WORLD RESOURCES INSTITUTE

INSIGHTS ON DEEP DECARBONIZATION

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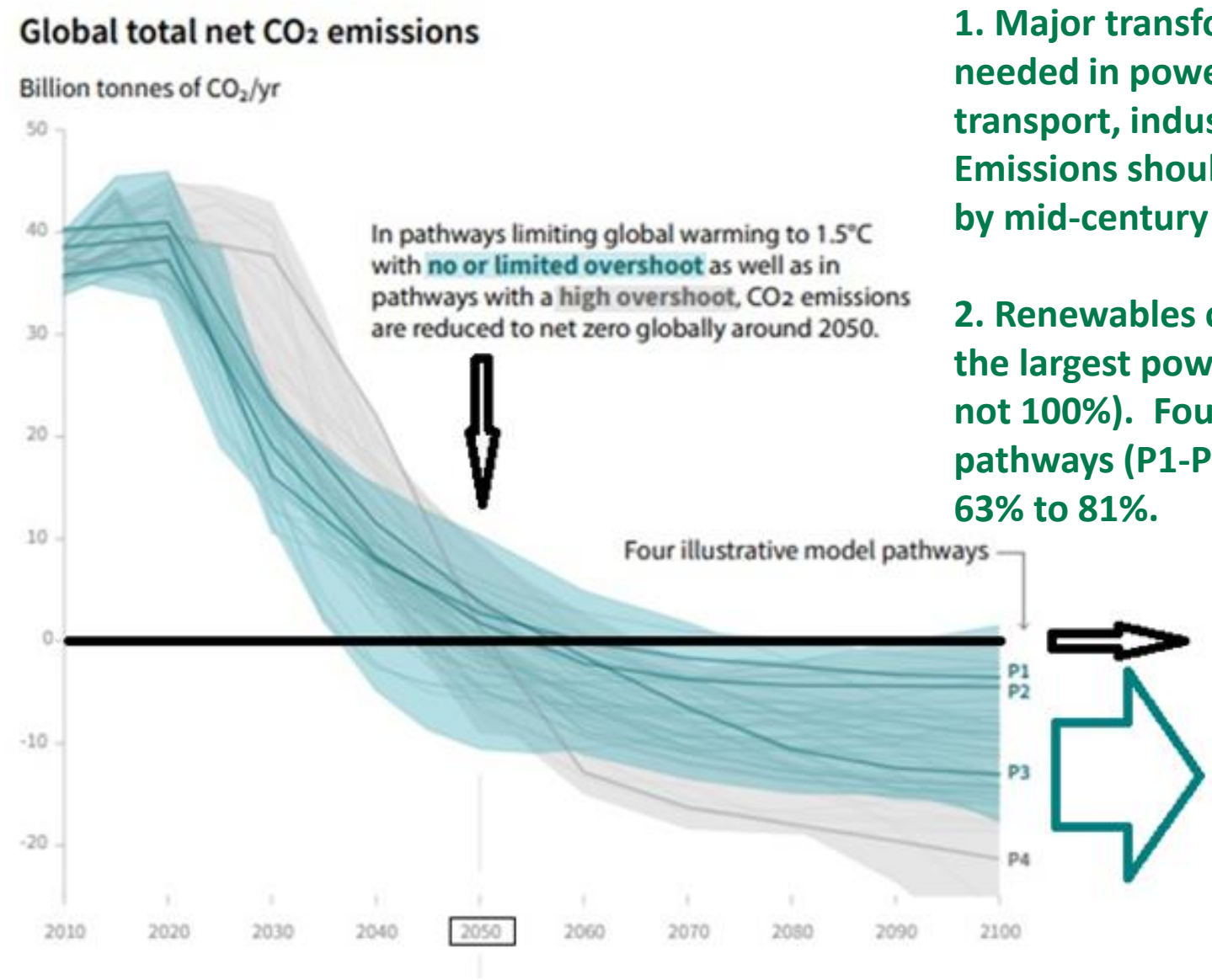
FOUR STRATEGIES FOR DEEP DECARBONIZATION

From Evolved Energy Research, *350 Pathways for the United States,* May 2019

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

1.5ºC PATHWAYS: THREE KEY TAKEAWAYS



1. Major transformations needed in power, buildings, transport, industry. Emissions should reach net-zero by mid-century

2. Renewables can grow to be the largest power source (but not 100%). Four illustrative pathways (P1-P4) have range of 63% to 81%.

