WORLD RESOURCES INSTITUTE

GETTING TO NET-ZERO: CLIMATE CHALLENGES AND SOLUTIONS

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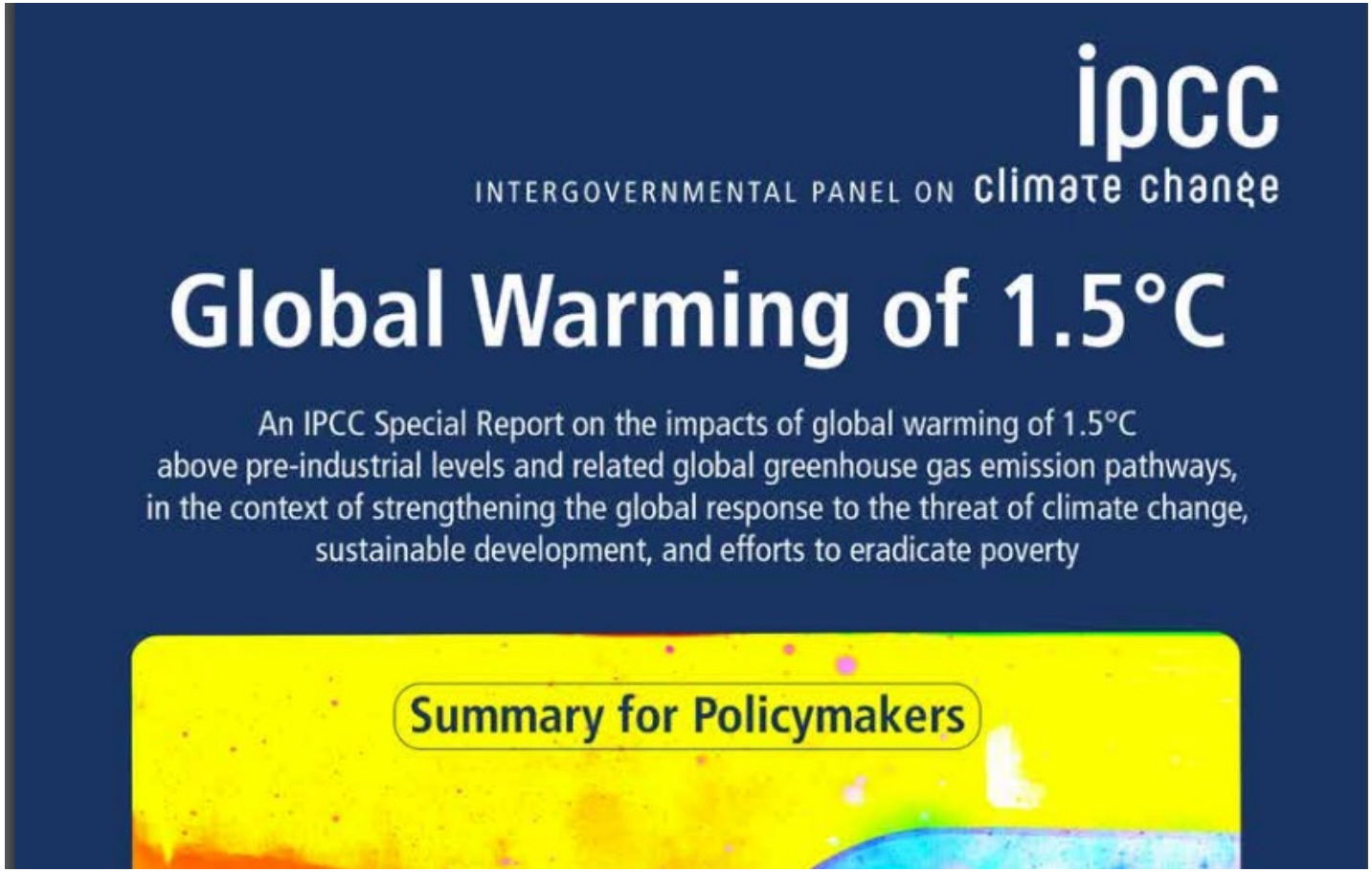
OUTLINE

- The net-zero challenge: the IPCC perspective
- Four key strategies for net-zero
  - Efficiency, electrification,
  - Zero-C electricity, carbon capture
- Electricity and the role of renewables
  - Obstacles to 100% renewables
  - A dissenting view
- Carbon capture: the imperative
  - A dissenting view
- The need to “spread our chips” Vegas-style
- Key messages

See weblinks throughout

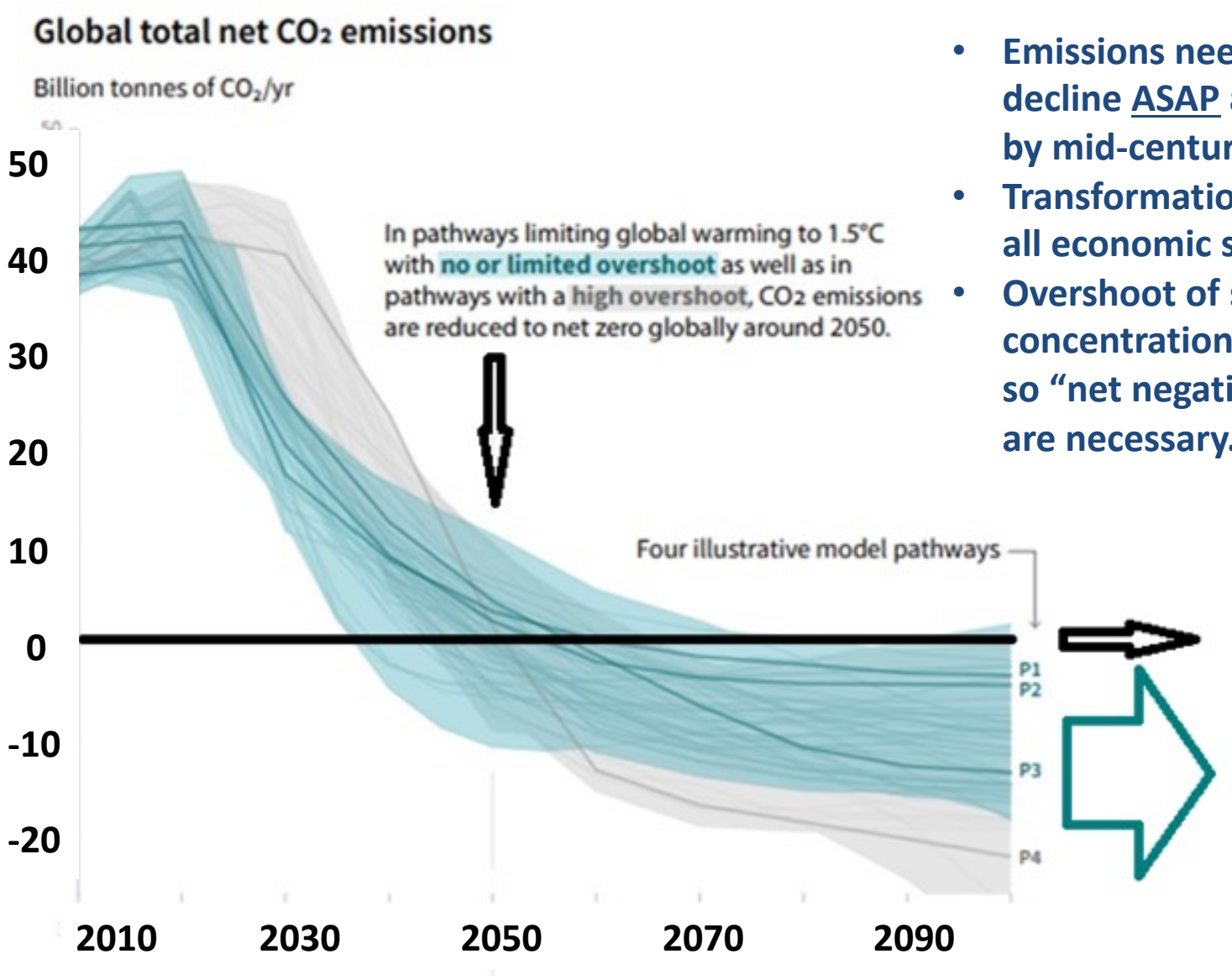
IPCC REPORT RELEASED IN OCT. 2018 LAYS OUT GLOBAL PATHWAYS TO A SAFE CLIMATE

Sixth Assessment Report (AR6): Science report (WG1) released August 2021. Impacts report (WG2) and Mitigation report (WG3) to be released in 2022.



