

WORLD Resources Institute

ZERO-NET EMISSIONS BY 2050: CLIMATE REALITIES AND CHALLENGES

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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

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

Global Warming of 1.5°C

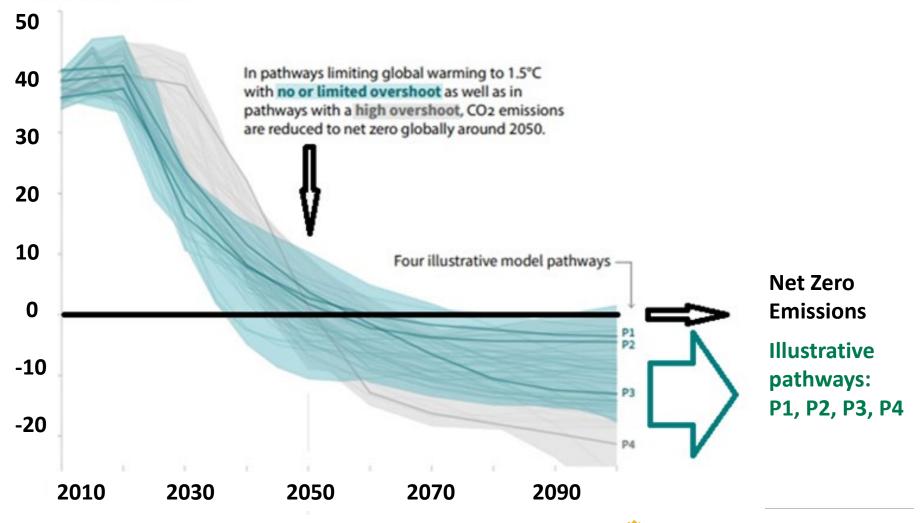
An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty

