New South Wales Government
Independent Planning Commission

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Please refer to the attached submission and related attachments

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]

Chinese Manufactured PV Solar Panels Increase GHG Emissions

- 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 manufacturers 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]

- 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 monochrystalline 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.

- 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 Ce = solar works (capacity X capacity factor X claimed life)/ base-load (capacity factor X economic life). e.g. for a 200MW solar (or wind) works Ce = (200 x 25% x 25 years)/ (90% x 50 years) = 27.8MW. Ce 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 x (63%/11%) = 1.5 x 5.727 = **8.6 years**
- **Ex-factory payback case 2.5 years:** 2.5 x (63%/11%) = 2.5 x 5.727 = **14.3 years**
- **Ex-factory average payback case 2.0 years:** 2.0 x (63%/11%) = 2.0 x 5.727 = **11.6 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

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.

[**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.

Save Our Surroundings (SOS) submission to the IPCN on the Middlebrook Solar Works and BESS proposals, SSD-10455

Contents

Background

Save Our Surroundings (SOS) wish to express our disappointment with the IPCN evaluation of the wind, solar and BESS projects approved by the IPCN so far. Despite the evidence you have been provided from multiple sources that the Proponents and the Department ignore the relevant omissions, make unsubstantiated claims, and make misleading and incorrect statements. The Department never-the-less makes assertions that the project is "in the public interest and approvable." The Conditions of Consent rarely or adequately address all the issues.

For example, the Amendment report (1.4 Proposed Amendments) for the stand alone Colembally BESS stated, *"In addition and as a result of the submission from Save our Surroundings, output calculations were checked and refined. The annual output of the proposal was wrongly calculated at 380,000 MWh if calculated in one charge/discharge per day. This has now been updated to 146,000 MWh."* The Department approved the project despite the implications the "error" has for the project's viability, AEMO planning, etc.

SOS has frequently highlighted "errors", omissions, and non-factual claims in project proposals that are not rectified yet the projects get recommended and approved anyway. Approvals which defy engineering, economics and physics reality as well as real world evidence and experiences.

It was reported recently that electricity prices have risen substantially and Australia's (also global) emissions have also risen over the last two years. SOS has been saying for years that this would happen because wind turbines, solar panels, batteries, EVs, supporting infrastructure are mainly made in China, the world' highest emissions country. Coal, gas and nuclear electricity generation are engineered to operate at full capacity 24/7 and for 60 years or more whereas wind, solar and hydro generators are not and on average are idle more than 70% of their short lifetime of 20 to 25 years. A poor and unsustainable use of

resources. Industrial BESS batteries last under 14 years if only charged/discharged once daily.

Yet embedded greenhouse emissions in Ruinables (solar, wind, BESS) are ignored. Also ignored is that Ruinables: drive up electricity prices; invariably destroy environments, habitat and wildlife; contravene Article 2b of the Paris agreement; create **increased** fire risks; cause social upheaval and disharmony; create enormous amounts of waste, much of it toxic that goes to landfill; pollute environments; are weather vulnerable; are unreliable generators; rapidly lose efficiency; complicate grid management; require huge tax payer subsidies (refer Appendix B) and favourable terms of operation; damage the economy; require frequent replacement; are weather vulnerable; have no social licence; etc.

The Middlebrook solar and BESS proposal will exacerbate the foregoing issues and other negative issues which SOS has raised many times previously. Refer to Appendix C for suggested changes required to properly assess renewables projects and conditions that should be applied should approval be justified.

Save Our Surroundings (SOS) and Save Our Surroundings Central West NSW wrote in its first research paper **"Wind and Solar Electricity Generation are the Answer. Seriously? November 2020" facts and conclusions that all proved true four years later as both from Australian and overseas experiences and further supporting evidence has materialised.**

Following is an extract from the SOS November 2020 paper, which involved many thousands of hours of research and inputs from around the world.

