

Chinese Manufactured PV Solar Panels Increase GHG Emissions

or Will the embedded GHG emissions in Chinese manufactured solar panels ever be offset?

Summary

Currently about 90% of all PV solar panels imported into Australia are manufactured in China. It is therefore relevant to understand how much carbon dioxide equivalents (CO₂e) are embedded in Chinese made panels. Good data is available for PV solar panels manufactured in France but little data is available for panels made in China.

Save Our Surroundings (SOS) has developed a methodology that compares French made panels to Chinese made panels in terms of the time it takes to produce enough electricity to offset the embedded CO₂e in each panel.

The payback period for offsetting embedded CO₂e in PV solar panels made in France is 1.5 - 2.5 years. The payback period for offsetting embedded CO₂e in PV solar panels made in China is 8.6 - 14.3 years. The range of the payback periods results from the latitude at which the panels are installed.

This significant difference in payback periods has substantial implications for the "clean" claims of proponents of industrial PV solar electricity generating works that install panels made in China.

The total embedded CO₂e of industrial PV solar works is all up front, unlike fossil fuel CO₂e emissions, which are released slowly over a 50 years or more life-time. Thus, from where PV solar panels are sourced is vital to achieving global CO₂e reductions. Solar panels, and other components, sourced from China will increase global CO₂ emissions. This is counter to the objectives of our Australian governments to reduce greenhouse gas emissions.

The evaluation of all industrial PV solar works proposals must include assessment of the likelihood that the project will actually substantially increase CO₂e emissions that may never be offset over its operational life-time and upon decommissioning, disposal and land rehabilitation.

A moratorium must be called on installing anymore solar works projects in Australia until a thorough understanding of the true impact on global emissions from PV solar panels are known.

Background

- There are many types of photovoltaic (PV) solar panels, all of which require substantial quantities of energy to produce, especially the silicon (Si) ingots from which silicon-wafers are made. [1]
- Si-wafer- based PV technology accounted for more than 95% of the total production in 2021. The share of mono-crystalline technology is about 84%, and growing, of total c-Si production. Multi-silicon PV panels accounted for 11% and thin film 5%. [2]

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- Fifty percent of a silicon ingot is lost when being cut into wafers for mono-crystalline solar panels. This loss is excluded from embedded CO₂e in solar panels. [1]
- The research that has been done suggests an Industrial PV solar electricity generating works takes ten years or more of electricity generation to offset its energy consumed in its construction, [p] but this was based on the use of mainly European or American manufactured panels [p] ???
- Recent research suggests even the standard greenhouse gas emissions (carbon dioxide equivalents or CO₂e) figures for PV solar panels quoted by the IPCC and IEA are understated by a factor of at least three. [5]
- Europe (1%) and North America (3%) only manufactured about 4% of the world's PV solar panels in 2021. Asia is now increasingly the primary source of PV solar panels, with China providing at least 80% of all PV solar panels.[2]
- 90% or more of PV solar panels (industrial and rooftop) imported into Australia are manufactured in China. [6]
- French legislation requires solar panels manufactured in France to specify the carbon footprint (embedded carbon dioxide equivalents or CO₂e) payback period of the solar panel. [7]
- Dualsun, a French company that manufactures PV solar panels in France, has stated that its PV solar panels, excluding the aluminium frame, have a payback period of 1.5 - 2.5 years depending on whether it is installed in Spain or Northern Europe, which is "very good, among the best in the world" it says. [8]
- The latitude of Southern Spain (37) in the Northern hemisphere is similar to that in the Southern hemisphere of Victoria (-38) and South Australia (-35). Gulgong NSW (-32) in the Central West Renewable Energy Zone is a similar latitude to Dallas Texas (32).
- The aluminium frame of a Dualsun 2.1m by 1.1m, 26kg, ECS value 510kg CO₂/KWc-e, FLASH 500W PERC monocrystalline PV solar panel weighs about 2 kilograms with an embedded CO₂e emissions of 16.2kg, which brings the total CO₂e embedded in the 500W framed panel to 271.2kg. [9]
- France's power generation mix in 2022 was 11% fossil fuel electricity production. [10]
- China's power generation mix in 2022 was 63% fossil fuel electricity production. [11]. By comparison, Australia's NEM grid was 66.6% fossil fuels generation at 30/06/23. [12]

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- Little information exists on Chinese manufactured PV solar panels and their carbon footprint. [5]
- China is by far the biggest emitter of greenhouse gases and currently generates about 31% of human-induced emissions, which is growing each year. [14]
- The CO₂e emissions embedded in Chinese manufactured PV solar panels is therefore of great importance to our understanding of the CO₂e payback period and whether they aid or hinder Australia's target of net zero emissions by 2050.
- The claimed life of an industrial PV solar works is usually about 20 - 25 years with a US study arriving at 21 years average economic life for decommissioned solar works. [4]
- PV solar panels have efficiencies ranging from 6% to the mid 20s% ex factory. [1] However, this efficiency drops by 2% on installation and declines linearly from 98% to 84.5% over 25 years. This will increase the payback period to offset the embedded CO₂ in the panel. [14]
- Apart from a PV solar panel's degradation with age it also drops about 0.5% in efficiency per degree as temperatures rise above 25 degrees Celsius. This will increase the payback period to offset the embedded CO₂ in the panel. [1]
- Save Our Surroundings has developed a methodology as presented below to determine a payback period for PV solar panels manufactured in China by using a French made solar panel as the base case and then relating the relative fossil fuel power generation of France and China in full year 2022.