Summary for Policymakers

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

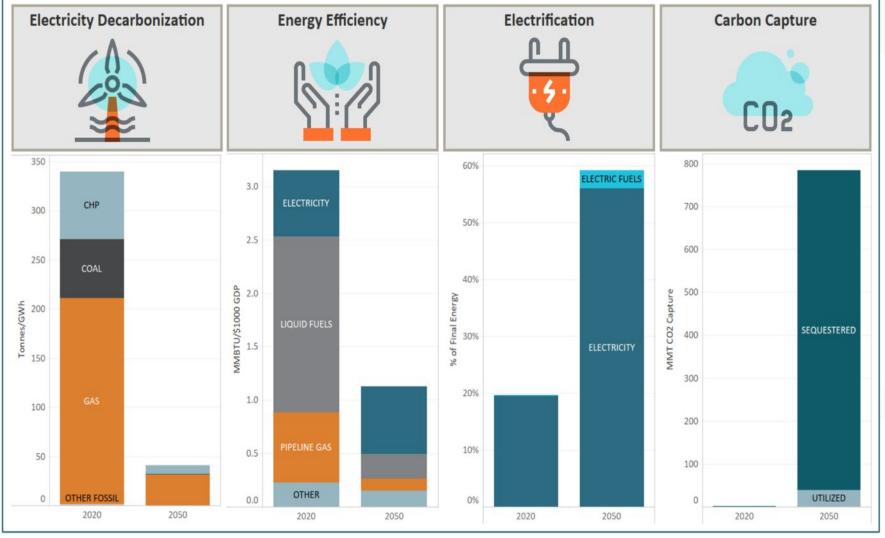
Global total net CO2 emissions

Billion tonnes of CO2/yr



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FOUR STRATEGIES TO TRANSFORM THE **ENERGY SYSTEM TO ZERO-CARBON**

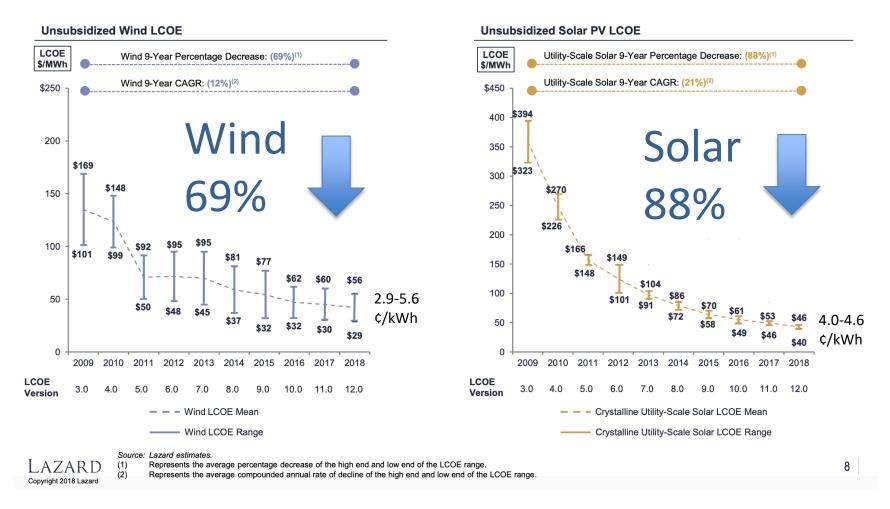


https://www.evolved.energy/single-post/2019/05/08/350-ppm-Pathways-for-the-United-States



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's LCOE Analysis, v.12.0, Nov. 2018, https://www.lazard.com/perspective/levelized-cost-of-energy-and-levelized-cost-of-storage-2018/



EMBRACING 100% RENEWABLES

100% IN 139 COUNTRIES Transition to 100% wind, water, and solar (WWS) for all purposes (electricity, transportation, heating/cooling, industry) Residential Commercial/govt rooftop solar rooftop solar 11.58% 14 89% Solar plant Wave energy PROJECTED 21.36% ENERGY MIX 0.58%

Geothermal energy

0.67%

4%

Hydroelectric

Concentrated

Onshore wind

solar plant

9.72%

23.52%

A Study by ENERGY GROUP LUT **V** University **NEW STUDY Energy Transition to 100% Renev**

in Europe Across Power, Hea Transport and Desalination Sec



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





RE100 - 100% Renewable Power



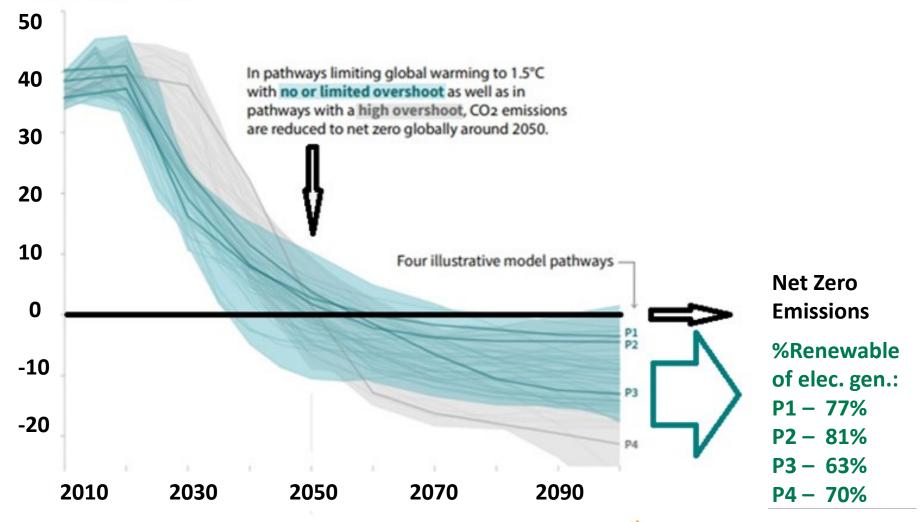
114 Companies committed

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



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

CAVEAT "BEYOND XX% RENEWABLES, SYSTEM COSTS INCREASE SHARPLY"