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

1.5ºC PATHWAYS: GLOBAL EMISSION TRAJECTORIES



- Emissions need to begin a steep decline ASAP and reach net-zero by mid-century.
- Transformations needed across all economic sectors.
- Overshoot of safe concentrations is likely, so "net negative emissions" are necessary.

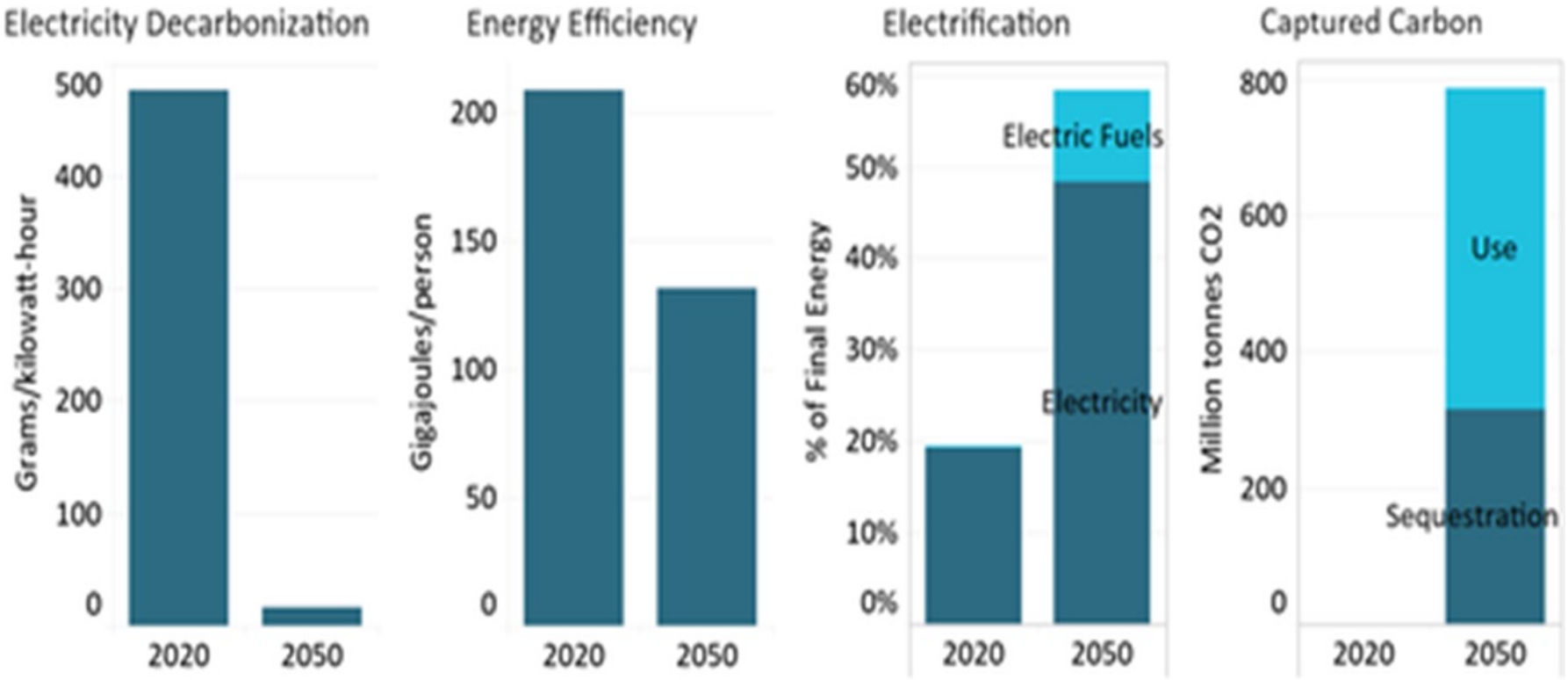
Net Zero Emissions

Net Negative Emissions

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

FOUR KEY STRATEGIES

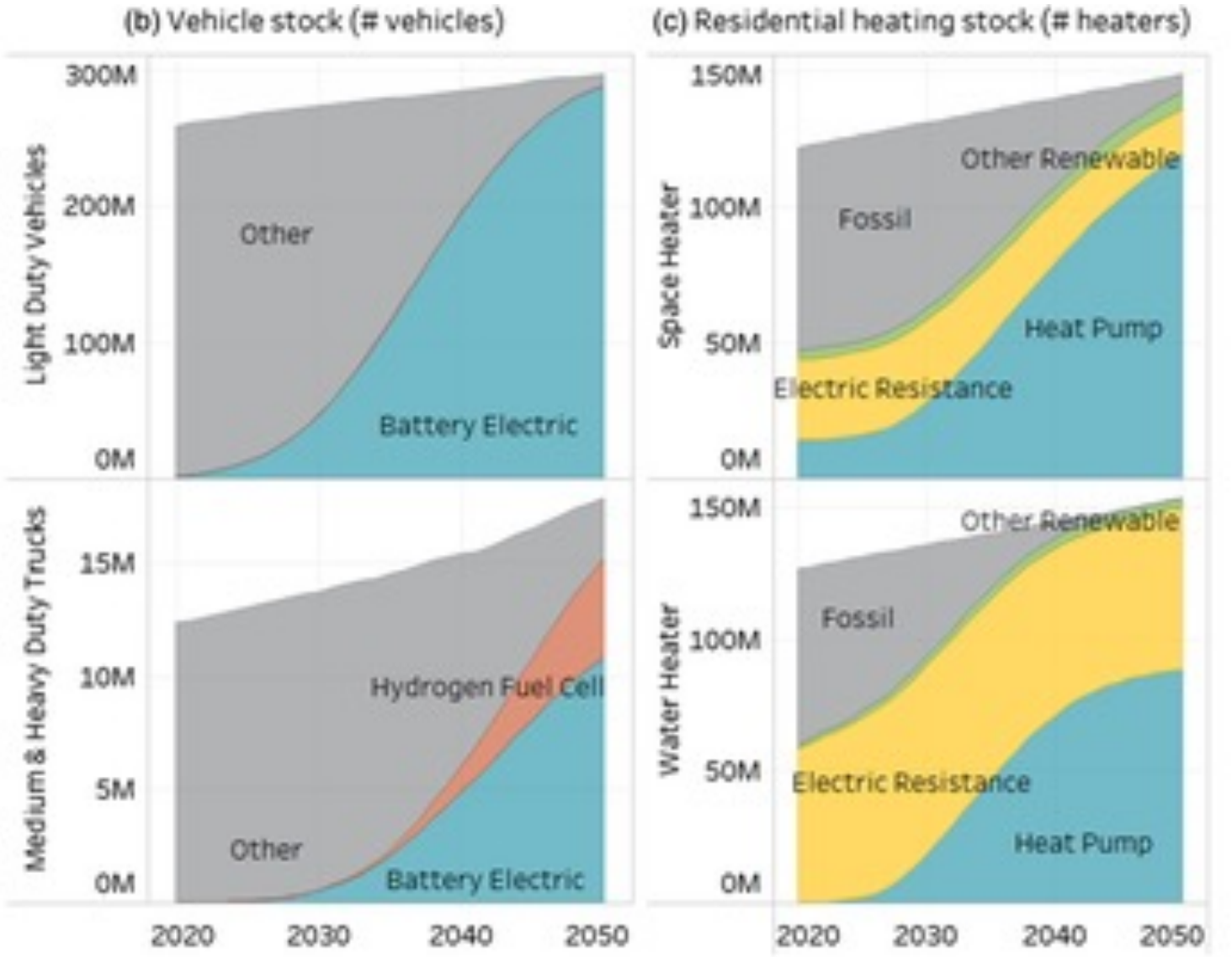
- **Consistent across net-zero pathway modeling**
  - **IPCC, IEA, IRENA, Princeton's *Net-Zero America* report, E3, EER**
  - **Example below: Jim Williams et al, *Carbon Neutral Pathways for the US***