The method

Inputs:

- Dualsun's payback periods of 1.5 - 2.5 years for a monocrystalline panel .[8]
- France's 11% power generation from fossil fuels in 2022. [10]
- China's 63% power generation from fossil fuels in 2022. [11]

Assumptions:

- The solar panel is of the same type and manufacturing process in both France and China.
- The energy input is the same with the only difference being the proportion of the energy generated from fossil fuels in each country.
- No aluminium frame is included.
- No loss of the 50% of a silicon ingot is attributed to a PV solar panel i.e. the embedded CO₂e of the lost ingot material is not included in the CO₂e footprint of a PV solar panel.

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- The payback period only relates to the solar panel before framing, packing and shipping from the factory.
- No allowance for the 0.5 - 0.8% annual decline in efficiency of installed PV solar panels or the reduced output due to temperature, weather or fire damage, maintenance downtime, etc. which reduces electricity production over time. [p]
- No allowance for all the embedded CO₂e in the other necessary components, infrastructure and services needed before commissioning of a PV solar works can occur.
- Little change is expected in the power generation mixes of France and China in the next decade or two. However, France has announced it will be building more nuclear power plants and China has indicated it will continue to rapidly increase adding coal-fired power plants. [p]
- No consideration of the non-equivalence of Solar Works capacity compared with base-load power plants. For example, a 200MW nameplate capacity Solar Works is equivalent to a 28MW base-load plant in terms of life-time electricity generation. SOS has developed a formula where Capacity equivalence $C_e = \text{solar works (capacity X capacity factor X claimed life)} / \text{base-load (capacity factor X economic life)}$. e.g. for a 200MW solar (or wind) works $C_e = (200 \times 25\% \times 25 \text{ years}) / (90\% \times 50 \text{ years}) = 27.8\text{MW}$. C_e will be even lower if solar panel degradation, solar works likely economic life and intermittency were taken into account.

Calculation of CO₂e Payback of Chinese made solar panels:

- **Formula:** France's payback years multiplied by (China's fossil fuel percentage divided by France's fossil fuel percentage)
- **Ex-factory payback case 1.5 years:** $1.5 \times (63\%/11\%) = 1.5 \times 5.727 = 8.6 \text{ years}$
- **Ex-factory payback case 2.5 years:** $2.5 \times (63\%/11\%) = 2.5 \times 5.727 = 14.3 \text{ years}$
- **Ex-factory average payback case 2.0 years:** $2.0 \times (63\%/11\%) = 2.0 \times 5.727 = 11.6 \text{ years}$

Conclusion

- Just the PV solar panels made in China before leaving the factory have upfront embedded CO₂e (carbon footprint or embedded greenhouse gas emissions) of between 8.6 years case and 14.3 years case, based on 2022 energy generation mixes of France and China. This is a significant result. In addition, very substantial embedded CO₂e emissions will occur in up to commissioning a solar works project. Not just the PV solar panel payback but all the embedded CO₂e in the rest of the project must be offset from the electricity generated by only the solar panels. This is unlikely to occur.
- The claimed life of an industrial PV solar works is about 20 - 25 years with a US study arriving at 21 years average economic life for decommissioned solar works. Therefore, it is unlikely when all embedded CO₂e is fully accounted for at the time of commissioning of an industrial PV solar works can ever be offset, especially as Australia's fossil fuel electricity generating plant fleet output is falling. Lower fossil fuel output results in longer payback times for each

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new solar and wind works project.

- The total embedded CO₂e of industrial PV solar works is all up front, unlike fossil fuel CO₂e emissions, which are released slowly over a 50 years or more life-time. Thus, from where PV solar panels are sourced is vital to achieving global CO₂e reductions. Solar panels, and other components, sourced from China will increase global CO₂ emissions. This is counter to the objectives of our Australian governments to reduce greenhouse emissions.
- The evaluation of all industrial PV solar works proposals must include assessment of the likelihood that the project will actually substantially increase CO₂e emissions that may never be offset over its operational life-time and upon decommissioning, disposal and land rehabilitation.
- A moratorium must be called on installing anymore solar works projects in Australia until a thorough understanding of the true impact on global emissions from PV solar panels are known. Comparisons must be made against the modern alternatives of High efficiency Low Emissions (HELE), Combined Cycle Gas Turbine (CCGT) and nuclear power plants, including small nuclear reactors (SMR).