The US Power Sector in a Net Zero World

Analyzing pathways for deep carbon reductions

[A Union of Concerned Scientists Working Paper]

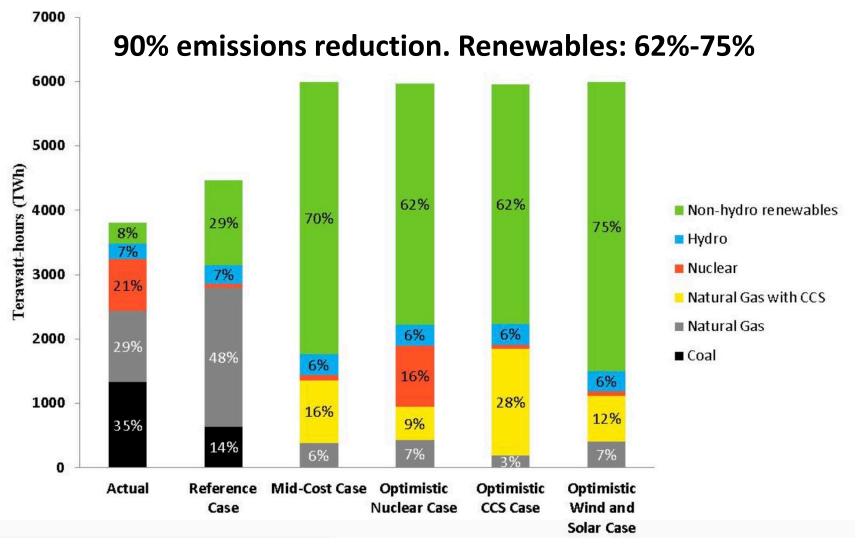
Rachel Cleetus Alison Bailie Steve Clemmer

November 2016

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

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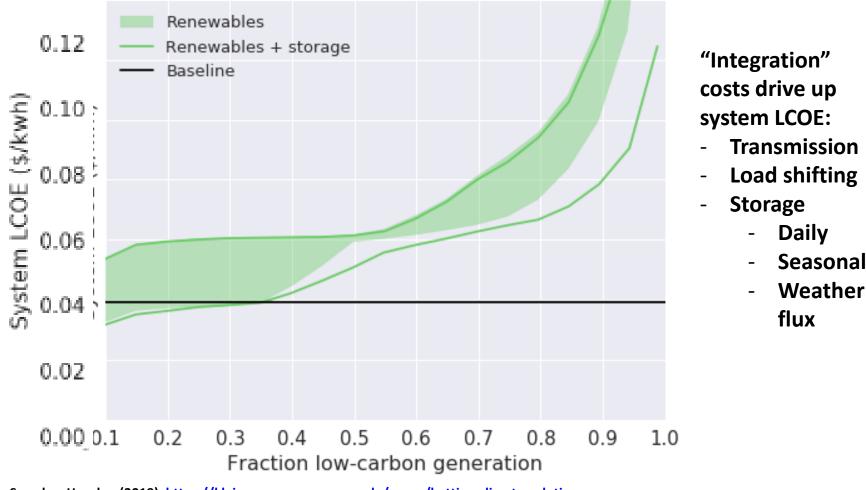
EXAMPLE OF A 2050 ELECTRICITY GENERATION MIX: FOUR SCENARIOS, UNION OF CONCERNED SCIENTISTS





"SYSTEM LCOE" INCREASES SHARPLY WITH HIGH RENEWABLE PENETRATION

0.14 ILLUSTRATIVE SYSTEM WITH WIND. SOLAR. AND STORAGE



See also: Hausker (2019), <u>https://kleinmanenergy.upenn.edu/paper/betting-climate-solutions</u> Frew et al (2016) , <u>https://web.stanford.edu/group/efmh/jacobson/Articles/Others/16-Frew-Energy.pdf</u> 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 ir
 US power sector emissions.