Extracts from SOS Research paper November 2020

The significant conclusions drawn from our research into weather-dependent wind and solar electricity generation, including the required backup using batteries and biomass, are that:

- *Australian governments cannot achieve their stated objectives of reducing global temperatures, significantly reducing electricity prices and creating substantial numbers of jobs: no state or country with a large proportion of wind and solar in their electricity generation mix has achieved these objectives.*

- *The risks to the safety of people and the damage to the environment are substantial and are being ignored: risks include life-cycle toxicity, fires, loss of productive farmland, pollution of the environment and abuses of people in developing countries, including children; globally, 82% of mining areas are now targeted to extract raw materials for "renewables".*

- *Resources are being misallocated: up to ten times more resources are needed for intermittent weather-dependent renewables than for alternatives such as reliable base-load modern gas or nuclear generators; subsidies and favourable policies for renewables distort the market place for energy generation.*

- *The public are not being told about the many negative aspects of weather-dependent electricity generation or are being mislead about the benefits; even so the public and community groups have rejected the case for excessive renewables several times already but our politicians continue to ignore the majority decisions by the voters.*

This paper presents many of our research findings in the hope that it will highlight folly of the Federal and State governments' policies in promoting and subsidising solar and wind electricity generating works at the expense of much better modern alternatives, such as HELE coal-fired power plants, combined closed cycle natural gas turbines and nuclear reactor electricity generation, which are all much less harmful to the global environment.

The two policy drivers promoted by governments to extensively change the methods of electricity production in Australia are:
(1) to lower carbon dioxide emissions to reduce Earth's projected temperature increases, and
(2) to provide a very low cost electricity supply so as to:

a) increase economic activity;
b) create sufficient jobs for an increasing population;
c) mitigate the impacts of the COVID-19 on Australia's economy, which resulted in an unacceptable unemployment rate.

First, some definitions:
It is important that the reader understand the terms and acronyms used when discussing electrical energy. For instance, a photovoltaic (PV) solar Industrial Electricity Generating Works (IEGW) with a rated capacity of 400 megawatts (MW) produces less than the third of the electricity over a year than does a modern closed cycle gas turbine (CCGT) power plant or nuclear reactor. The electricity output of a power plant is described as megawatt hours (MWh). More detailed definitions are shown at Appendix B.

Second, some basic facts:

- *It is estimated from IPCC data that human-induced carbon dioxide (CO2) from all sources, not just electricity generation, is **3%** of the small amount of the CO2 in the atmosphere. Australia is responsible for about **0.039%** (i.e. 1.3% of the 3%**)** of human-induced amount of total global emissions of carbon dioxide (generally stated as the main driver of global warming) and by signing the Paris Climate Agreement has undertaken to reduce its human related carbon dioxide emissions over time*

  *However, Australia's Chief Scientist of Australia, Dr Finkel, told the Senate in June 2017 that if Australia reduced its **total** carbon emissions to **zero**, that it would do **virtually nothing to reduce global temperatures.***

  *Thus, Australia's policies on emissions reductions should be based on logic and practicality. For Australia, electricity consumption is about **39%** of our total energy consumption, i.e. much less than half of our total CO2 emissions. Restructuring our electricity system can have no affect on our climate.*

  There is no justification for spending multi-billions of dollars every year in direct and indirect subsidies for no climate benefit, yet causing higher electricity bills, increasing hardship to Australians, damage to our economy and wide-scale damage to our environment, both in Australia and overseas.
  [ref: https://www.facebook.com/SenatorIanMacdonald/videos/1343186319100574/; IPCC AR4 2007]

- *Every country, such as Australia, Germany and Denmark or state, such as California and South Australia, that have significantly introduced solar and wind technologies into their electricity generation mix have not only significantly increased their electricity prices but also destabilised their electricity grids, which leads to more expenditure on 100% backup, extension of transmission lines and more difficult grid management.*

Doing more of the same thing (i.e. increasing the percentage of weather-dependent renewables) and expecting a different result is totally illogical.
[ref: afr.com 5/8/17 "MarkIntell, US Energy Information Administration"]

- *The NSW Government in November 2019 declared the Central-West a Renewable Energy Zone (C-W REZ), which will be a **3,000MW** installed capacity pilot for two other NSW Renewable Energy Zones. The NSW Electricity Strategy states it aims are to provide low cost electricity to consumers and provide a stable and reliable energy system, while achieving a net-zero emissions target by 2050. "For households, the Strategy will lead to estimated bill savings of **$40 per year** " by **2040**. Really?*

  *The current average residential bills are: **18-29yo $1906**; **60syo $1458**. We need to reduce electricity bills by **half or more not a miniscule $40 or even $130 in 20 years' time**. No country or state so far has been able to have a high percentage of renewables in their electricity system mix and still provide cheaper electricity or even a stable or reliable supply. Australians already support renewables through direct and indirect subsidies and other means to the tune of **$1300pa** per household, amounting to over **$13 billion** nationally each year.*

