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ENERGY REPORTING 101 FOR ENVIRONMENTAL JOURNALISTS

Understanding the Puzzle of Low-Cost Solar and Wind and
the Need for Clean Firm Power

Karl Hausker, Ph.D.
Senior Fellow
khausker@wri.org

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MY TOPIC

- **Resolve this puzzle:**

- **Solar/wind/batteries** are typically the **lowest-cost** incremental source of electricity **now** in many parts of the world.
- Governments, utilities, companies, and large buyers have begun major investments in “**clean firm power**”
 - Especially: advanced geothermal, advanced nuclear, enhanced geothermal, and gas with carbon capture and storage (CCS), along with long duration storage technologies –
 - AND – these technologies appear to be **more expensive** than solar, wind, and 4-hour batteries.

- **WHY?**

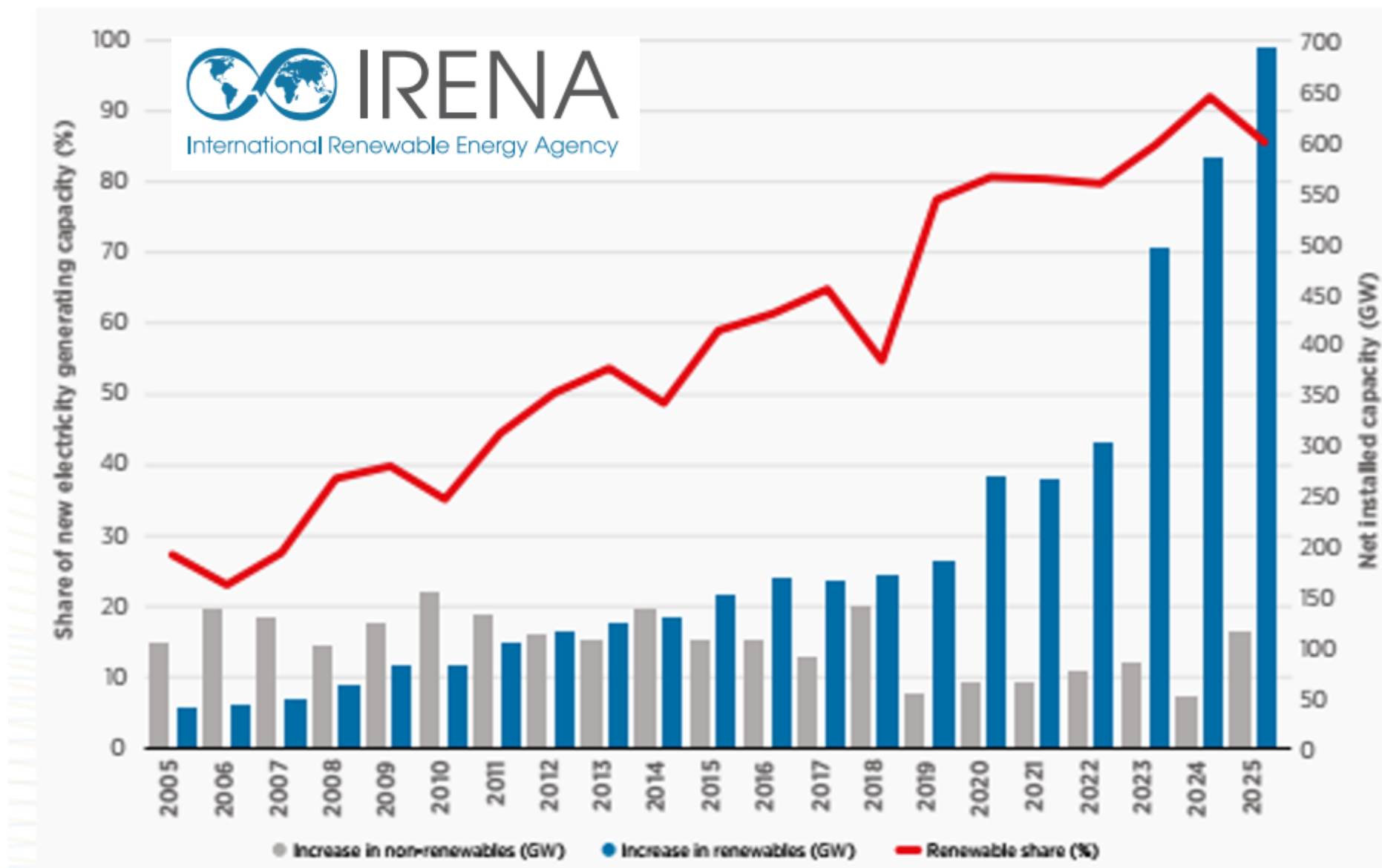
- **Definitions**

- “Clean” means zero-carbon or very low-carbon
- “Firm” means providing power whenever needed, for as long as needed (in contrast to solar and wind which are “variable”, depending on weather/season – “variable renewables”)
 - in the 2030s and beyond. Need to move fwd on commercialization **now**.