SMALL MODULAR REACTORS HOLD PROMISE

Concerned Scientists

The Nuclear Power Dilemma

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

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Deep Dive	Opinion	Podcasts	Library	Events	Jobs	
Gener	ation T&	D Solar	Storage	Demand	Response	Distribu

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

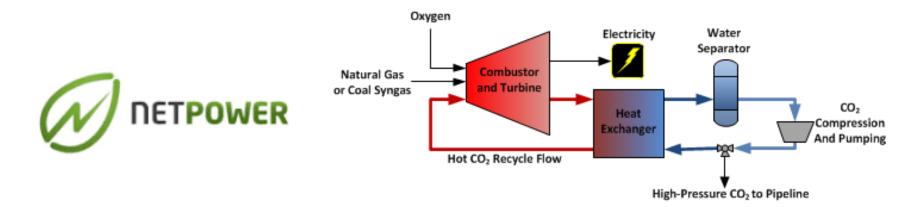


RECODE EXPLAINERS THE HIGHLIGHT FUTURE PERFECT THE GOODS POLITICS & POLICY MORE 🕶 🈏 🛉

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



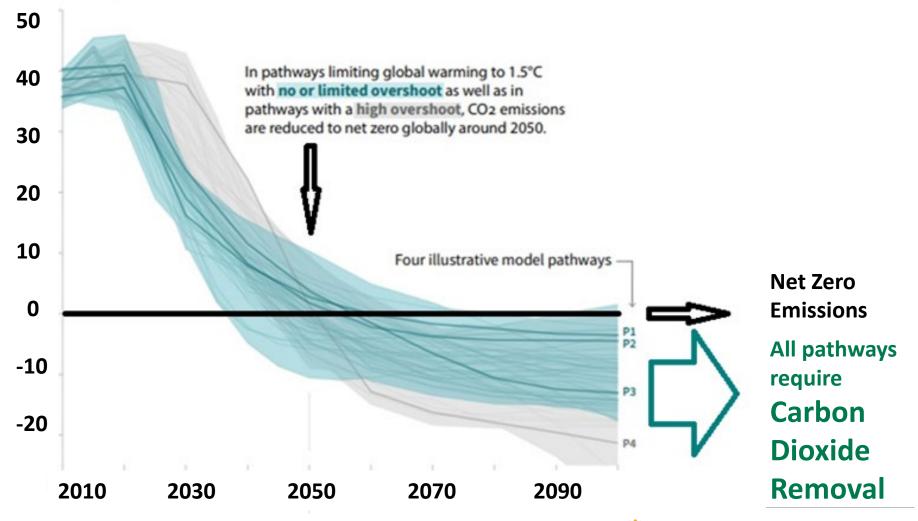
NETPOWER



CARBON CAPTURE MUST BE FULLY COMMERCIALIZED CRITICAL FOR INDUSTRY AND FOR CARBON DIOXIDE REMOVAL

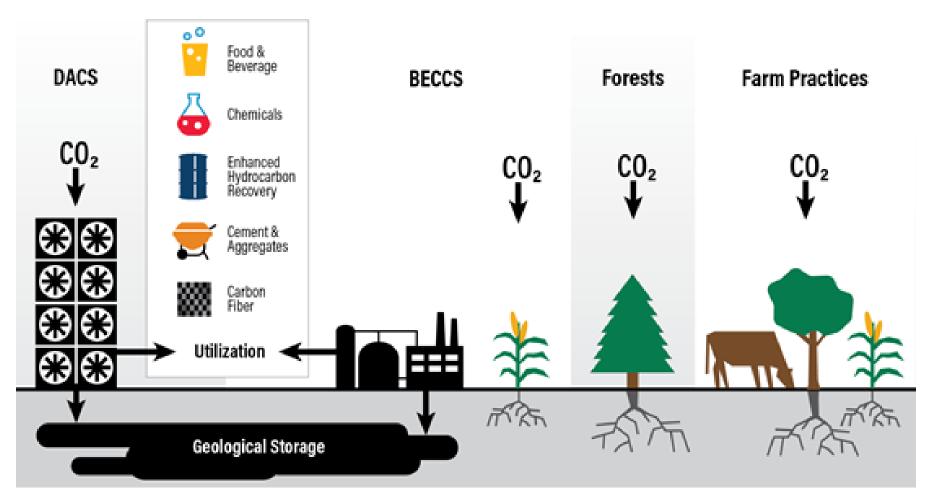
Global total net CO2 emissions

Billion tonnes of CO₂/yr



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CARBON DIOXIDE REMOVAL TECHNIQUES



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



FOUR ILLUSTRATIVE PATHWAYS – ROLE OF CDR

- Carbon dioxide removal (CDR) needed via AFOLU (Agriculture, Forestry, • Other Land Use), BECCS (Bioenergy with CCS), and/or other technologies and processes (e.g. DACS (Direct Air Capture and Storage))
- P1, P2 and P3: "no or limited overshoot" •

BECCS

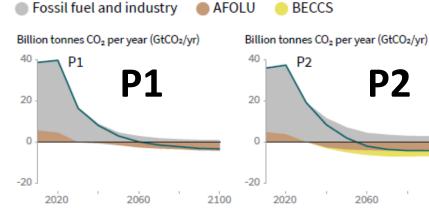
P2

2020

P4: "high overshoot"

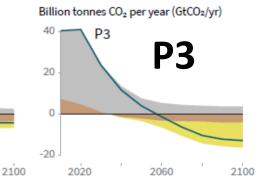
Breakdown of contributions to global net CO₂ emissions in four illustrative model pathways

P7

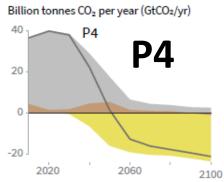


P1: A scenario in which social. business, and technological innovations result in lower energy demand up to 2050 while living standards rise, especially in the global South. A down-sized energy system enables rapid decarbonisation of energy supply. Afforestation is the only CDR option considered; neither fossil fuels with CCS nor BECCS are used.

