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Solar must move beyond promises and prove its climate contribution

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Solar's role in the energy transition is well established, but how much carbon does a solar farm actually prevent from entering the atmosphere? As scrutiny of green claims intensifies, robust data and transparent calculations are essential to demonstrating the true climate benefits of photovoltaic (PV) projects.

In just a few years, photovoltaics has gone from an alternative technology to a pillar of the energy transition. In 2025, global solar electricity generation grew by 30% and met 75% of the increase in global electricity demand.[1] This growth confirms solar's role in transforming electricity systems.

As installed capacity increases, however, how can we demonstrate that this generation actually helps reduce greenhouse gas emissions?

For a long time, the promise seemed simple: generating solar electricity reduces dependence on fossil fuels. That remains true, but investors and non-financial reporting requirements now demand stronger evidence. Tackling greenwashing also means backing climate benefits with solid data, clearly stated assumptions and a verifiable methodology.

Measuring avoided emissions depends on the reference scenario

Avoided emissions are the difference between the emissions of a reference scenario, describing what would have happened without the project, and those of the scenario in which the project goes ahead. This indicator complements a traditional carbon footprint assessment, which accounts for the emissions generated by an activity. Avoided emissions estimate its contribution to decarbonisation.

The two results must be reported separately, rather than added together as though they measured the same thing.[2]

The calculation starts with a question: which electricity generation does the solar farm actually replace? The reference scenario must be plausible and appropriate to the context. It may draw on the grid's electricity mix, the generation sources likely to meet demand at a given time or a future scenario for the electricity system. Always choosing the most carbon-intensive source would artificially inflate the claimed benefit.

Several inputs are then needed: the farm's expected or measured output, the emission factors for the reference electricity supply, the assessment period and the assessment boundaries. Results also depend on assumptions about grid operation, cross-border electricity flows and the generation that would have supplied electricity without the project.

Where the data are available, hourly analysis can refine the assessment. Assumptions, sources and any limitations must be documented so that others can understand and reproduce the result.

France and Poland show how the same output can have different effects

A megawatt-hour of solar electricity does not have the same climate value everywhere. In France, 95% of the electricity generated in 2024 came from low-carbon sources, mainly nuclear power and renewables. The average carbon intensity of electricity generation was 21.7 gCO_2e/kWh.[3] In Poland, where coal still plays a significant role, it reached 582 gCO_2e/kWh in 2024.[4]

This difference shows why location matters when assessing a solar project. In a carbon-intensive electricity system, solar generation is more likely to displace fossil fuel generation. In a system that is already low-carbon, the benefit associated with an additional kilowatt-hour may be smaller. The analysis must therefore look beyond national averages and consider the project's characteristics and local generation conditions.

This does not mean that solar has no value in France. It can help meet rising demand from electrification, reduce the use of thermal power plants at certain times and support cross-border flows of low-carbon electricity. National averages provide a starting point, rather than a precise measure of each project's effect.

The timing of generation matters too

The grid's carbon intensity varies from hour to hour with demand, power plant availability and electricity flows to and from neighbouring countries. When the grid already has abundant low-carbon generation, additional solar output may have a limited effect. At other times, it may reduce the use of fossil fuel generation.



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The assessment must therefore consider the farm's generation profile and the sources likely to be used in its absence, rather than routinely applying an annual average factor.

A battery can shift some solar output to more favourable hours, but its climate benefit is not automatic. It depends on factors including charging and discharging losses, the electricity used for charging and the emissions associated with manufacturing the battery. The analysis must distinguish between electricity generated, electricity actually fed into the grid and electricity stored and subsequently discharged.

Including emissions across the full lifecycle

A photovoltaic farm is not emissions-free. Emissions arise from raw material extraction, the manufacture of panels and mounting structures, transport, installation, maintenance and end-of-life treatment. The operating lifetime and the amount of electricity generated strongly influence the footprint per kilowatt-hour.