**Lots of
links for
deeper
dives**

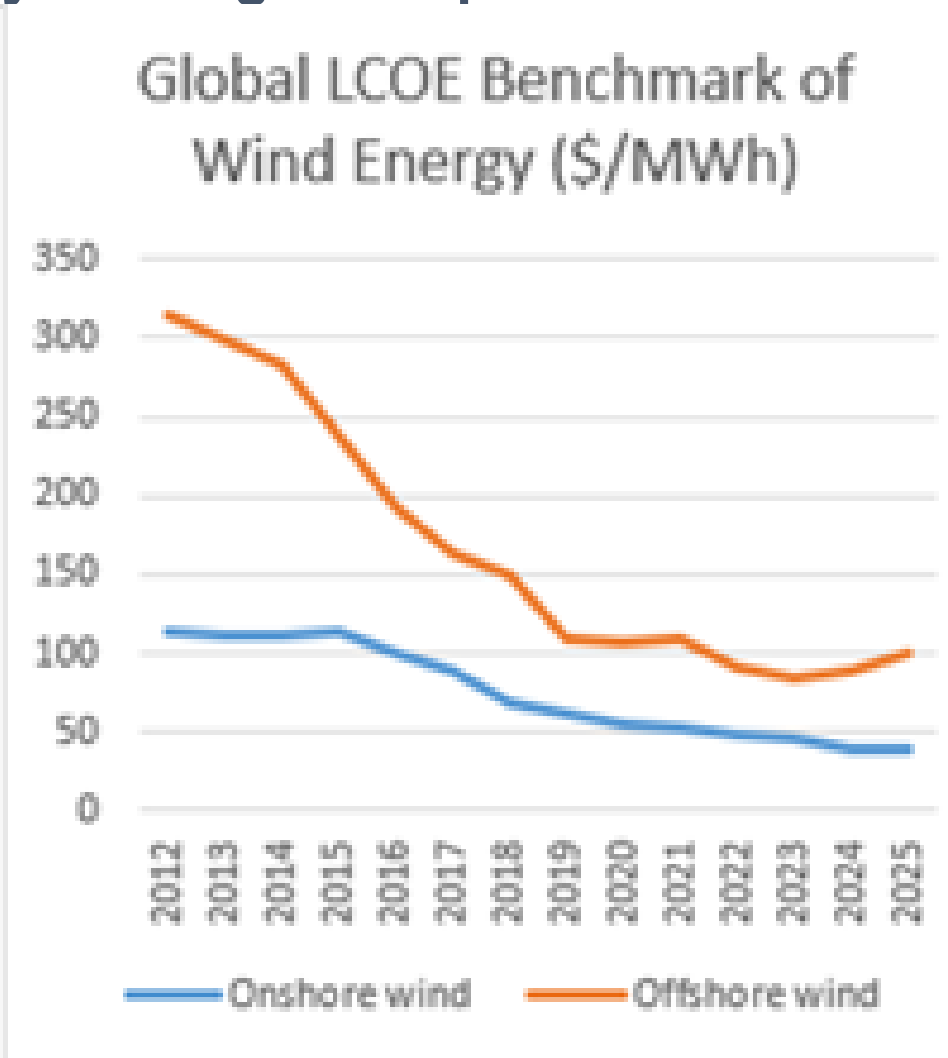
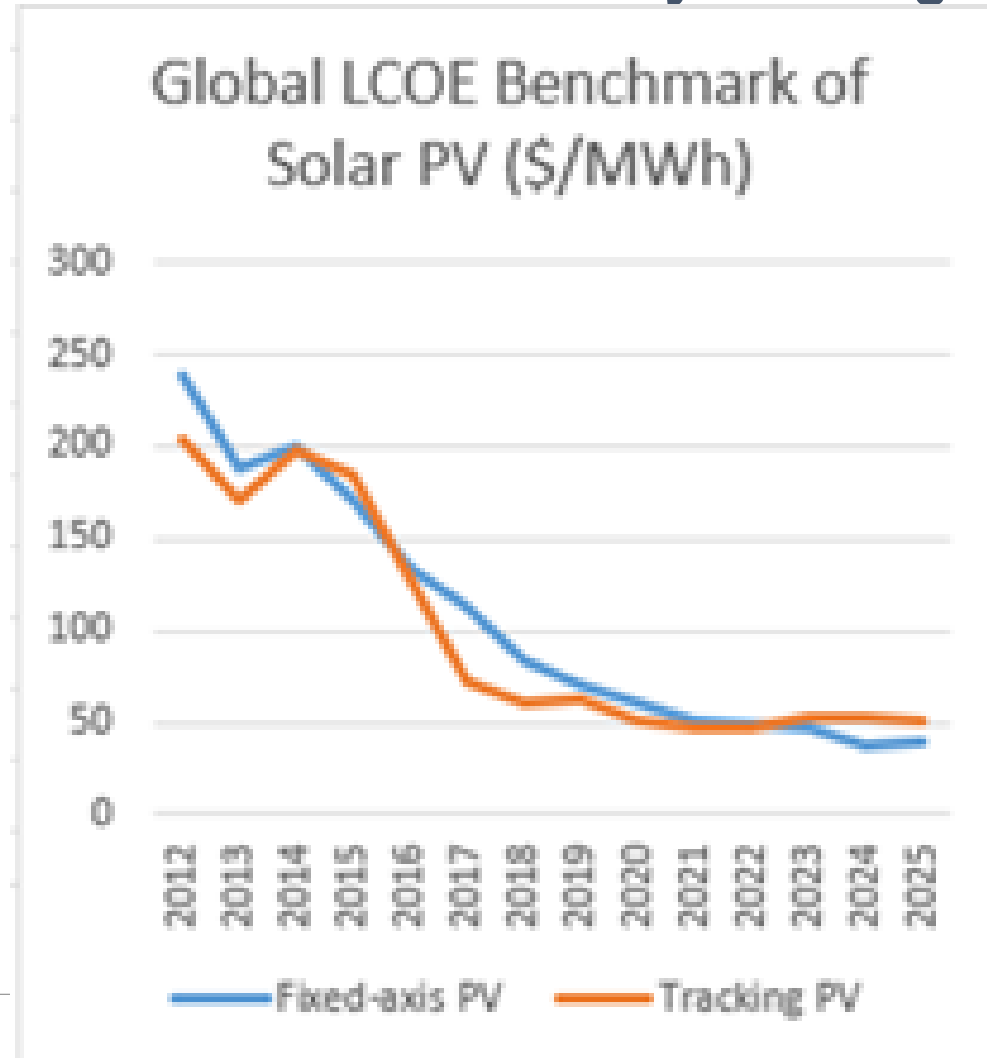