  Use of the renewables subsidies to build two or three modern long-life HELE coal-fired (China, India, Japan and others are building more right now) or combined-cycle gas fired and/or nuclear plant (50 nuclear reactors are globally under construction right now) and the average electricity bills will drop by meaningful amounts within in a few years.
  [ref: https://energy.nsw.gov.au/media/1921/ " NSW Electricity Strategy"; afr.com 5/8/17 "MarkIntell, US Energy Information Administration"; afr.com 5/8/17 "MarkIntell, US Energy Information Administration"; 23/08/20 Report by Dr Moran "The Hidden Cost of Renewables on Electricity Prices"; ddears.com/2020/07/14/dont-ignore-coal/ ; world-nuclear.org/information-library/current-and-future-generation/plans-for-new-reactors-worldwide.aspx' Daily Telegraph p2 9/11/20 "Road to cheaper and cleaner power in NSW"]

- *Two of the biggest emitters of CO2 in 2018 were China (**27.8%**) and India (**7.3%**) who, under the Paris Climate Agreement, can continue to increase their emissions for several more decades. The USA, while the second biggest CO2 emitter in 2018 (**15.2%**) has reduced its emissions by **12.1%** since Kyoto Protocol commenced in 2005, largely by significantly increasing gas for electricity generation instead of using coal. In 2019 China's emissions rose despite a slower economy, increased renewables and the full-year operation of seven large-scale nuclear reactors.*
  Australia can have no practical effect in reducing global CO2 emissions.
  [ref: "2019 BP Statistical Review of World Energy"; Paris Agreement targets; iea.org/articles/global-co2-emissions-in-2019 ; https://www.facebook.com/SenatorIanMacdonald/videos/1343186319100574/;]

- *Germany and Denmark are regarded as world leaders in transitioning to renewable energy electricity generation, yet in 2019 Germany had the highest electricity prices (**US$0.381/KWh**) in the world with Denmark second (**US$0.361/KWh**), despite their massive shift to renewables at **46.5%** and **63%** respectively; the world average electricity price in 2019 was **US$0.14/KWh** , Australia was **US$0.242** and, China and India, who generate most of their electricity from using coal, were each **US$0.08/KWh**.*
  The evidence is clear: the more weather-dependent renewables there are the greater the increase the overall cost of electricity supply. How can Australia be competitive when our electricity cost three times more than our competition?
  [ref: globalpetrolprices.com "Electricity prices for households, December 2019".]

- *For energy generation, wind is an ancient technology and solar cells (invented in 1883 by C Fritz) and the first viable solar panel developed by Bell Laboratories in 1953, are both dilute*

inefficient and inconsistent forms of energy conversion. The energy density (amount of energy in mega-joules [Mj] released per kg) of different fuels in increasing order is wood (16Mj/kg), coal (24), oil (45), natural gas(55) and nuclear (3,900,000). The higher the energy density the lower the total demand on all resources and the higher the efficiency in producing electricity. A mega-joule is equivalent to 0.278KWh of energy.
Logically, natural gas and zero emissions nuclear are the preferred fuels at this time.
[ref: understandsolar.com "Who invented solar panels?"; energyeducation.ca/encyclopedia/energy_density]

- *A study of Germany's electricity generation found that over their operating life solar and wind have very low energy output compared to the energy used to make and install them. The energy generated by nuclear, hydro, wind and solar was, respectively,* ***75, 35, 3.9*** *and* ***1.6*** *times greater than the energy required to make them. Wind and solar provide a poor return on an energy in/energy out basis compared with other methods.*
  Logically, nuclear energy should be preferred as it gives the best energy result.
  [ref: 30/6/20 M Shellenberger "Apocalypse Never" p192]

- *Australia is the only country of the top 20 developed countries and the top 'developing' countries (China, India) that do not depend on zero-emissions nuclear power for part of their electricity generation. There are currently about* ***50*** *nuclear power reactors under construction, mainly in China, India, Russia and UAE.*
  Australia is being left behind due to its illogical and damaging ban on nuclear energy.
  [ref: World Nuclear Association "Plans for New Reactors Worldwide" September 2020]

- *California at the end of 2019 had 13 in-state sources of electricity (excludes over 30% imported from interstate); installed capacity (MW) was PV solar* ***14.1%****, wind* ***7.5%****, natural gas* ***50.6%,*** *nuclear* ***3%****, hydro* ***17.6%,*** *others* ***7.2%.*** *California, America's most populous state, is among the most expensive states for electricity and its electricity prices have increased at five times the average rate of the rest of the USA as they move each year to higher percentages of "renewables" and elimination of fossil fuels and nuclear power sources.*
  Again, gas and nuclear should be the preferred power sources for Australia, especially as they do not involve major changes to the electricity grid or place huge demands on scarce resources as do weather-dependent renewables.
  [ref : 2001-2019 www.energy.ca.gov "Electric Generation Capacity and Energy"]

Various updates to our research paper have taken place. The last one in November 2022. Just as the first was paper is still valid the last paper just expands the supporting evidence.