References

- [1] [Comprehensive Guide to Solar Panel Types | Aurora Solar](#) 2021; easy to understand descriptions of PV solar panels types and features; a lot of silicon is wasted to produce one monocrystalline cell, sometimes reaching over 50%; panel efficiencies 6 -25%; LID degradation 1 - 3%
- [2] [Photovoltaics Report \(fraunhofer.de\)](#) ©Fraunhofer ISE: Photovoltaics Report, updated: 21 February 2023; In 2021 producers from Asia count for 94% of total c-Si PV module production. China (mainland) holds the lead with a share of 75%. Europe contributed with a share of 1%; USA/CAN with 3%; Si-wafer based PV technology accounted for more than 95% of the total production in 2021. The share of monocrystalline technology is about 84% of total c-Si production
- [3] [By the numbers: China's net-zero ambitions \(nature.com\)](#) 05042022; China's emissions 31% for 2020, USA 14%; EU + UK 8%; India 7%; rest of world 40%; China's electricity energy generation was >80% dependent on fossil fuels in 2020 (34TWh v 40TWh total)
- [4] [Energy intensities, EROIs \(energy returned on invested\), and energy payback times of electricity generating power plants - ScienceDirect](#) G Ruprecht, etal, 1 April 2013
- [5] [Solar Panels Are Three Times More Carbon-Intensive Than IPCC Claims \(substack.com\)](#) C.P. Colum and Lea Booth 24/07/2023; a report published by Public in collaboration with Environmental Progress and The Blind Spot; lack of Chinese data on carbon footprint of the 97% of Si-wafers they produce and 80% of all solar panels); Marutti's 'calculation put it at between 170 and 250g of carbon dioxide per kilowatt hour (kWh), as opposed to the official estimate from the Intergovernmental Panel on Climate Change (IPCC) of 20-40g per kWh. Way off.'
- [6] [Australia relies on China for 90 per cent of solar panel imports | news.com.au — Australia's leading news site](#) 25 Nov 2021
- [7] [The weekend read: Playing by the carbon footprint rules – pv magazine International \(pv-magazine.com\)](#) EmilianoBellini 27/04/2019; France's CRE4 low carbon regulations require a carbon assessment of less than a certain limit of kg CO₂/kW for solar panels.
- [8] [The environmental impact of solar panels \(dualsun.com\)](#) Dualsun 26/03/20; "There is general consensus that it takes an average of **1.5 to 2.5** years for a photovoltaic system to generate as much energy as was used to manufacture it. Any variations depend on the amount of sunshine absorbed, and therefore the location of the installation." "The results of the evaluation demonstrate that our hybrid panel emits **435.3 kgCO₂ per kWp** (value for the 1st generation DualSun hybrid panel)."
- [9] [DualSun - EN - Datasheet FLASH 500 Half-Cut Black - v1.14](#) 500W industrial 2.094m x 1.134m x 35mm; 26kg, PERC mono-crystalline; frame black anodised AL; ECS value 510kg CO₂e/KWc-e (Capacity); minimum efficiency 20.8% but declines 2% first year and down to 84.8% after 25 years
- [10] [France: electricity produced share by source 2022 | Statista](#) Distribution of electricity production in France in 2022, by energy source. Nuclear 63%. Hydro 11%, Gas 10%, Wind 9%, Solar 4%, waste 2%, other fossil 1%. Total fossil fuel 11%.
- [11] [China: electricity generation share by source 2022 | Statista](#) Distribution of electricity production in China in 2022, by energy source. Fossil Fuel 63%, Nuclear 5%, Rest 32% as have to pay for full detail.
- [12] [Generation capacity and output by fuel source - NEM | Australian Energy Regulator \(AER\)](#) AER 18/10/23; as at 30/06/23 % MW/MWh Black coal 27.5/44.5, Brown coal 8/17.1, Gas 15.8/5, (total fossils 51.3/66.6), Hydro 14.1/10.2, Wind 16.3/15.3, Grid solar 13.8/7, Battery 2.1/0.5 (total wind, solar. battery 32.2/22.8), Others 2.4/0.4.

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[13] [Australia relies on China for 90 per cent of solar panel imports | news.com.au — Australia's leading news site](#)

[14] [450 Solar Panel, 450 Watt Solar Panel Specifications | INLUX Solar](#) 2.1m by 1.0 25.5kg 450W mono perc solar panel. Chart showing efficiency drop of 2% year 1, and linear 0.61% over 25 years down to 84.8% (98% to 84.8% = 0.53% degradation). Harsh environment test does not include temperatures. Anodised Aluminium alloy frame used.