RENEWABLE SHARE OF CAPACITY ADDITIONS: >80% since 2022



DRIVING RAPID EXPANSION: HUGE DECLINE IN COST OF SOLAR AND WIND

LCOE = “Levelized Cost of Electricity” or roughly “average cost per MWh”



MORE FACTORS DRIVING RAPID EXPANSION OF SOLAR AND WIND

- **Battery Storage costs**

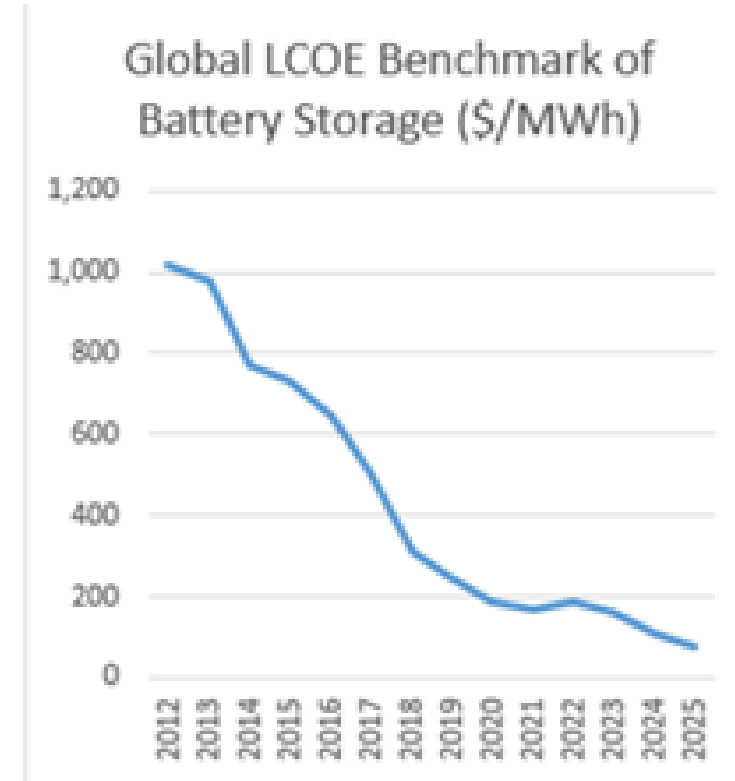
- Declined 90% from 2012-2025 allowing solar and wind to deliver more value.

