(Mis)forecasting the future

WHY ACCURATELY FORECASTING SOLAR PV MATTERS

Global Solar PV Brain Trust

In cooperation with PV Think Tank Germany

Report of the
Global Solar PV Brain Trust

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Key takeaways

1 Forecasting the future of solar PV has proved to be challenging as **modelers struggle to adjust their models (including both mental and economic) to the exponential growth and unprecedented cost declines of solar.** Developing more accurate scenarios and forecasts for the growth of solar PV, storage, and the extent of sector coupling ("power-to-X") is critical to navigate the transition toward a zero-carbon future rapidly, and at the lowest cost to society.

2 **The two leading agencies conducting long-term energy system modeling, the IEA and IRENA, are not applying cost-optimization in their long-term scenarios (WEO and WETO).** As such, these agencies are not accurately depicting the role that solar PV is likely to play in future energy systems. In models that use a cost-optimized approach, the share of solar PV is typically two to three times higher than assumed in either IEA or IRENA scenarios.

3 **The IEA and IRENA do not disclose key modelling assumptions for solar PV** (or for any other technologies): this makes a more informed and robust international discussion on modelling inputs and assumptions more difficult, if not impossible. When putting forward forecasts and scenarios, agencies should make all key modelling assumptions accessible to the public. Black box modeling does little to advance the wider debate about the energy transition.

4 **Inadequate energy system modelling directly impacts global climate mitigation efforts:** Most models used in the IPCC's reports are based on completely outdated solar PV cost data. The IPPC continues to assume costs that are 2 to 4 times higher than recent cost trends.[1] When key international scientific bodies like the IPCC are mis-representing the costs and future growth of solar, it is the global climate system that risks paying the price.

5 **Now that solar PV is the least-cost source of new energy supply, the assumptions that modelers make about the size and share of solar PV in the global energy supply mix directly impact forecasts of the total societal costs of the energy transition.** In turn, the costs of the transition have direct impacts on social acceptance; this makes cost-optimized scenarios a vital reference point for policymakers.

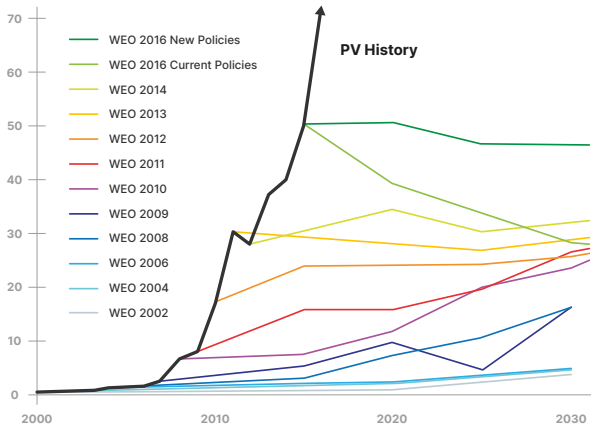
6 **As low-cost storage and power-to-X spreads, there are fewer and fewer limits on how much solar can be realistically deployed.** To date, most modeling conducted by the leading agencies continues to limit solar PV's role largely to the power sector. To produce more accurate forecasts of solar's role, this will have to change.

Solar PV is reaching new highs

Solar continues to shatter new records in cell efficiency, module cost reductions, installed costs, as well as global deployment levels. Despite this track record, solar PV's rise has been repeatedly underestimated.

While the International Energy Agency (IEA) has received the brunt of this criticism, it is in good company: many of the leading energy forecasters continue to get their forecasts for solar PV wrong, radically underestimating the role that solar PV can play in future energy systems.[2]

The IEA's World Energy Outlook has earned notoriety for its repeated failure to accurately forecast solar's rise[3]

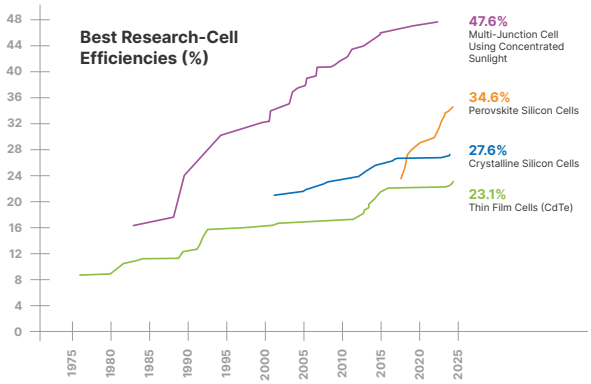


Annual PV additions: Historic data vs IEA WEO predictions
In GW of added capacity per year. Sources: World Energy Outlook and PVMA.