Middlebrook Solar and BESS Proposal

Save Our Surroundings opposes consent of this proposed project on numerous grounds which make it 'not fit for purpose'. That is, it does not satisfy the key assessment considerations stated by the DPHI in its Assessment report. These considerations being "...energy security, land use compatibility, transport, social and visual amenity."

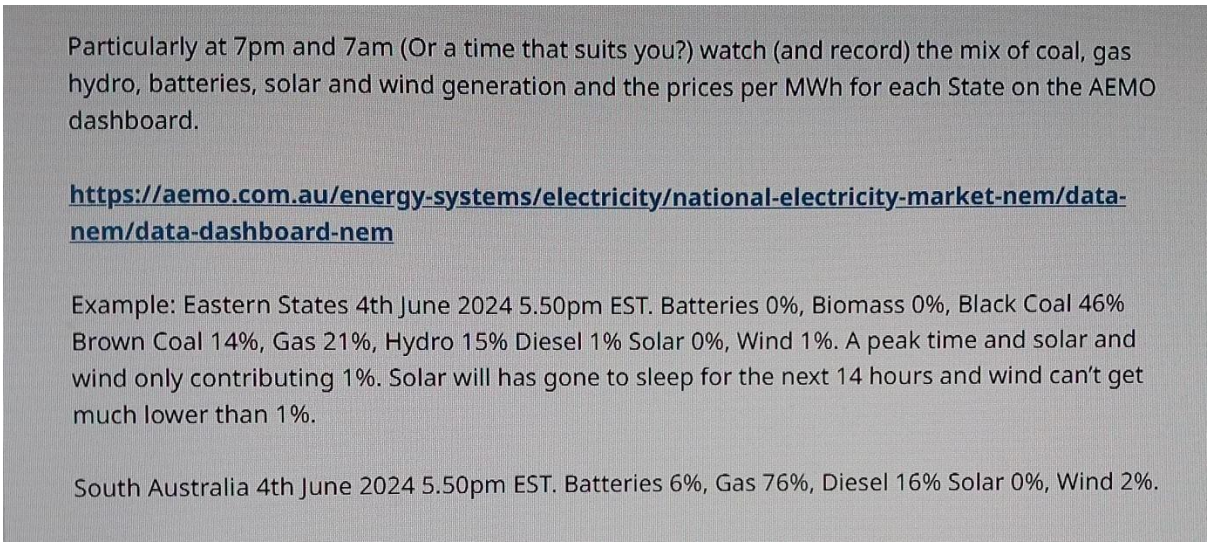
In addition, the project and recommendations ignore a huge number of relevant negative issues that this project would create, but which the Assessment Report largely or completely ignores, such as:

- increased emissions;
- increased power prices for consumers;
- a change the character of the landscape;