Harmonised analyses of the carbon footprint of photovoltaic modules published by the European Commission's Joint Research Centre in 2025 report results ranging from 10.8 to 44 gCO_2e/kWh across the scenarios studied.

The variation depends on factors including the electricity used in manufacturing, the materials and the assumed lifetime. This range shows how manufacturing conditions affect the result. It is not a universal factor that can be applied to every solar farm.[5]

Estimating net avoided emissions requires comparing the reference scenario's emissions with those of the project, using the lifecycle boundaries defined by the methodology. This ensures that manufacturing and installation emissions are included and allows more consistent comparisons between projects.

A numerical example and its limitations

Consider two installations, each generating 1 GWh of electricity. For illustration, applying the average generation intensities for 2024, 21.7 gCO_2e/kWh in France and 582 gCO_2e/kWh in Poland, would give emissions of approximately 21.7 tonnes and 582 tonnes of CO_2e respectively for an equivalent volume of electricity generation.[3,4]

These figures do not represent the emissions actually avoided by the two solar farms. They apply national average factors to the same volume of electricity. A project-level assessment would need to identify which generation is actually displaced, account for the installation's hourly generation profile and include lifecycle emissions within the chosen boundaries.

It would also need to state the assumptions clearly and test their influence on the result. The example shows how much an asset's climate impact depends on its context and the methodology used. A single figure cannot tell the whole story.

Credible results require transparency

Electricity grids will change during a solar farm's lifetime. As the electricity mix becomes less carbon-intensive, avoided emissions per kilowatt-hour may decline. Results calculated using historical data must therefore be distinguished from projections over 20 or 30 years, which rely on assumptions about demand, new capacity and power plant closures. Treating today's emission factor as constant throughout an asset's lifetime would give a misleading picture.

For results to be credible, readers need to see how they were reached. This means publishing the data, reference scenario, assessment boundaries, assumptions and uncertainties.

It also means testing several scenarios where results are sensitive to methodological choices and seeking independent verification where appropriate. Double counting must be avoided, and avoided emissions must be presented separately from the company's emissions inventory.[2]

For developers, this means incorporating the assessment from the project design stage. Asset owners can use it to monitor performance and revise estimates as data or market conditions change. For investors, avoided emissions complement carbon footprint analysis, helping them select assets, carry out due diligence and monitor an asset's climate contribution throughout the holding period.

Avoided emissions are not, in themselves, a measure of financial value. Their credibility depends on realistic scenarios, cautious attribution and robust data. Estimates must be reviewed as the electricity mix or technologies evolve, and reported separately from the carbon footprint.

Solar remains a major contributor to decarbonisation, but installed capacity and generation volumes alone do not show its full climate contribution. Location, the timing of generation, lifecycle emissions and changes in the electricity system all matter. The industry needs to demonstrate, through sound methodology, how, where and to what extent photovoltaics actually avoids emissions.

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References

[1] Ember, 'Global Electricity Review 2026', 21st April 2026. https://ember-energy.org/latest-insights/global-electricity-review-2026/

[2] GHG Protocol, resources on accounting for avoided emissions and distinguishing them from emissions inventories. https://ghgprotocol.org/

[3] RTE, '2024 Electricity Review: summary' (French-language source). https://analysesetdonnees.rte-france.com/bilan-electrique-2024/synthese

[4] RTE, '2024 Electricity Review: Europe', comparative data on the carbon intensity of European electricity systems. https://assets.rte-france.com/analyse-et-donnees/2025-11/RTE%20-%20Annual%20electricity%20review%202024%20-%20Full%20report.pdf

[5] European Commission, Joint Research Centre, 'Photovoltaic panels: new rules for assessment of the carbon footprint', 7th July 2025. https://joint-research-centre.ec.europa.eu/jrc-news-and-updates/photovoltaic-panels-new-rules-assessment-carbon-footprint-2025-07-07_en