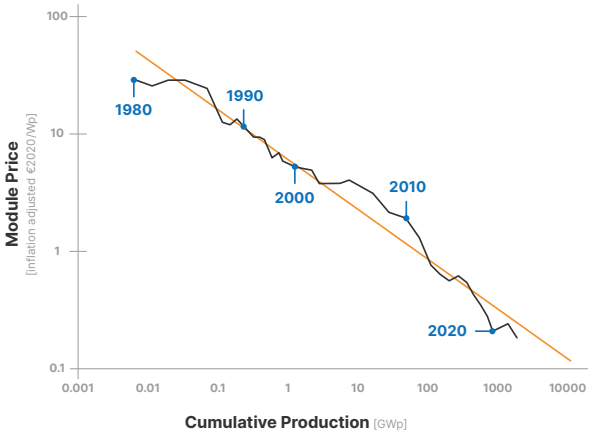
To be fair, solar has not made forecasters' job easy: solar has experienced the fastest cost reduction of any technology in history.[4]

Over the last four decades solar has broken record after record: annual deployments have surpassed the previous year's installations every single year in the last 22 years.[5]

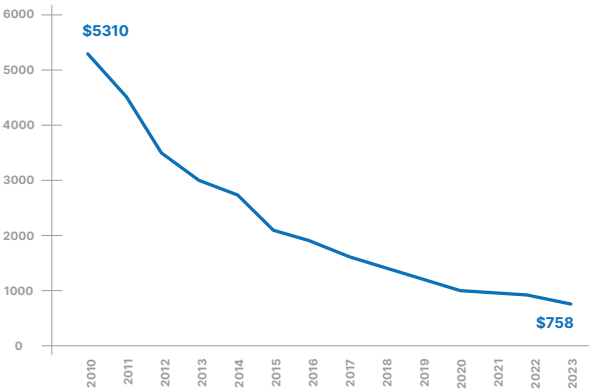
Solar cell efficiencies continue breaking new records[6]



Learning rate for solar PV has been over 24% since the 1970s and has increased in recent years, log-scale[7]

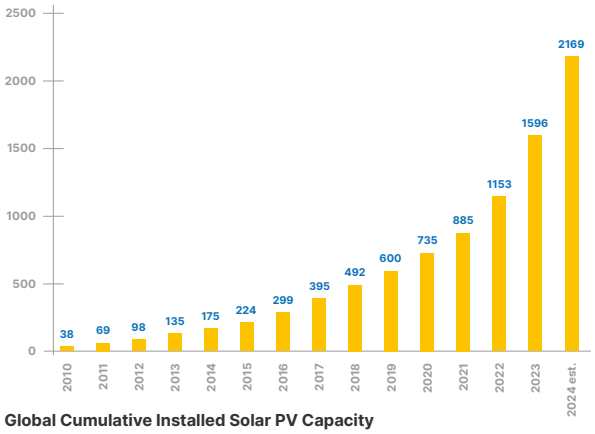


The global average installed cost has continued to decline[8]



Global Average Solar PV Installed Cost
USD $/kW

The growth in the deployment of solar PV continues to break records[9]



Global Cumulative Installed Solar PV Capacity
[GW]

Based on these trends, **solar PV is on track to fundamentally re-define the way the world supplies energy in the 21st Century**.

From representing less than 1% of global power sector additions twenty years ago, solar power now represents **roughly 550GW of the approximately 700GW (75%) of new electricity generation capacity being added each year**.[10]

Making reasonable forecasts about the future in the midst of such meteoric growth is difficult, particularly as many factors that drive demand for solar change, including government policy, geopolitical shocks, cheap storage, and new business models.

Against this backdrop, it may be surprising to many that **the key forecasting agencies such as the IEA and IRENA continue to assume flat or even shrinking annual solar PV deployment in the years ahead**.

Why forecasting solar more accurately matters

The challenge of accurately modeling solar PV cuts to the heart of the energy transition: as the largest, most widely distributed, and lowest cost source of electricity, solar PV is poised to play an outsized role in the energy transition.

If forecasters are getting the future of solar wrong, they risk of sending the wrong signals to policymakers. Sending faulty signals carries three main risks:

- **Mis-allocation of capital:** higher cost technologies (such as nuclear, fossil fuels, CCS or biomass) are likely to continue to be promoted, despite their far higher costs.
- **Greater social opposition:** in turn, higher costs are likely to translate into lower social acceptance for the energy transition as a whole.
- **Slower progress on tackling climate change:** by downplaying the role of solar, policymakers and modelers risk underestimating the speed of the energy transition. As the blistering pace of deployment in 2023 and 2024 has shown, solar can be deployed much more quickly than any other power generation technology. Policymakers should seek out ways to leverage this speed.