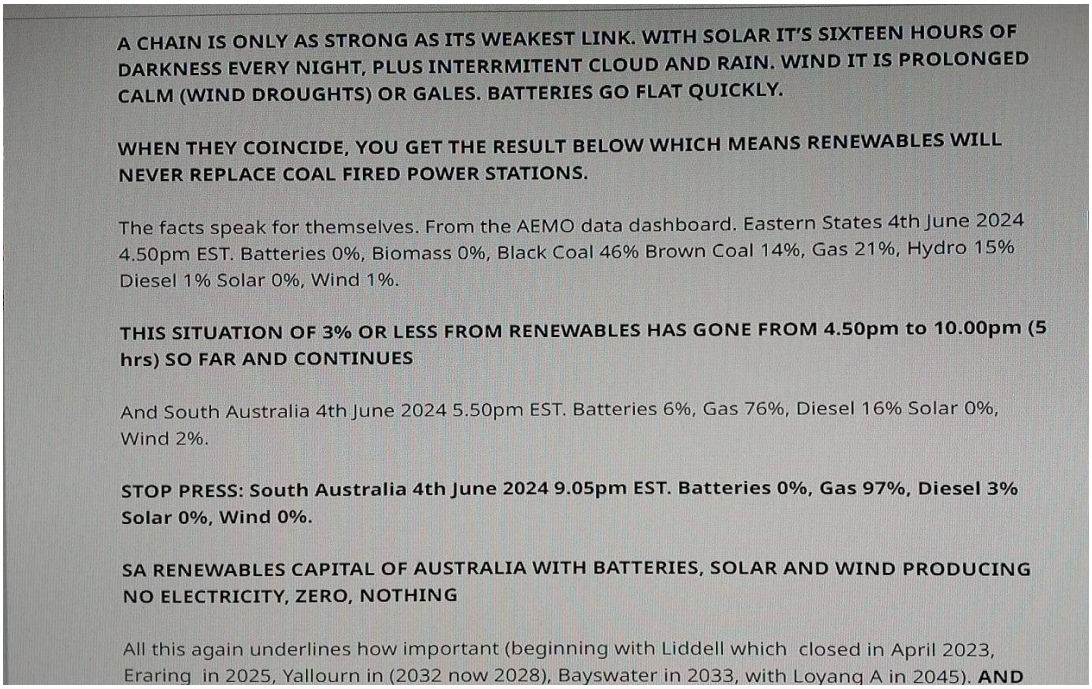
- degradation of the land;
- a breach of the Paris Agreement;
- wildlife impacts;
- increased fire risks;
- facilitation of the use of slave labour;
- decreased grid stability;
- excessive material requirements;
- increase in grid vulnerability;
- not having social licence or community consent to proceed;
- inconsistency with similar projects;
- a poor use of resources;
- huge amounts of waste;
- low Australian content;
- the extent of subsidies provided;
- end of life impacts
- ignoring real life experiences with existing similar projects;
- negative cumulative impacts.

The above will be addressed in this submission, but first a simple factual example, which is one of many, taken from the AEMO's website dashboard and provided by John Moore on change.org.

On 4th June 2024 at the peak demand period for power from the NEM grid only 1% was generated by solar, wind, and batteries, which are currently well over 32% of the capacity of the National Energy Market (NEM). So much for the AEMO's claim that "a mix of solar and wind is needed, and they offer complimentary daily and seasonal profiles."



On the 4th June 2024 from 5.50pm EST to 9:05pm EST, South Australia, which has over 60% wind and solar capacity and big batteries, went from providing energy from batteries 6%, solar 0% and wind 2% to zero supply from its "renewables" capacity in under three hours!



A CHAIN IS ONLY AS STRONG AS ITS WEAKEST LINK. WITH SOLAR IT'S SIXTEEN HOURS OF DARKNESS EVERY NIGHT, PLUS INTERRMITENT CLOUD AND RAIN. WIND IT IS PROLONGED CALM (WIND DROUGHTS) OR GALES. BATTERIES GO FLAT QUICKLY.

WHEN THEY COINCIDE, YOU GET THE RESULT BELOW WHICH MEANS RENEWABLES WILL NEVER REPLACE COAL FIRED POWER STATIONS.

The facts speak for themselves. From the AEMO data dashboard. Eastern States 4th June 2024 4.50pm EST. Batteries 0%, Biomass 0%, Black Coal 46% Brown Coal 14%, Gas 21%, Hydro 15% Diesel 1% Solar 0%, Wind 1%.

THIS SITUATION OF 3% OR LESS FROM RENEWABLES HAS GONE FROM 4.50pm to 10.00pm (5 hrs) SO FAR AND CONTINUES

And South Australia 4th June 2024 5.50pm EST. Batteries 6%, Gas 76%, Diesel 16% Solar 0%, Wind 2%.

STOP PRESS: South Australia 4th June 2024 9.05pm EST. Batteries 0%, Gas 97%, Diesel 3% Solar 0%, Wind 0%.

SA RENEWABLES CAPITAL OF AUSTRALIA WITH BATTERIES, SOLAR AND WIND PRODUCING NO ELECTRICITY, ZERO, NOTHING

All this again underlines how important (beginning with Liddell which closed in April 2023, Eraring in 2025, Yallourn in (2032 now 2028), Bayswater in 2033, with Loyang A in 2045). **AND**

How much more evidence does the DPHI and the IPCN need to reject the applicant's erroneous claims, and repeated by the DPHI, that the project will:

- replace the output of retiring coal-fired power stations (non-equivalence of capacities)
- increase the reliability of the grid (exact opposite, no power at times, unreliable source)
- provide cheaper electricity (massive increases to date with more to come)
- provide energy security (intermittent weather dependent can never by secure, nor can sourcing most of the components from one unreliable source)
- be in the public interest (e.g. increased cost of energy, business failures, companies moving overseas, $b increased government debt and interest costs from subsidies, net job losses; increased emissions, intergenerational inequality, social upheaval, reduced food production, environmental damage).

