the last decade, nuclear power has provided most of the nation's carbon-free electricity. However, the industry has shut down many nuclear plants in the last five years as uneconomic plants to close their doors with better alternatives. Business closures, government's slow carbon pricing policies, and regulations have the impact of early retirement. The primary reasons for these early closures are the economic challenges brought on by cheap natural gas, diminished demand for electricity, high fuel costs for renewable energy, rising operating costs, and safety and performance problems. The possibility that the nation will replace existing nuclear plants with natural gas and coal rather than low-carbon sources raises serious concerns about our ability to achieve the deep cuts in carbon emissions needed to limit the worst impacts of climate change.

As of the end of 2017, 79 reactors at 60 power plants provided 20 percent of U.S. electricity generation. The reactors have retired six reactors at five plants since 2013, closed seven reactors at five more plants in 2018, and will retire another six reactors at four more plants in the next few years if they do not receive new financial support. In addition, Illinois, New Jersey, and New York have generally financial support to keep six reactors at seven plants operating for at least 40 more years.

The economic challenges facing nuclear plants are part of a historic transition in the U.S. electricity sector. Over the last decade, natural gas generation and renewable energy generation from wind and solar have grown rapidly on their prices



The new economic base built by natural gas and solar power plants are expected to be built and built over the next decade. The industry will need to make an aggressive effort to stay open and stay open for the next 40 years.

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Generation T&D Solar Storage Demand Response Distrib

BRIEF

Big milestone for a small reactor: NRC completes next phases of NuScale review

CARBON CAPTURE AND STORAGE WORKS

COSTS WILL DECREASE WITH INNOVATION AND SCALE



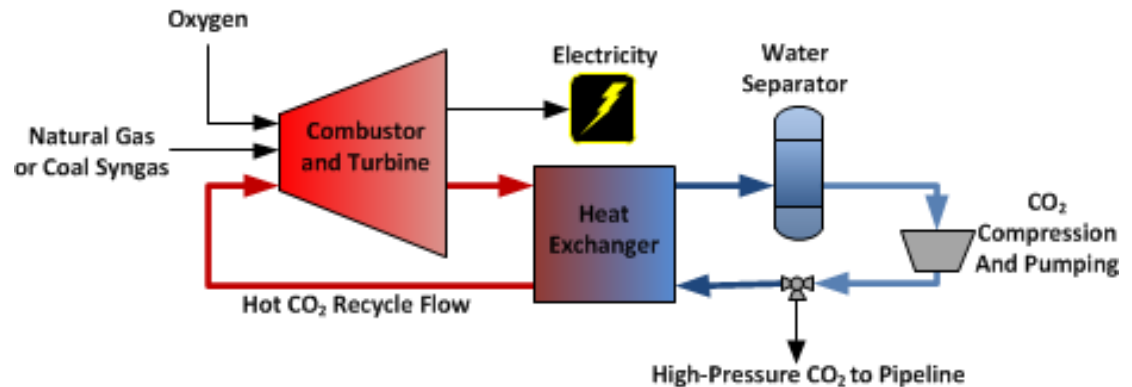
RECODE EXPLAINERS THE HIGHLIGHT FUTURE PERFECT THE GOODS POLITICS & POLICY MORE ▾



That natural gas power plant with no carbon emissions or air pollution? It works.

The carbon-capture game is about to change.