- **Supportive government policies**

- [More than 130 governments have policies](#) that encourage the deployment of renewable technologies (subsidies and other financial incentives, mandatory purchasing, carbon pricing policies, etc.)

- **Corporate purchasing**

- Hundreds of firms have pledged and achieved the goal of using 100% renewable electricity through alliances such as [RE100](#).
- Driving roughly half of corporate purchases are large buyers such as Google, Meta, Amazon, and Microsoft, accounting for about [27 GW](#) of new solar and wind capacity in 2025.



NEW IRENA REPORT: RENEWABLES + BATTERIES CAN PROVIDE FIRM '24/7' ELECTRICITY CHEAPER THAN FOSSIL FUELS



THE ECONOMICS OF
FIRM SOLAR AND WIND



24/7 Renewables Outcompete Fossil Fuels on Costs

6 May 2026 | Press Releases

See similar Ember 2025 Report: [Solar electricity every hour of every day is here and it changes everything](#)

[IRENA, 24-7 Renewables – The Economics of Firm Solar and Wind](#)

IF SOLAR / WIND / BATTERIES ARE CHEAPEST, WHY BUILD ANYTHING ELSE?

- Six years ago (2020), Google set an [ambitious new goal](#): to operate on carbon-free electricity, 24 hours a day, 7 days a week, 365 days a year.
 - Portfolio now includes advanced geothermal, nuclear, and gas with CCS
- Five years ago (2021), California [ordered utilities](#) to buy “clean firm power” to help ensure reliability
 - Limited to advanced geothermal
 - Sparked projects in California, Nevada, Utah
- [California S.B. 846](#) (2022) provides support for keeping Diablo Canyon reactor open

WITH RECENT LOAD GROWTH: STATES OPEN DOORS TO NUCLEAR

New York plans new advanced nuclear power plant upstate, governor says

June 23, 2025 5:13 PM EDT · Updated June 23, 2025



New Jersey ends de-facto nuclear power plant moratorium

April 8, 2026 4:27 PM EDT · Updated April 9, 2026



POLICY

Illinois lifts moratorium on new large nuclear reactors

Fri, Jan 9, 2026, 10:34AM | Nuclear News

WITH AI BOOM: LARGE BUYERS ARE ENTERING CONTRACTS AND INVESTING IN NUCLEAR, GAS WITH CCS, GEOTHERMAL

7 companies helping Amazon, Google, Meta and Microsoft go nuclear

Nuclear energy could meet up to 10 percent of data center electricity demand by 2035, a Deloitte analysis predicts.

By Heather Clancy | June 12, 2025



[Meta signs deal](#) to power data centers with TerraPower and Oklo reactors
--AP News 1/29/26

Google backs US gas power plant with carbon capture for Midwest data centers

October 23, 2025 2:39 PM EDT · Updated October 23, 2025



SOLVING THE PUZZLE

- Focus on **system** costs, not **individual plant costs**.
 - Misleading to simply compare **LCOE** across technologies
 - See WRI, [2019](#) and Clean Air Task Force, [2025](#)
 - A clean, affordable, reliable power **system** requires a **team** of technologies playing different roles
 - Clean firm power **complements** solar and wind, along with other “integration” tools (e.g., storage, load shifting).
- Need to start **now** to fully commercialize clean firm options for scale-up in 2030s and beyond.
 - Just as solar, wind and batteries needed >15 years to commercialize
 - Options are at different stages, needing R&D or demonstrations or deployment support.

WHAT DOES “THE TEAM” LOOK LIKE?