P2: A scenario with a broad focus on sustainability including energy intensity, human development, economic convergence and international cooperation, as well as shifts towards sustainable and healthy consumption patterns, low-carbon technology innovation, and well-managed land systems with limited societal acceptability for BECCS.



P3: A middle-of-the-road scenario in which societal as well as technological development follows historical patterns. Emissions reductions are mainly achieved by changing the way in which energy and products are produced, and to a lesser degree by reductions in demand.



P4: A resource and energy-intensive scenario in which economic growth and globalization lead to widespread adoption of greenhouse-gas intensive lifestyles, including high demand for transportation fuels and livestock products. Emissions reductions are mainly achieved through technological means, making strong use of CDR through the deployment of BECCS.



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

100% Renewable 100% Clean (zero carbon) By 2035: Climate Solutions Act, By 2030: Green New Deal Resolution, • H.R. 330 (Lieu), 2019. (AOC-Markey)2019. By 2050: "100% Renewable" -By 2050: Clean Energy Standard Act Federal **Sanders** (Smith/Lujan), 2019. By 2045: California S.B.100, 2018. By 2045: Hawaii, H.B. 623, • ٠ 2015. By 2045: New Mexico S.B. 489, 2019. • By 2050: Puerto Rico, P.S. 1121, By 2045: Washington S.B. 5116, 2019 • 2019. By 2050: Nevada S.B. 358, 2019 • By 2032: District of Columbia, By 2040: New York, Governor's Green • State Clean Energy DC Omnibus Act, New Deal proposal, 2019. 2018 By 2050: New Jersey, Governor's E.O. • By 2040: Colorado, Governor's #28 on Energy Master Plan proposal for 100% renewable **By 2050:** Campaign commitments electricity. from governors in CT, IL, ME, MI, WI. Black = enacted Blue = proposed

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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 <u>must</u> 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





THANK YOU

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