By David Roberts | @drvox | david@vox.com | Jun 1, 2018, 9:40am EDT



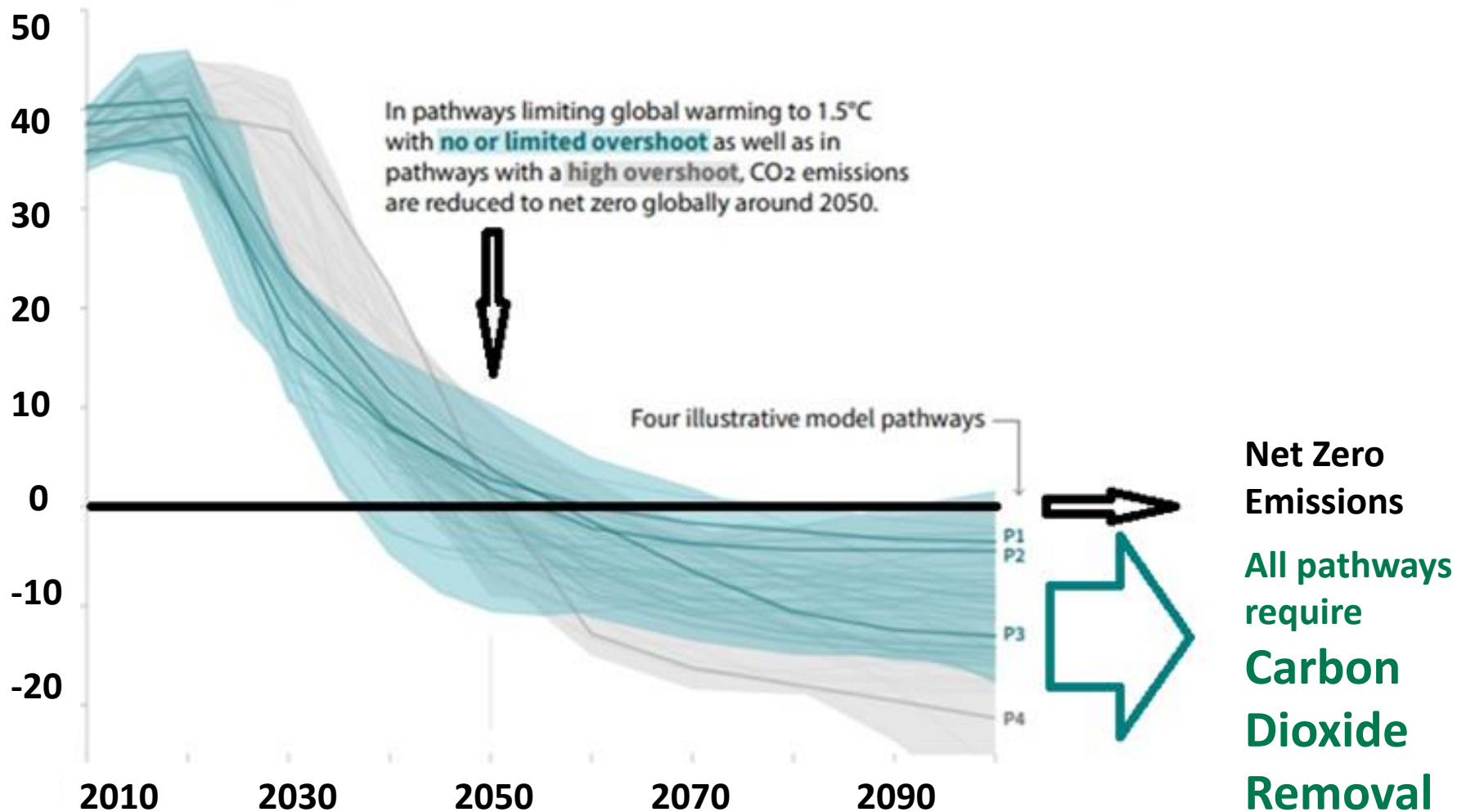
NETPOWER

CARBON CAPTURE MUST BE FULLY COMMERCIALIZED

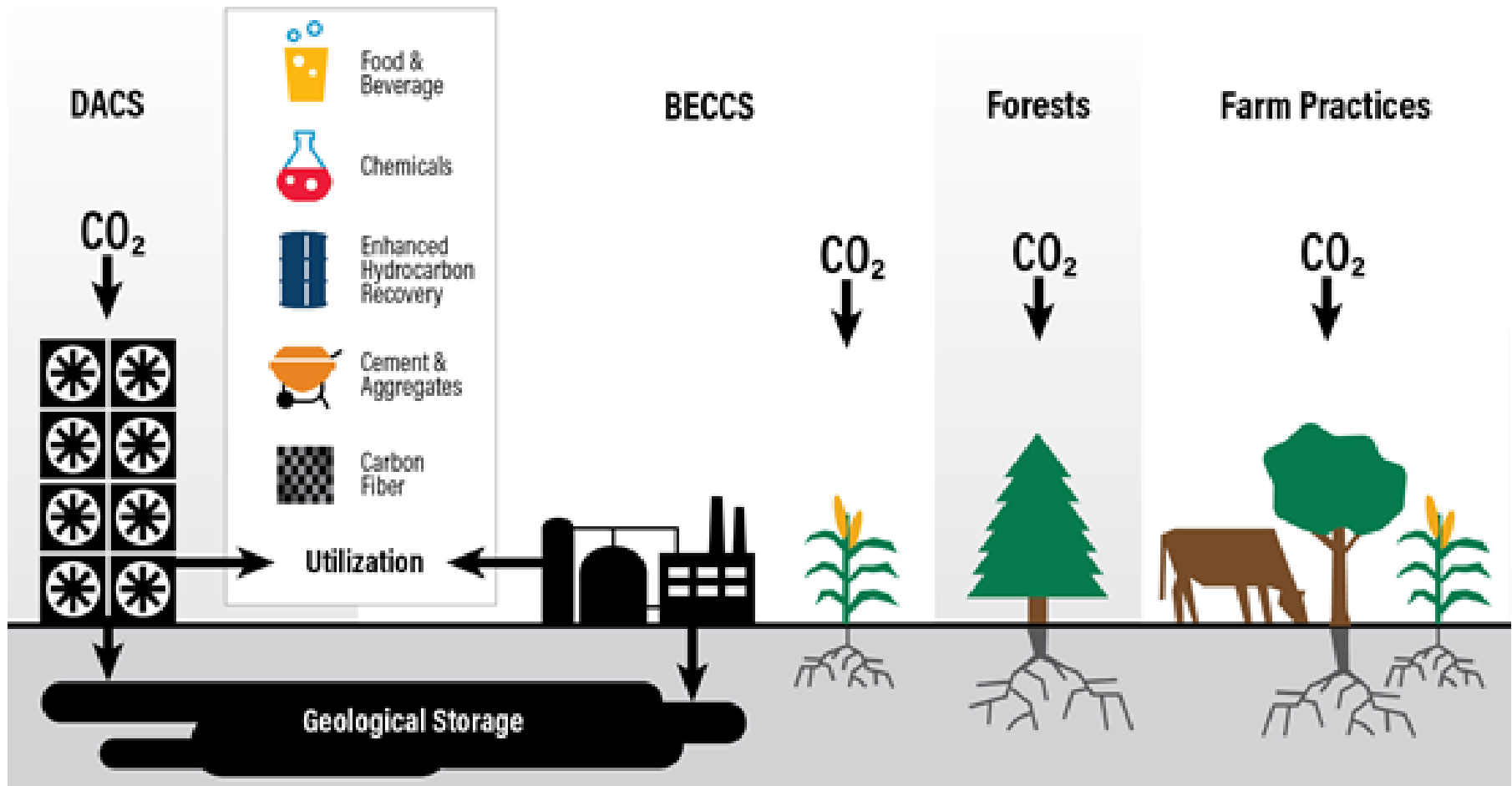
CRITICAL FOR INDUSTRY AND FOR CARBON DIOXIDE REMOVAL

Global total net CO₂ emissions

Billion tonnes of CO₂/yr



CARBON DIOXIDE REMOVAL TECHNIQUES



Also at research stage: Enhanced weathering of rocks/minerals, and seawater capture

EXAMPLES OF FEDERAL AND STATE GOALS: 100% RENEWABLE VS 100% CLEAN (WITH RPS BOOST...)

100% Renewable

100% Clean (zero carbon)

Federal

- *By 2035: Climate Solutions Act, H.R. 330 (Lieu), 2019.*
- *By 2050: "100%" - Sanders*

- *By 2030: Green New Deal Resolution, (AOC-Markey)2019.*
- *By 2050: Clean Energy Standard Act (Smith/Lujan), 2019.*

State

- **By 2045: Hawaii, H.B. 623, 2015.**
- **By 2050: Puerto Rico, P.S. 1121, 2019.**
- **By 2032: District of Columbia, Clean Energy DC Omnibus Act, 2018**
- *By 2040: Colorado, Governor's proposal for 100% renewable electricity.*

- **By 2045: California S.B.100, 2018.**
- **By 2045: New Mexico S.B. 489, 2019.**
- **By 2045: Washington S.B. 5116, 2019**
- **By 2050: Nevada S.B. 358, 2019**
- *By 2040: New York, Governor's Green New Deal proposal, 2019.*
- *By 2050: New Jersey, Governor's E.O. #28 on Energy Master Plan*
- *By 2050: Campaign commitments from governors in CT, IL, ME, MI, WI.*

Black = enacted

Blue = proposed

KEY MESSAGES

- 100% renewables vs. 100% clean energy
 - 100% RE for corporate/city/other buyers is OK – an incremental boost to demand for RE – but should evolve to 100% CE
 - 100% RE requirement for a state or country poses challenges in terms of performance, reliability, cost.
 - A broad portfolio of zero-carbon electricity options is valuable from cost and risk management perspectives (“*spread your chips*”).
 - CCS for carbon dioxide removal is critical to meeting 1.5 or 2 degree goals. CCS must be fully commercialized in the 2020s.
- Importance of RD&D programs with a broad portfolio.
- An expanded transmission system is critical in any scenario.
- Role of existing nuclear plants (*UCS report, Nov. 2018*)
- Global perspectives – food for thought...
 - Nuclear power
 - CCS



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THANK YOU

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