IEA, *Net Zero Roadmap*, 2021. IRENA, *Global energy transformation: The REmap transition pathway*, 2019.
E3, various publications: https://www.ethree.com/publication/ https://netzeroamerica.princeton.edu

https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1029/2020AV000284

ELECTRIFYING VEHICLES AND BUILDINGS



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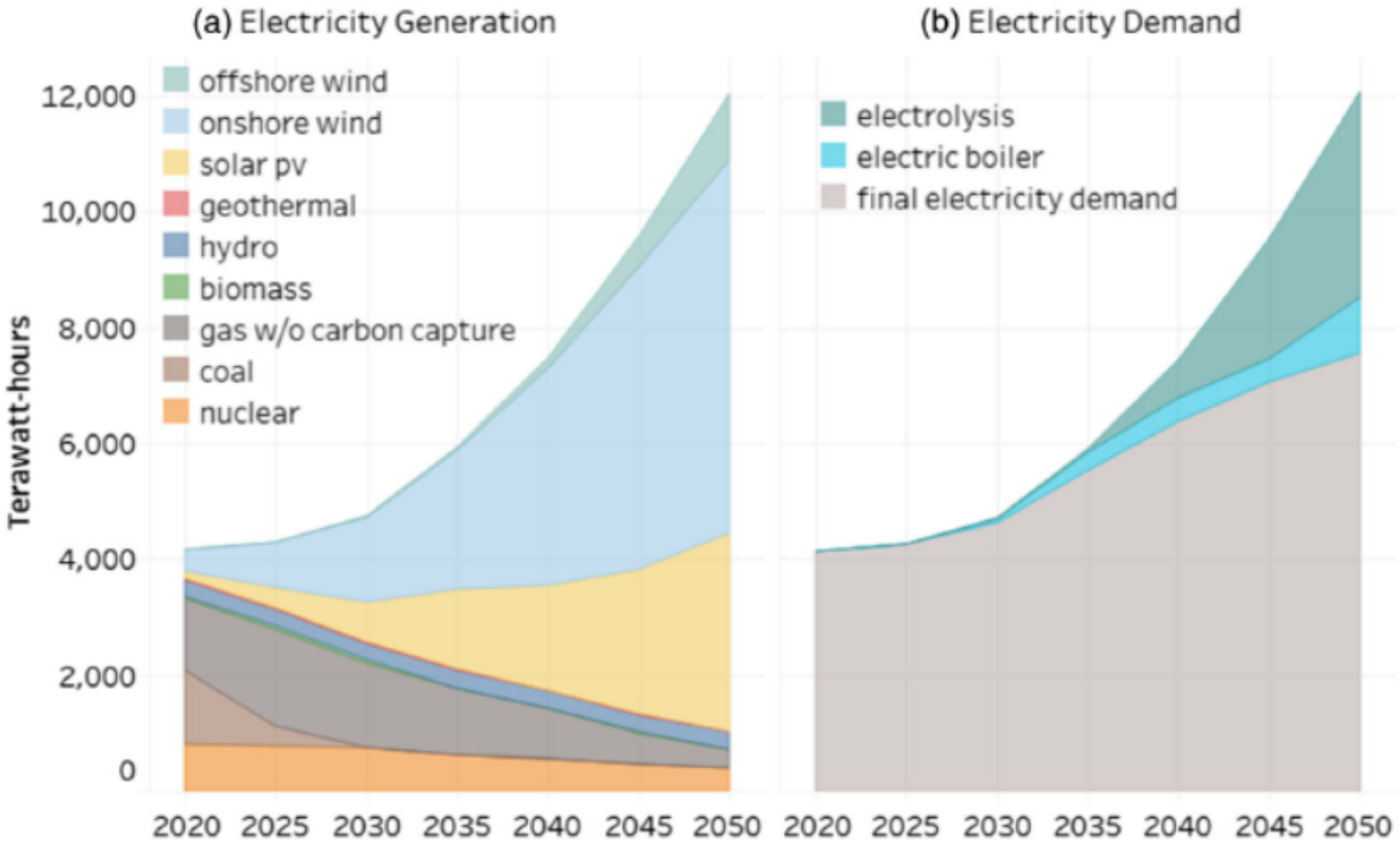
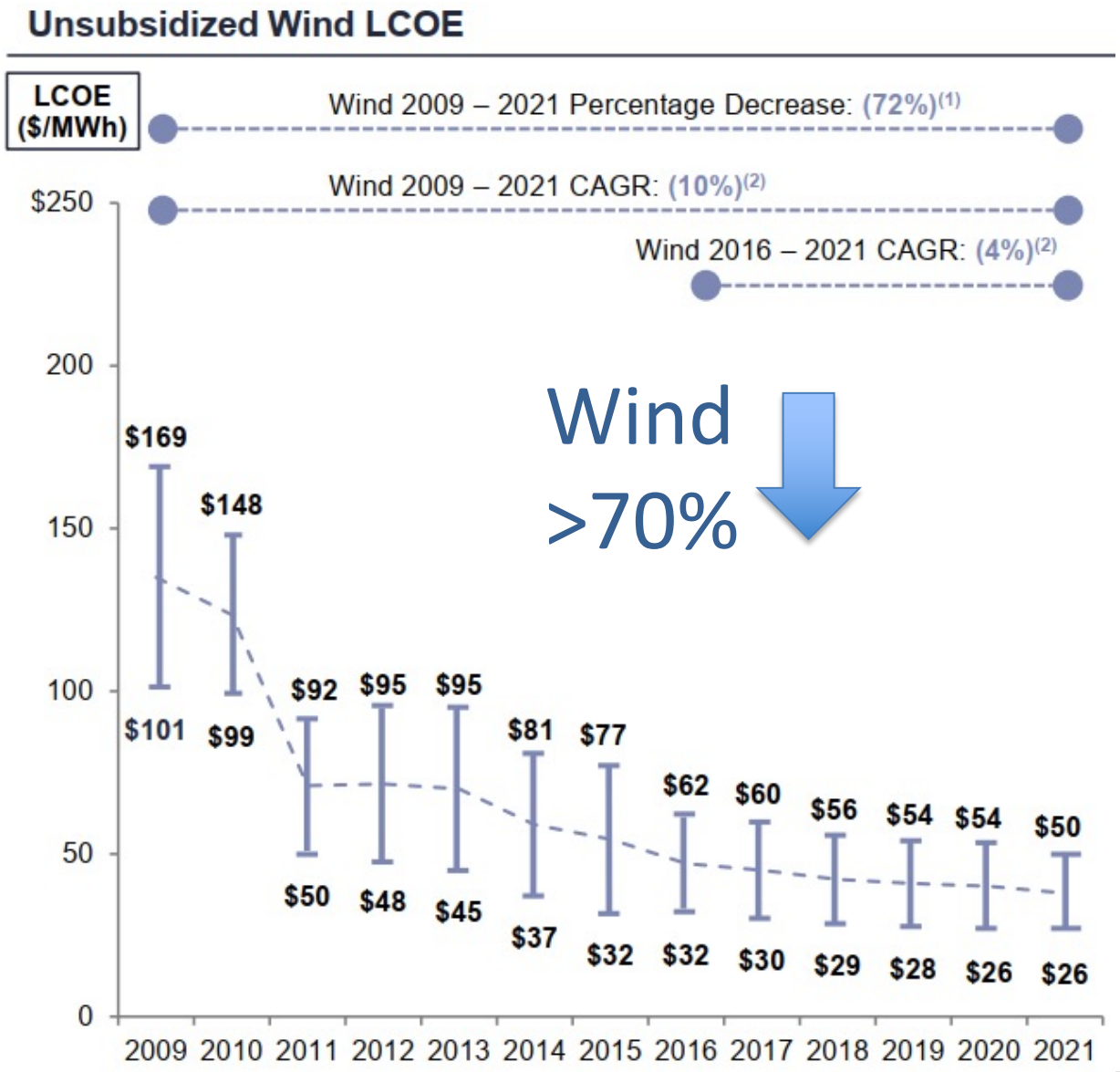
ELECTRICITY GENERATION AND DEMAND