- Credible modeling shows consistent conclusions for decarbonized grids supporting a net-zero emission economy in 2050 :
 - **Triple total electricity generation** to enable widespread electrification of end-uses
 - At the **global** level, “The Team” is **~70-75% solar and wind and ~25-30% clean firm power** (*varies by country, of course*)
- Credible modeling examples:
 - IRENA, [2023](#), [2024](#), [2026](#)
 - International Energy Agency (IEA), [2024](#)
 - Bloomberg New Energy Finance (BNEF), [2026](#)
 - Intergovernmental Panel on Climate Change (IPCC), [2022](#)
 - For a deep dive on IPCC power sector conclusions see Hausker, [2023](#)

EXAMPLE SCENARIO: IRENA, 2023

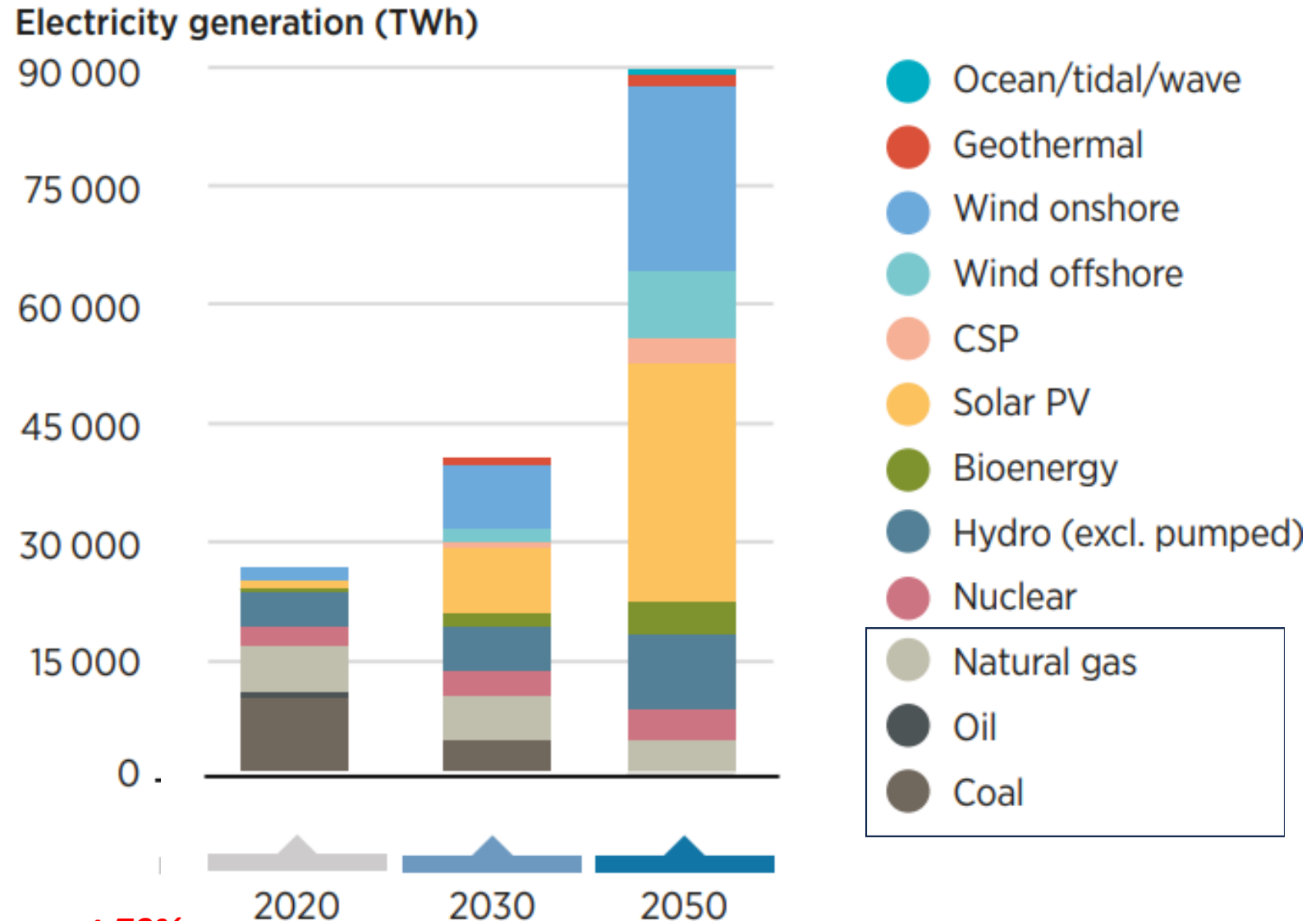
International Renewable Energy Agency

Total Electricity Demand

- Triples from ~30k TWh to 90k TWh

Generation Mix

- **Solar & wind ('VRE') provide ~75% of total generation in 2050**
- **'Clean firm power' provides the other ~25%**
 - Nuclear, geothermal, hydro, bioenergy.
 - IRENA includes some natural gas without CCS