Net Zero Emissions

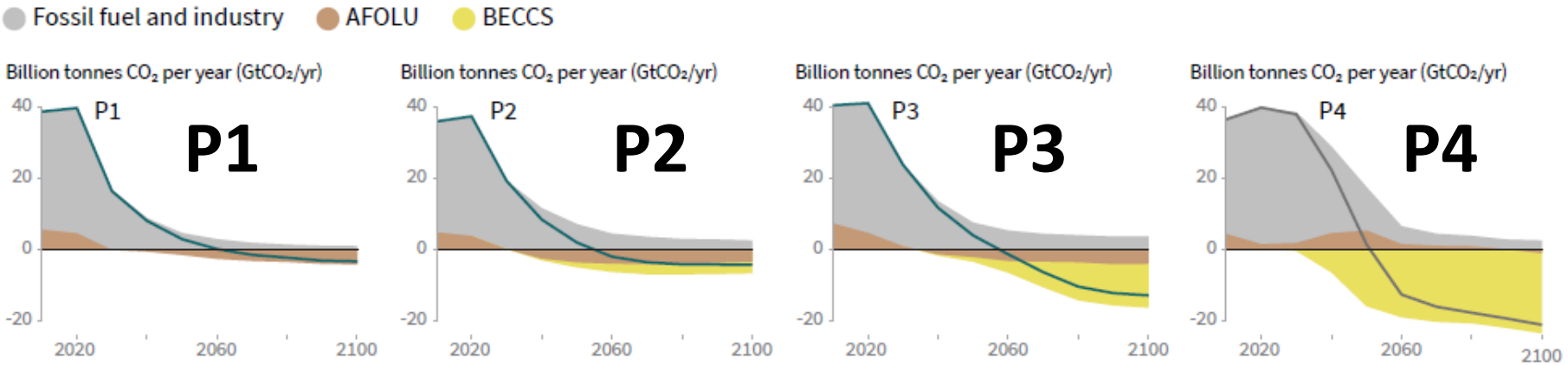
3. All pathways require Carbon Dioxide Removal

https://www.ipcc.ch/sr15/chapter/summary-for-policy-makers/

IPCC PATHWAYS – CRITICAL 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" P4: "high overshoot"**

Breakdown of contributions to global net CO_2 emissions in four illustrative model pathways



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.