Total generation triples. Wind and solar (>90%) are complemented by "clean firm": hydro, bioenergy, nuclear, gas

https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1029/2020AV000284

RENEWABLES REVOLUTION – WIND POWER



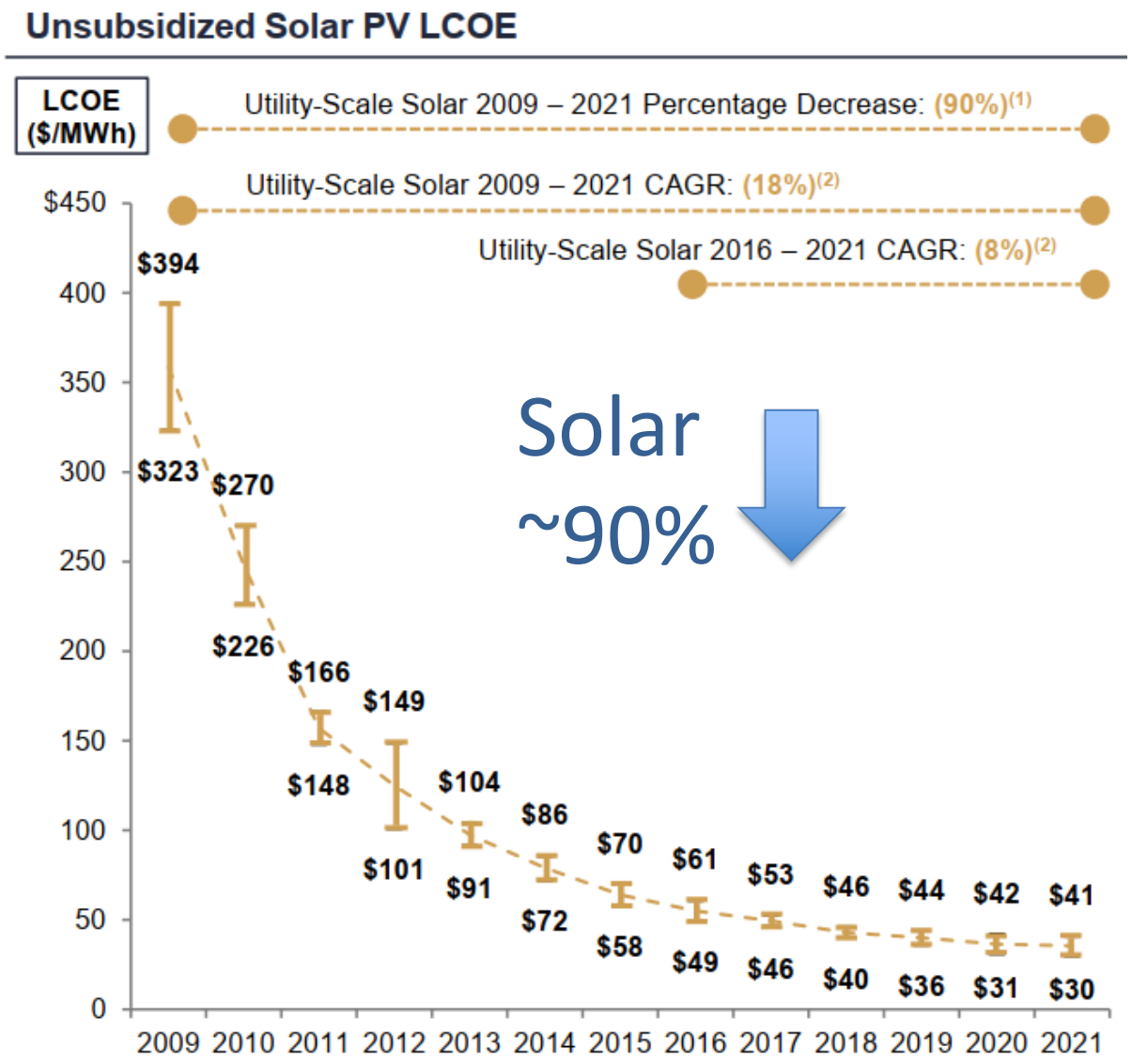
Dramatic cost decreases in wind power over the past decade.

Wind: 26– 50 $/MWh.

Key caveat: LCOE = "Levelized Cost of Energy" = average cost of a MWh from a standalone wind plant

Lazard's LCOE Analysis, v.15.0, Oct. 2021,
https://www.lazard.com/media/451905/lazards-levelized-cost-of-energy-version-150-vf.pdf

RENEWABLES REVOLUTION – SOLAR PV



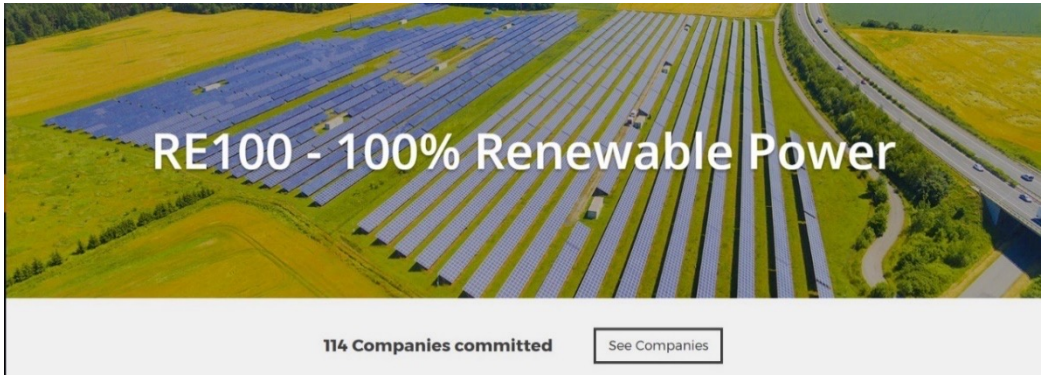
Dramatic cost decreases in solar PV over the past decade.