IRENA 2024 update has solar and wind lower at 70%

WHY NOT 100% RENEWABLE? -- CAUTIONS FROM 16 AUTHORS FROM THE NATIONAL RENEWABLE ENERGY LAB (NREL)

Joule

CellPress

The challenges of achieving a 100% renewable electricity system in the United States

NATIONAL
LABORATORY
OF THE ROCKIES

Paul Denholm,^{1,*} Douglas J. Arent,¹ Samuel F. Baldwin,² Daniel E. Bilello,¹ Gregory L. Brinkman,¹ Jaquelin M. Cochran,¹ Wesley J. Cole,¹ Bethany Frew,¹ Vahan Gevorgian,¹ Jenny Heeter,¹ Bri-Mathias S. Hodge,^{1,3} Benjamin Kroposki,¹ Trieu Mai,¹ Mark J. O'Malley,¹ Bryan Palmintier,¹ Daniel Steinberg,¹ and Yingchen Zhang¹

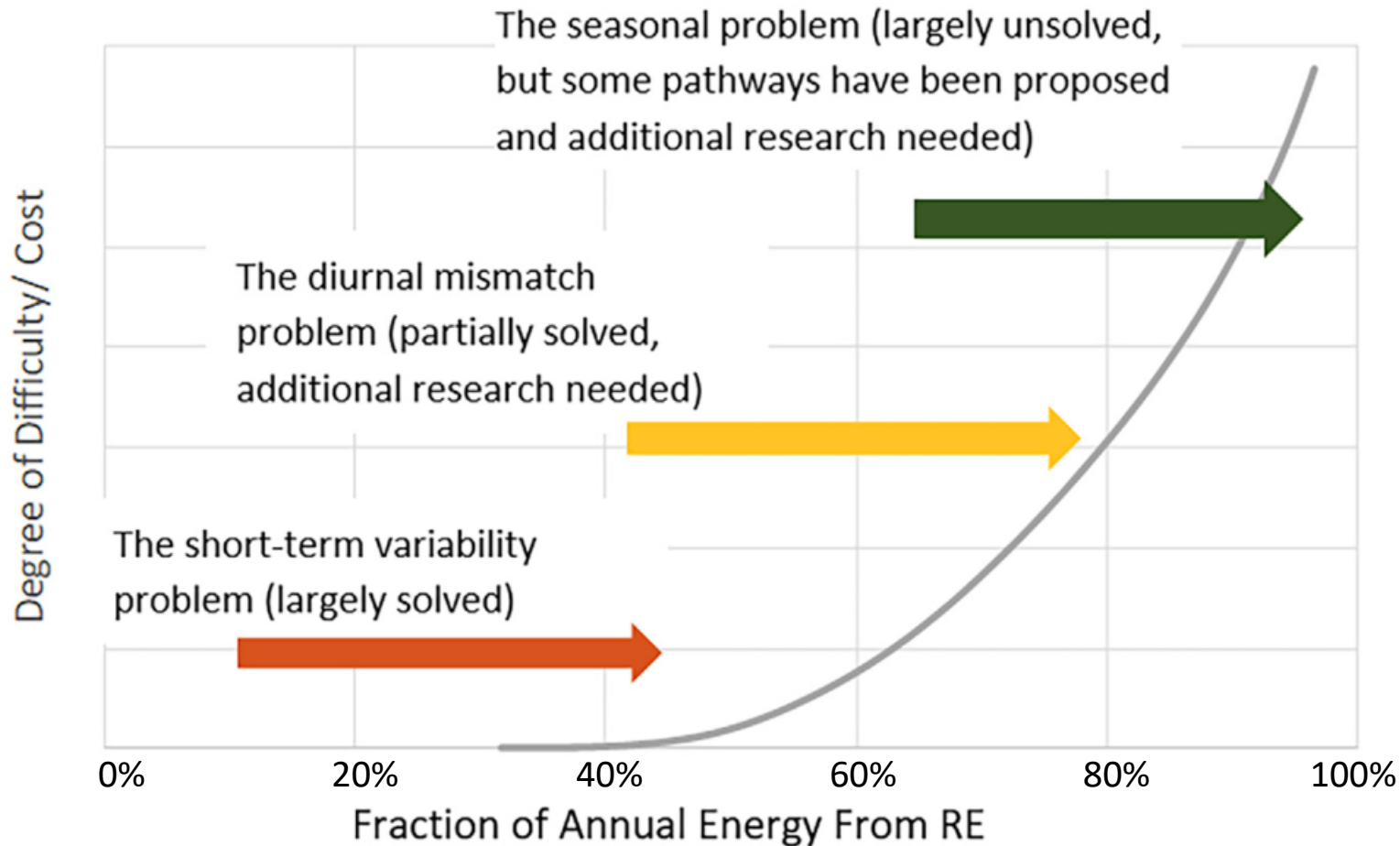
“Significant unanswered questions remain regarding moving toward or achieving 100% RE at a national scale for all hours of the year.