Repeating the same mistakes: It is important to get storage right too

The challenge of predicting future solar PV costs can also be observed with other technologies experiencing exponential growth, notably battery storage. The majority of energy system modelers continue to use inaccurate inputs and assumptions for the costs and future uptake of battery storage technologies.

Recent forecasts put out by the IEA as recently as 2019 envisioned battery costs reaching $200/kWh by 2040. With the rapid cost declines seen in recent years, current battery costs have already dipped below USD $100/kWh in certain parts of the world in 2024.

In the coming years, it is likely that a growing share of solar PV projects will include battery storage. Given the greater ease of integrating battery-linked systems into the power grid, **adding storage vastly expands the total volume of solar that can be installed, as well as the pace at which that deployment can be sustained**.

It is therefore not just the assumptions around the current and future costs of solar that matter: **solar and batteries increasingly need to be thought of, and modeled, together**.

Note to Modelers

With the unprecedented cost declines that solar has experienced in recent years, it is time for a comprehensive re-assessment of solar power's role in the global energy mix, and in efforts to tackle climate change.

- **Avoid black box modelling:** Long a rallying cry for the scientific revolution, the principle of trusting "no one's word alone" has a long history. In this context, it should serve as a reminder to leading agencies that their forecasts should not be trusted on word alone either, and that all cost data and assumptions used in models and scenarios should be published too. Black box modelling does little to advance the conversation.
- **Think and model holistically:** As sector coupling and storage expand, electricity is expected to power a growing share of total final energy demand. This makes the total "addressable market" for solar power far greater than under a future in which the heating, transport, industry, and power sectors continue operating largely in isolation. In response, modelers should run a far wider range of scenarios, including scenarios with far higher levels of storage and sector coupling.
- **If modelers, power utilities, energy companies, or governments want to include costlier options, they should state explicitly that this is what they are doing and explain why.** For instance, modelers can add a disclaimer stating that the least-cost scenarios have been over-ruled for such and such a set of reasons. Given that it is ultimately citizens and businesses who pay the energy bill, more transparency and openness can go a long way to building more trust, and fostering better outcomes.

With the costs of solar PV continuing to fall, and battery and electrolyzer costs also declining at 15% or more every year, solar PV combined with storage and power-to-X are poised to have a transformational impact on the global energy mix.

By failing to adequately model solar PV and storage costs, and ignoring the impact of sector coupling, modelers risk steering the global energy system toward more stranded assets and a host of other costly planning errors, with potentially severe consequences for the global climate and the energy transition.

The fact that the major forecasting agencies continue to underestimate solar should serve as a wake-up call to us all.

Endnotes

1 The "AIM", "GEM-E3" and "POLES" models use outdated cost data, assuming solar PV CAPEX ranging from 1382-2200 USD in 2030. Only the "REMIND" and "WITCH" models use more accurate cost data, ranging from 320-1000 USD in 2030.

2 Creutzig, F., et al. (2017). "The underestimated potential of solar energy to mitigate climate change." Nature Energy 2(9): 17140. https://www.nature.com/articles/nenergy2017140

3 Adapted from: Auke Hoekstra

4 International Energy Forum (January 2024). The Remarkable Rise of Solar Power, https://www.ief.org/news/the-remarkable-rise-of-solar-power

5 REN21 (2024). Renewables 2024: Global Status Report, https://www.ren21.net/gsr-2024/modules/global_overview/

6 Adapted from NREL (2024), https://www.nrel.gov/pv/assets/pdfs/best-research-cell-efficiencies.pdf

7 Fraunhofer ISE (2024), https://www.ise.fraunhofer.de/content/dam/ise/de/documents/publications/studies/Photovoltaics-Report.pdf

8 IRENA (2024). Power Generation Costs 2023, https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2024/Sep/IRENA_Renewable_power_generation_costs_in_2023.pdf

9 IEA (2024). Electricity, https://www.iea.org/reports/renewables-2023/electricity; see also: PV Magazine (September 19 2024). https://www.pv-magazine.com/2024/09/19/us-think-tank-predicts-593-gw-of-new-global-pv-installations-for-2024/

10 IEA (2024). https://www.iea.org/news/massive-expansion-of-renewable-power-opens-door-to-achieving-global-tripling-goal-set-at-cop28

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Information about the GLOBAL PV BRAIN TRUST

The Global PV Brain Trust is a loose association of experts who are passionate about the future of solar PV locally, and worldwide (non-profit). The group consist of experts from Australia, Asia, Africa, Europe and North America, including members from academia, industry and government.

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