Solar PV: 30– 41 $/MWh.

Same caveat: LCOE = "Levelized Cost of Energy" = average cost of a MWh from a standalone solar PV plant

Lazard's LCOE Analysis, v.15.0, Oct. 2021,
https://www.lazard.com/media/451905/lazards-levelized-cost-of-energy-version-150-vf.pdf

WHY NOT 100% RENEWABLE?



MAYORS FOR 100% CLEAN ENERGY
#Mayors4CleanEnergy

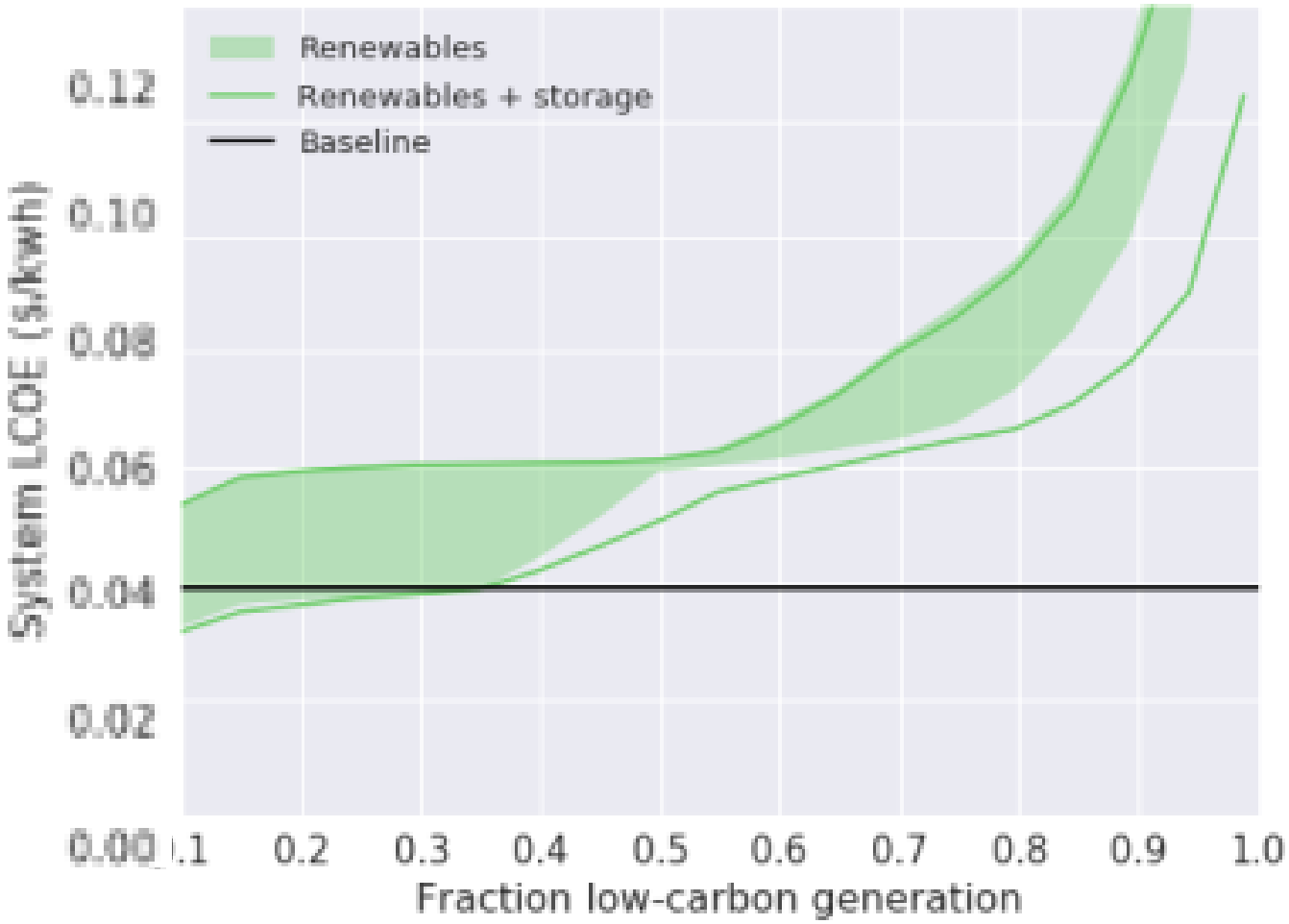
GO 100% RENEWABLE ENERGY

Mainstream modelers project that, as a power system moves closer and closer to 100% solar and wind, at some point the total system costs increase sharply.

This is the riddle of “cheap renewables” vs. high total system costs...

SOLVING THE RIDDLE OF "CHEAP RENEWABLES" AND HIGH SYSTEM COSTS

ILLUSTRATIVE SYSTEM WITH WIND, SOLAR & STORAGE



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*

Platt, et al (2017) https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3015424

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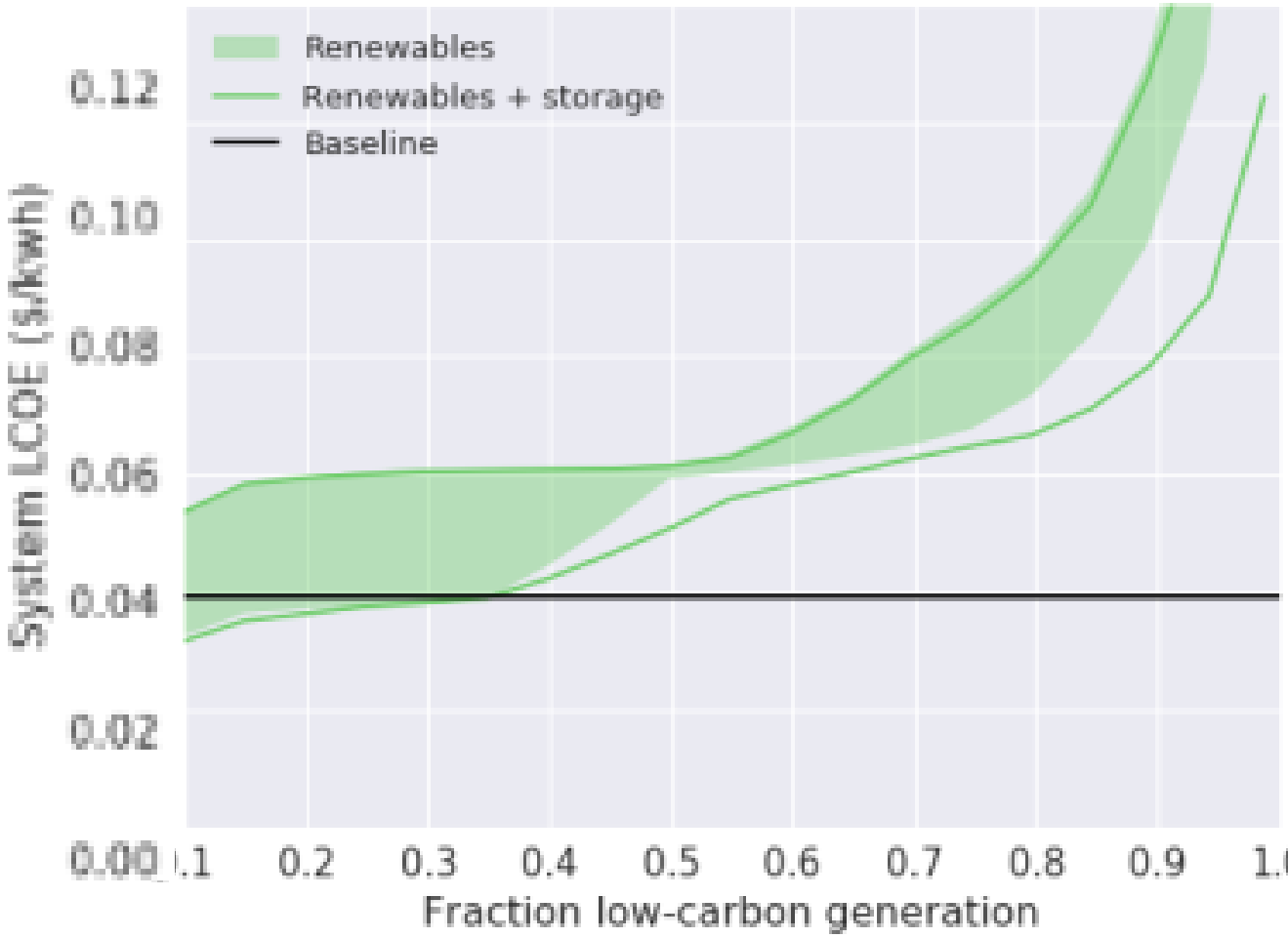