There is no simple answer to how far we can increase RE penetration before costs rise dramatically or reliability becomes compromised.”

[p.17]

INTEGRATION COSTS RISE EXPONENTIALLY WITH HIGH VRE

Three Zones of Difficulty and Cost in Integrating Renewables



VRE Integration Tools

- More transmission
- Storage
- Demand mgmt. and load-shifting
- Overgeneration / curtailment

For deep dive, watch: [Zero-Carbon Electricity: The Key to the Clean Energy Transition](#) (minute 49 fwd, but I recommend the whole hour!)

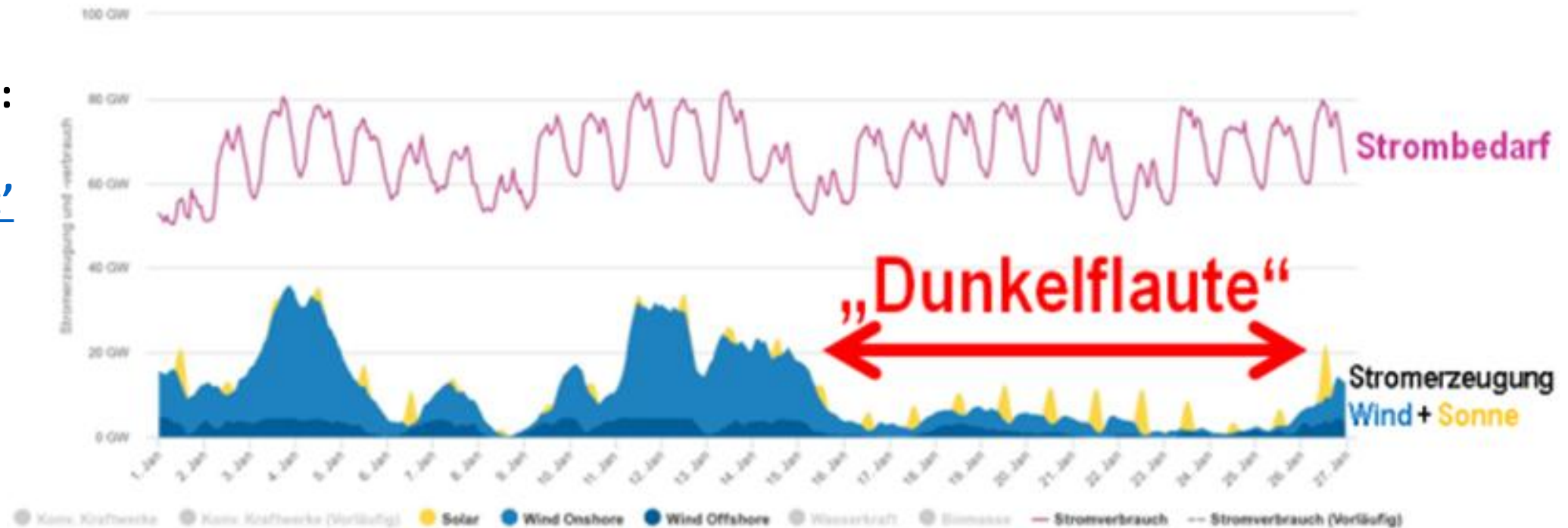
Figure 1. A simple framework for discussing the degree of difficulty and cost of increased RE deployment associated with the balance challenge

A MAJOR INTEGRATION CHALLENGE: RANDOM WEATHER VARIATION or ‘DUNKELFLAUTE’ Solar and wind output can drop to very low levels for days

Germany:
‘The Dark
Doldrums’

United States:
‘Solar and
wind drought’

Januar 2017, 10 Tage „Dunkelflaute“:
Kaum Stromerzeugung durch Windkraft und Sonne