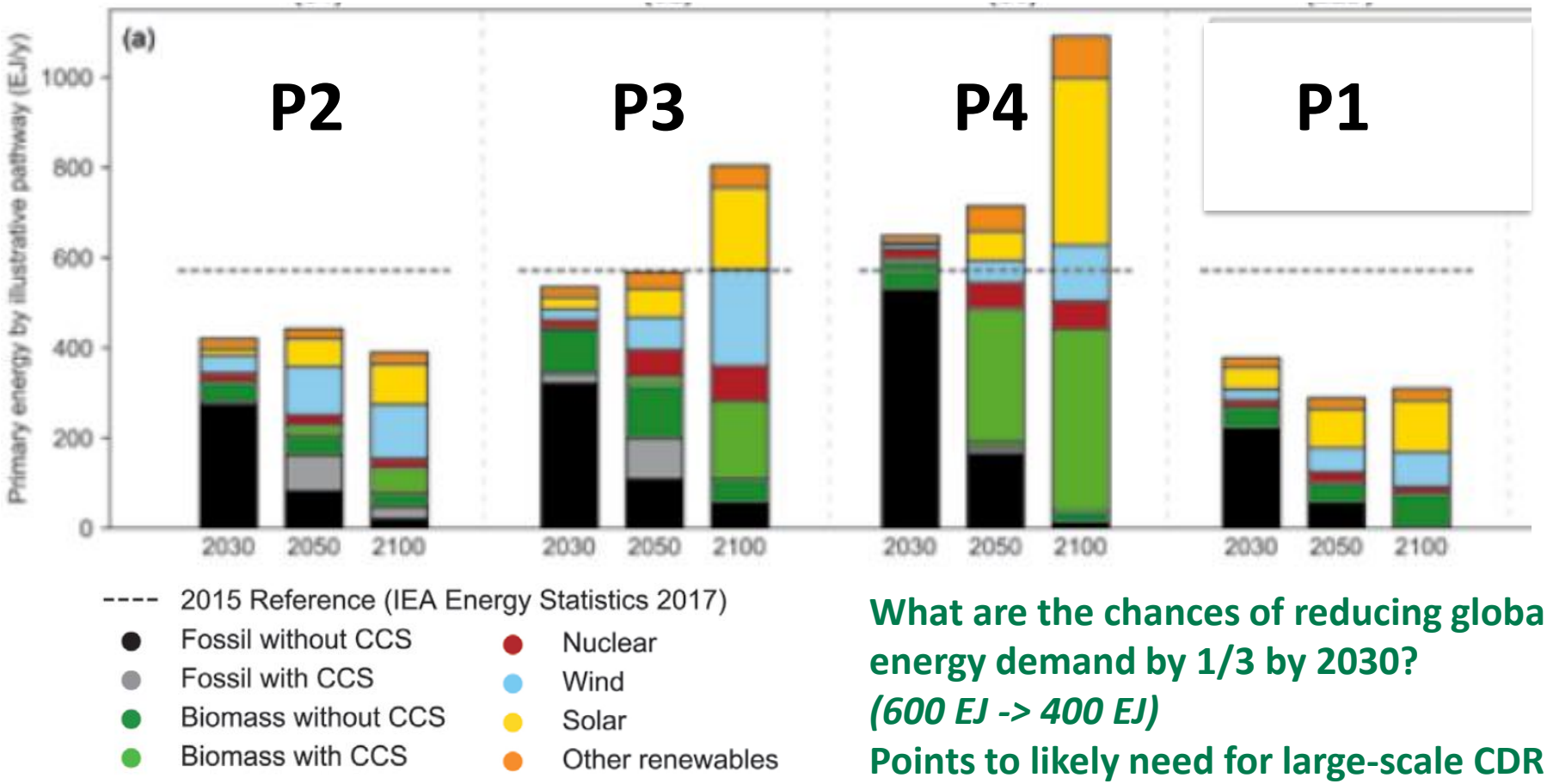
P3: A middle-of-the-road scenario in which societal as well as technological development follows historical patterns. Emissions reductions are mainly achieved by changing the way in which energy and products are produced, and to a lesser degree by reductions in demand.

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.

https://www.ipcc.ch/site/assets/uploads/sites/2/2018/07/SR15_SPM_version_stand_alone_LR.pdf