"Integration" costs drive up system LCOE:

1. Transmission
2. Load shifting
3. Storage
   - Daily
   - Seasonal
   - Weather flux
4. "Overgeneration"

Spreading large capital costs over infrequent but challenging periods of low RE generation would be very costly

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

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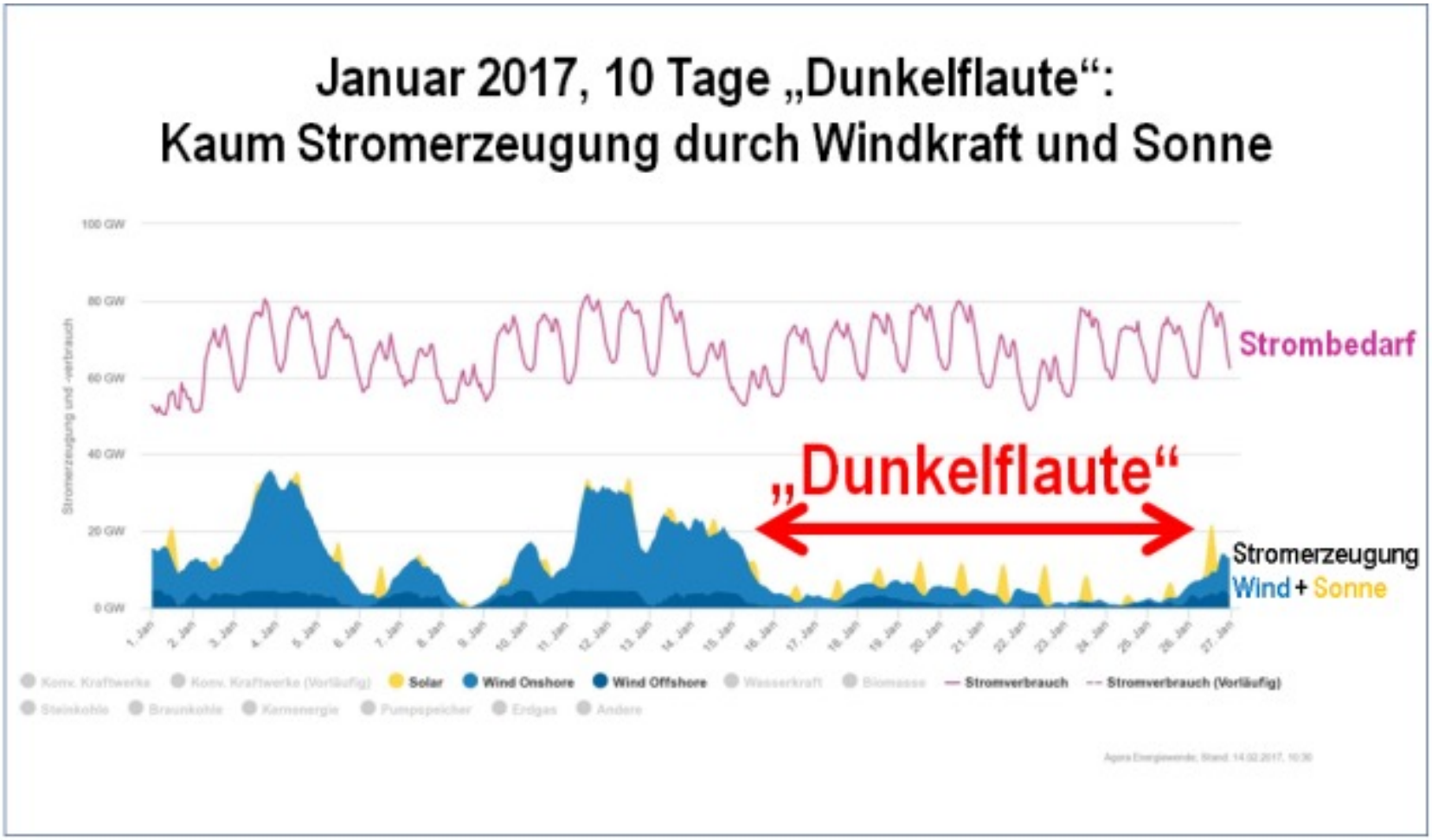
WEATHER FLUCTUATION: SOLAR AND WIND OUTPUT CAN DROP TO VERY LOW LEVELS FOR DAYS

THE GERMANS HAVE A WORD FOR THAT: "DUNKELFLAUTE" (DARK DOLDRUMS)



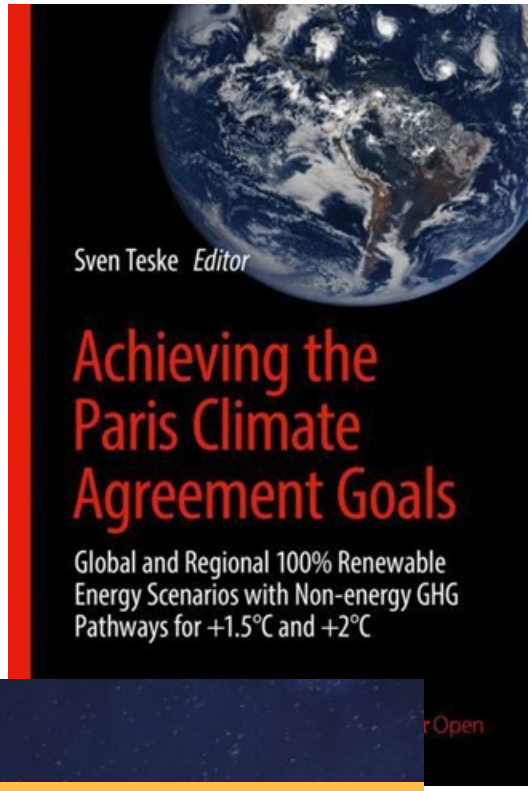
https://deepresource.wordpress.com/2019/11/03/heat-storage-as-key-to-seasonal-energy-storage/
This article proposes seasonal thermal storage to help overcome dunkelflaute