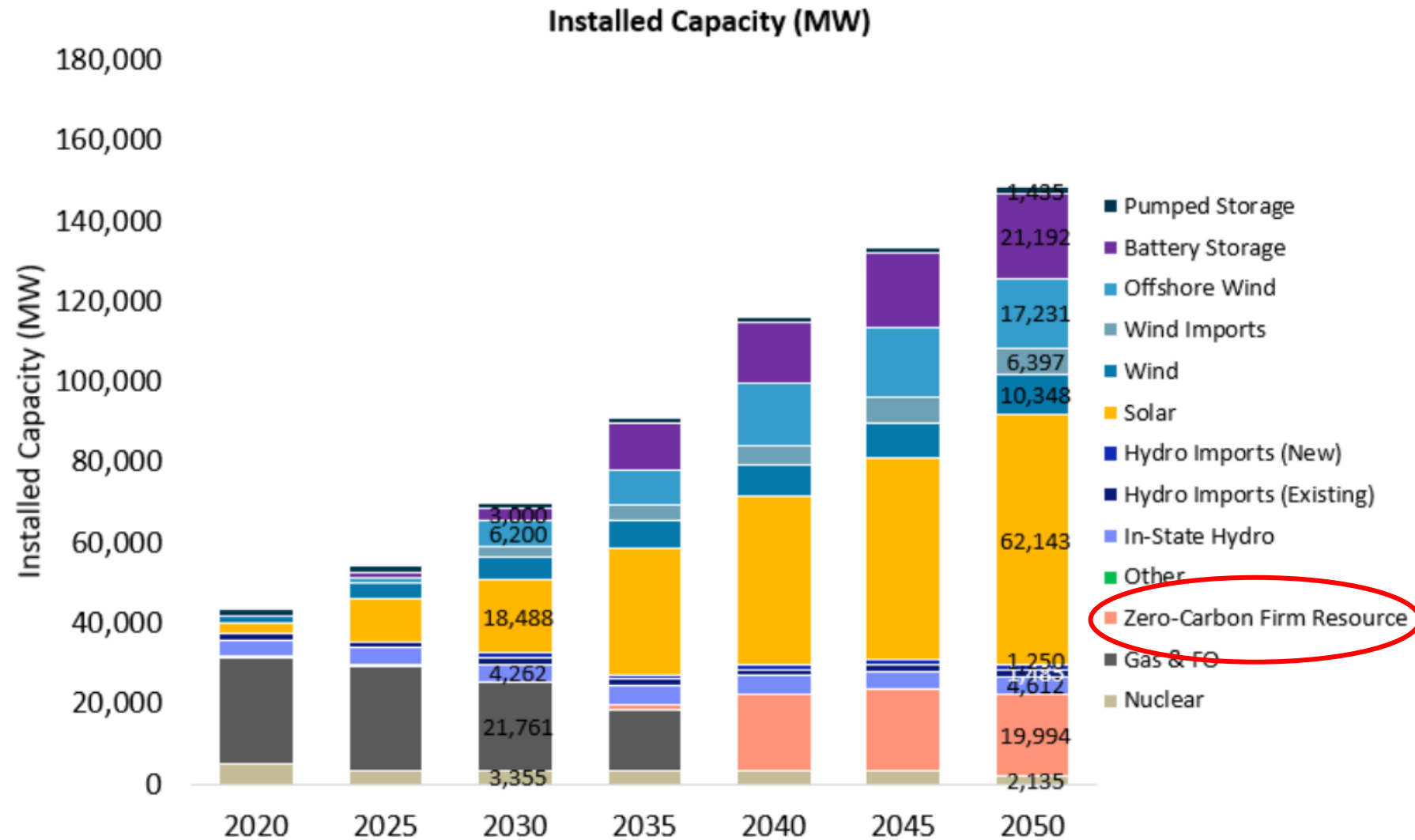
SCENARIO: NEW YORK STATE SCOPING PLAN, 2022

Clean/firm sources in plan for 100% zero-emission electricity by 2040

“[F]irm resources are needed to serve load and maintain system reliability during multi-day periods of low renewable output – periods in which the contributions of short-duration battery storage are limited.”

Plan identified a need for 18-23 GW of firm, zero-carbon capacity – in addition to NY’s existing hydro and nuclear facilities

Figure 29. Installed Capacity and Annual Generation for Scenario 3: Accelerated Transition away from Combustion³⁴



RECAP

- A clean, affordable, reliable power **system** requires a **team** of technologies playing different roles
- Solar, wind, and batteries can grow to be the anchors of such systems
- Clean firm power **complements** solar and wind, along with other “integration” tools