IPCC FOUR PATHWAYS: PRIMARY ENERGY SUPPLY

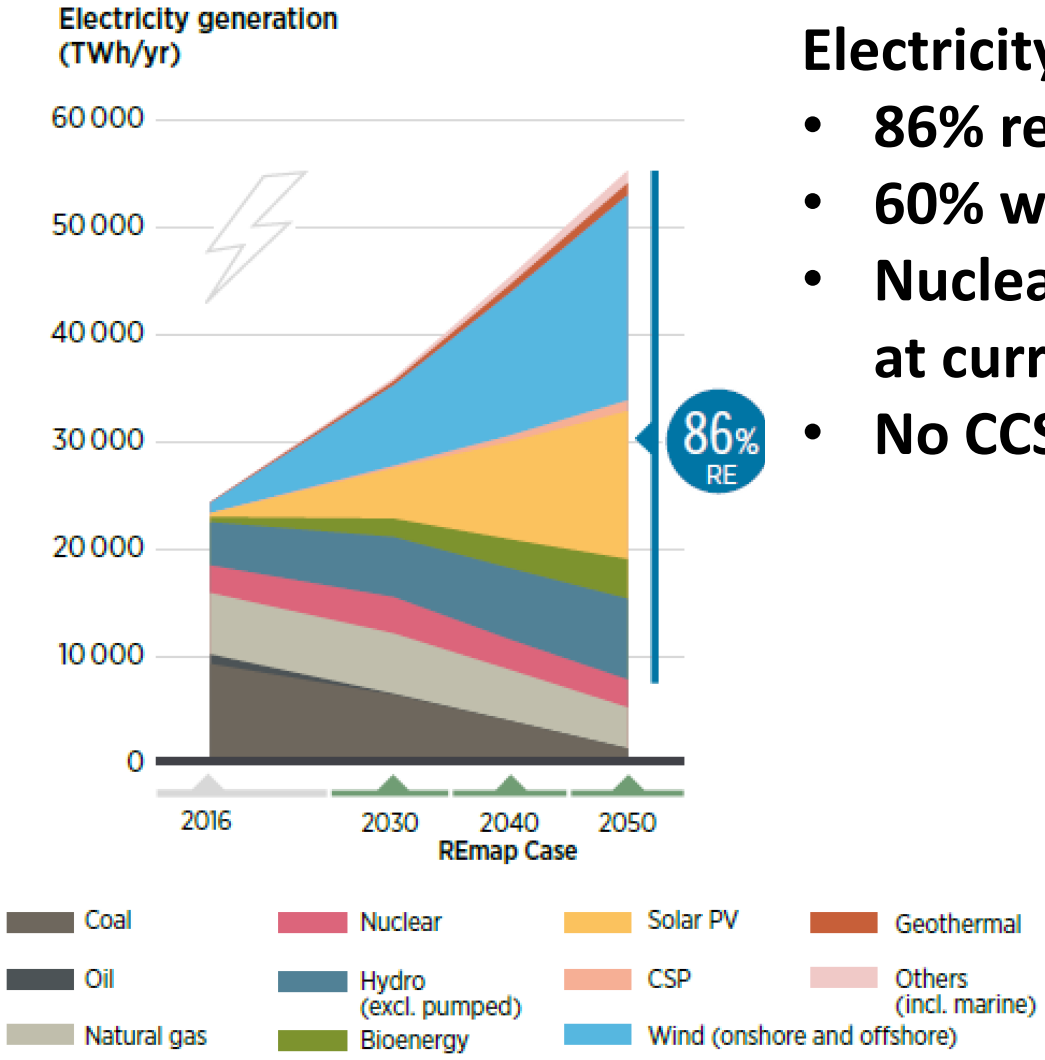
Renewables grow exponentially. CCS and nuclear play key roles.
P1 and P2: primary energy decreases from ~600 EJ/yr to ~400 EJ/yr by 2030
P3: slight decrease by 2030; back to ~600 EJ/yr by 2050.
P4: slow growth through 2050



What are the chances of reducing global energy demand by 1/3 by 2030?
(600 EJ -> 400 EJ)
Points to likely need for large-scale CDR

https://www.ipcc.ch/site/assets/uploads/sites/2/2018/07/SR15_SPM_version_stand_alone_LR.pdf Fig. 2.16

LATEST 2050 SCENARIO FROM IRENA



Electricity generation mix:

- **86% renewable (all)**
- **60% wind and solar**
- **Nuclear generation continues at current levels**
- **No CCS (but used in industry)**

IRENA

https://www.irena.org/publications/2019/Apr/Global-energy-transformation-The-REmap-transition-pathway

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

	100% Renewable	100% Clean
Federal	• ***By 2035**: Climate Solutions Act, H.R. 330 (Lieu), 2019.*	• ***By 2030:** AOC-Markey **Green New Deal** Resolution, 2019.* • ***By 2050: Clean Energy Standard Act (Smith/Lujan)***
State	• **By 2045**: **Hawaii**, H.B. 623, 2015. • **By 2050**: **Puerto Rico**, P.S. 1121, 2019. • **By 2050: Maine, L.D. 1494, 2019** • ***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 2050: New York, 2019** • **By 2050: Colorado's Xcel Energy (100% clean power). H.B. 1261 (90% reduction in GHG)** • ***By 2050: New Jersey**, Governor's E.O. #28 on Energy Master Plan* • ***By 2050:** Campaign commitments from governors in CT, IL, MI, WI.*

Black = enacted
Blue = proposed

KEY TAKEAWAYS

- 100% renewables vs. 100% clean energy
  - 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. Implies need for aggressive RD&D to fully commercialize in the 2020s.
  - 100% RE for corporate/city/other buyers is helpful – creates an incremental boost to demand for RE – but should evolve to 100% CE
  - 100% RE supply requirement for a state or country poses challenges in terms of performance, reliability, cost.
- Importance of RD&D programs with a broad portfolio.
- An expanded transmission system is critical in any scenario.
- Role of existing nuclear plants *(per UCS report, 2018)*
- Global perspectives – food for thought…
  - Nuclear power
  - CCS