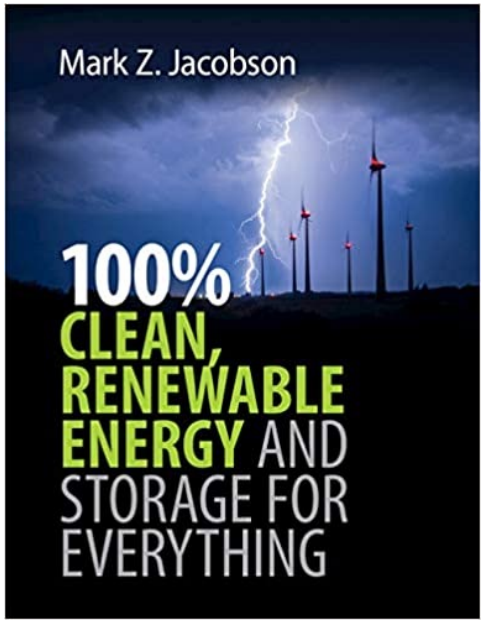
DISSENTING VIEWS…

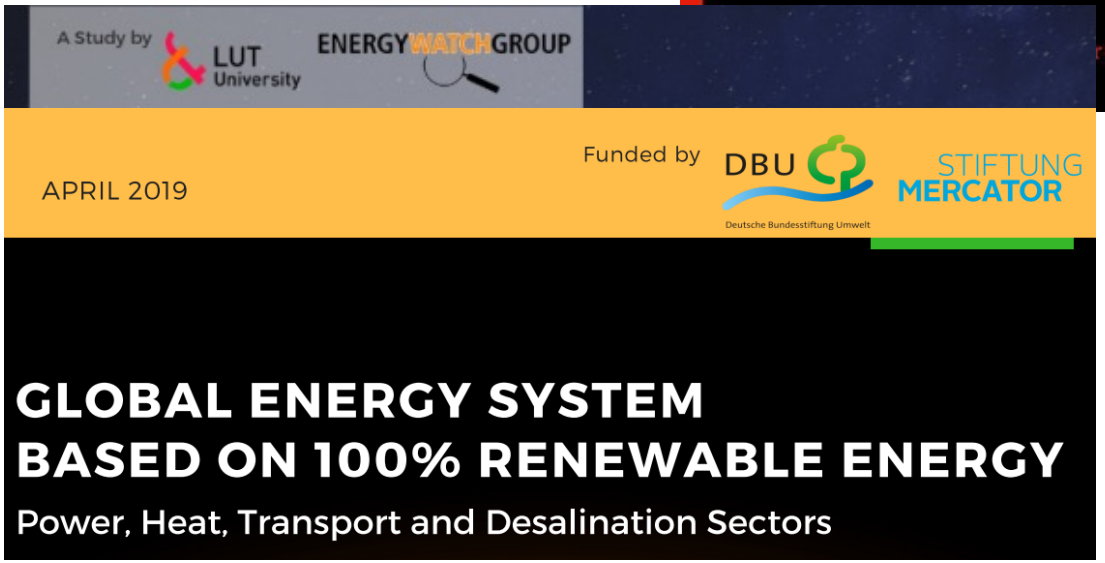
Some modelers rule out certain options (nuclear, carbon capture and storage) and create and advocate for "100% renewable" pathways. Typically they include:

- **Massive expansion of transmission systems**
- **Massive amounts of battery storage and/or thermal storage, load shifting**
- **Hydro, geothermal, hydrogen turbines**

This may be technically feasible…







http://energywatchgroup.org/wp-content/uploads/EWG_LUT_100RE_All_Sectors_Global_Report_2019.pdf

GIVING 16 AUTHORS FROM NREL THE LAST WORD

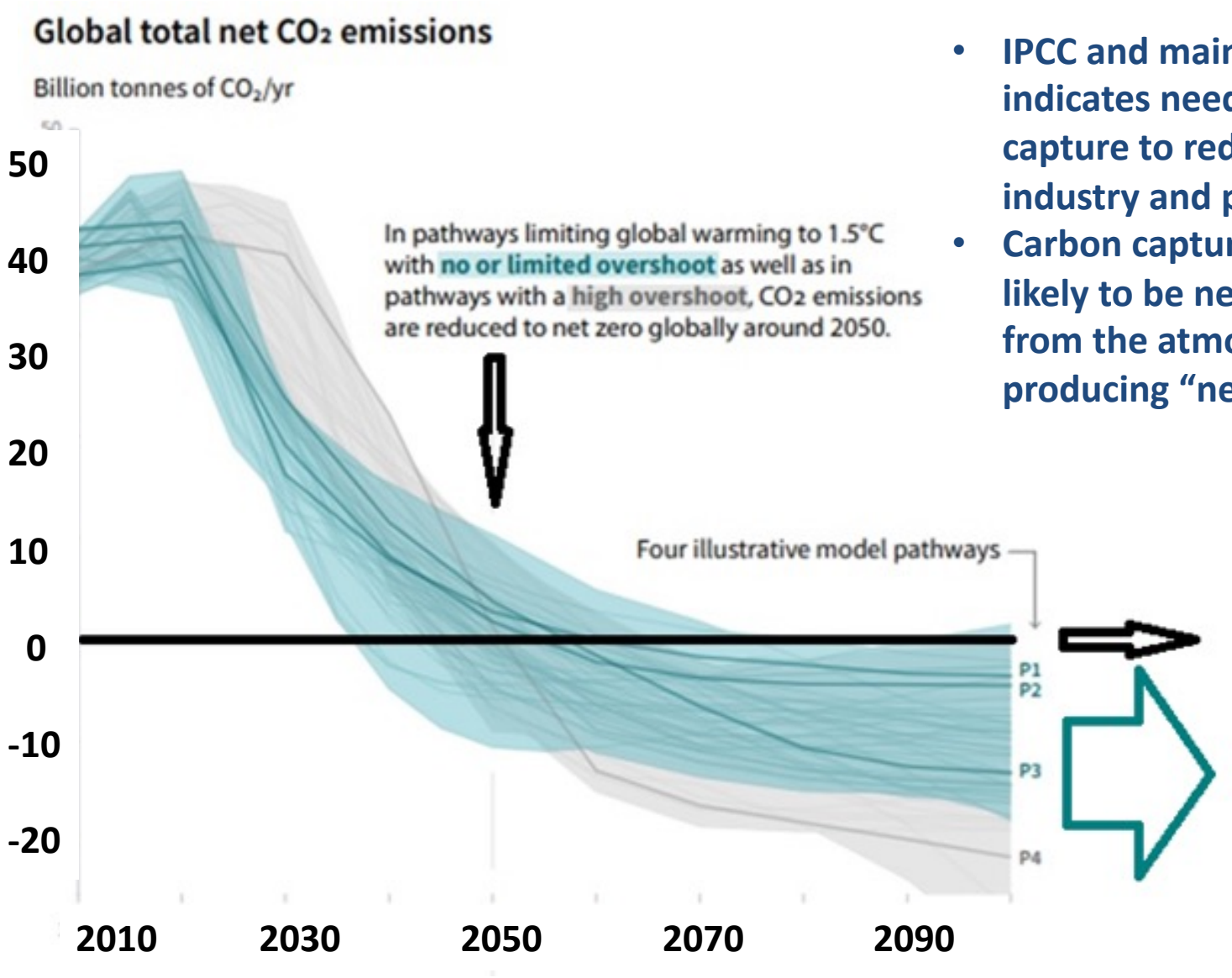
From: Denholm et al, "The challenges of achieving a 100% renewable electricity system in the United States." *Joule*. 2021

"Significant unanswered questions remain regarding moving toward or achieving 100% RE at a national scale for all hours of the year. There is no simple answer to how far we can increase RE penetration before costs rise dramatically or reliability becomes compromised." [p.17]

"Reducing the costs of low-carbon generation in the electric sector, potentially by keeping non-RE options (including CCS and nuclear) available, enables electrifying and thus decarbonizing other sectors, reducing economy-wide carbon emissions." [p.18]

In other words, don't bet ALL your chips on RE…

1.5ºC PATHWAYS: ROLE OF CARBON CAPTURE

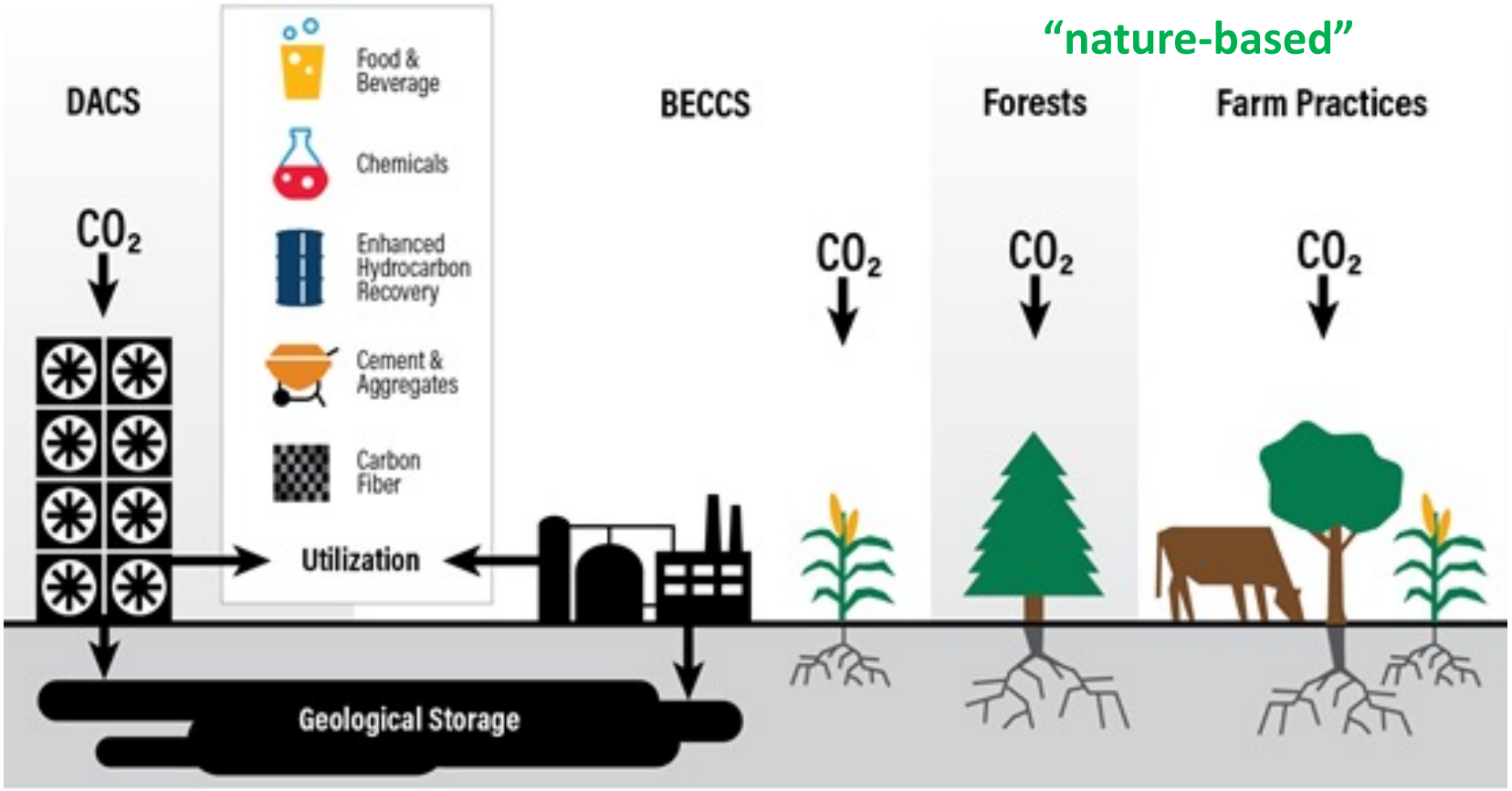


- IPCC and mainstream modeling indicates need for carbon capture to reduce emissions in industry and power sector.
- Carbon capture is also very likely to be need to remove CO2 from the atmosphere, i.e., producing “negative emissons”.

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

REMOVING CO2 FROM THE ATMOSPHERE

- **"Nature-based": use of forests and soil management**
- **"Technology-based": Direct Air Capture & Storage (DACS), Bioenergy with Carbon Capture & Storage (BECCS), utilization strategies**



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

https://www.wri.org/publication-series/carbonshot-creating-options-carbon-removal-scale-united-states

DISSENTING VIEWS ON CARBON CAPTURE

- ‘doesn’t work’
- ‘too expensive’
- ‘too risky’
- ‘prolongs dependence on fossil fuels’

SIERRA CLUB
IOWA CHAPTER

Say NO to two CO2 pipeline projects proposed in Iowa!

We want real climate solutions - not greenwashing schemes!

It’s Time to End Carbon Capture of Climate Policy

An Open Letter to US and Canadian Leaders

On behalf of our millions of members and supporters across the United States and Canada, we call on policymakers to recognize that carbon capture and storage (CCS) is not a climate solution. It is a dangerous distraction driven by the same big polluters who created the climate emergency.

https://www.ciel.org/wp-content/uploads/2021/07/Confronting-the-Myth-of-Carbon-Free-Fossil-Fuels.pdf

BETTING ON CLIMATE SOLUTIONS: SHOULD WE…

Place all our chips on renewables?

Are the risks of nuclear power unacceptable?
Should carbon capture be excluded from our options?
Should we "Leave It in the Ground"?

… Or spread our chips on a broader portfolio?

KEY MESSAGES

- Be extremely efficient
- "Electrify everything"
  - Make hydrogen and other low/zero-carbon fuels to fill niches
- Produce mountains of zero-carbon electricity
  - Build out wind and solar aggressively – integration costs are still low.
  - Build more transmission. Keep existing nuclear plans operating, if safe.
  - Create viable nuclear, CCS, and other options, along with long-term storage. Deploy if and as needed.
  - Expand the transmission system to tap areas rich in wind and solar
- Commercialize carbon capture for CDR, industry, electricity.
  - CCS should become fully commercialized in the 2020s.
  - Capture, pipelines, injection sites, governance, public acceptance
- Spread your chips: need aggressive, well-designed RD&D programs with a broad portfolio

TURNING IDEAS INTO ACTION [DRAFT]

RCAT
ROTARY CLIMATE LEADER

1. Take the Pledge

2. Start a Team

Go Now >

3. Take Action

Go Now >

- Shape policy – federal, state, local
- Reduce the carbon footprints of your business, organization, and household
- Increase the resilience of your community to extreme weather events

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THANK YOU

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