But even more factual evidence is available, most of it from experts in their field. The IPC panel heard some of these experts at the Middlebrook public meeting. Yet neither the DPHI or the Applicant responded to those presentations. Their summing up just ignored every speaker, just as they repeatedly ignore factual objecting submissions, except for their preferred few topics for which they have stock answers and conditions ready.

Each negative point referred to earlier is only presented in brief form in table 1 below. They are not all the issues that we could have included. There are many research papers, scientific papers, books, documentaries, manufacturer's specifications and documents, government information, legal cases, media articles, data from applicants, etc. to support these negative impacts. The IPC must make themselves familiar with such works to be in a position to properly assess solar, wind and BESS projects.

Our concerns are that the DPHI and the IPCN are still too inexperienced in assessing solar, wind and BESS proposals and just rely far too heavily on the marketing statements of the Applicants, even when misleading statements are made and obvious errors, inconsistencies and omissions occur. One

SOS submission to the IPCN on the Middlebrook Solar Works and BESS proposals

DPIE Project Contact once told SOS that they do not have the resources to investigate claims contained in objecting submissions. This shows a serious flaw in the planning evaluation and approval process. The lack of analysis and comparisons by the now DPHI is unacceptable given the importance of energy to all Australians and the negative consequences of their recommendations.

Table 1 Summary of some of the unsatisfactorily addressed negative issues

#	Issue	Points	Comment
1	increased emissions	Embedded GHG upfront; ignores long payback time of just the panels let alone all the direct & indirect emissions from supporting infrastructure; use of fossil fuels from grid use; emissions from maintenance operations; vegetation removal & burn offs; no substantiation of CO2e reduction claims, project output or claimed economic life; Australia's total anthropogenic emissions reductions will have negligible effect on climate.	SOS papers previously supplied to IPCN. Australia's GHG emissions are about 1% of the 3% of anthropogenic contribution to the global atmosphere. 2017 Chief Scientist statement to senate enquiry.
2	increased power prices for consumers	Solar works are idle at least 75% of their short lifetime; actual consumer power prices have outstripped CPI for a decade; no jurisdiction in the world with over 30% of wind & solar have cheap electricity; 61% increase in small business failures already in 2024; massive increase in consumers unable to pay their electricity bills.	Actual capacity factors & degradation rates. SA has Australia's highest power prices with 60% renewables capacity; gov't handouts to compensate for failed achievement of actual reductions
3	a change the character of the landscape	Rural character reduced; A BESS is not an approved structure on RU1 land as it not an electricity generation works; cumulative impacts of closeness of similar projects; DPEI dismisses impact on landscape character	Land & Environment Court ruling on Burrundulla Solar & definition of visual amenity vs landscape character
4	degradation of the land	Erosion; soil contamination; soil salinity increased; increased compaction; water diversion to neighbours; no soil improvement activities	Per expert & land holder presentations at IPC public meeting. Solar panels are e-waste in Victoria & EU
5	a breach of the Paris Agreement	Food production should not be impacted; proposed animal grazing is not a significant offset to lost production of the original site; "Article 2.1(b)... in a manner that does not threaten food production;"	A presentation at IPCN public meeting.
6	wildlife impacts	Fully fenced site hindering wildlife movement, foraging, etc.; elimination of dams; koalas & other animals threatened as noise (from construction & operation) is known to drive fauna away from traditional habitats or prevent movement into new areas	CSIRO research papers re impact of noise on animals
7	increased fire risks	Solar work & BESS fires already occur in Australia; RFS volunteer numbers are falling; numerous out-of-control fires have and will continue to occur ; firefighters will not enter a burning solar works, 20,000L onsite water take is totally inadequate	SOS papers previously supplied to IPCN. A presentation at IPCN meeting. Expert fire consultants advice
8	facilitation of the use of slave labour	Most components are made in China and slave labour is largely involved in China & the DRC. Over 90% of PV solar panels and most of a BESS is made in China. Virtually untraceable.	Expert presentation at IPC meeting. SOS papers previously supplied to IPCN. UN studies.
9	decreased grid	The NEM has become more & more unstable as more wind & solar works are added to the grid;	AEMO statements; NSW Gov't extending life of

#	Issue	Points	Comment
	stability	AEMO increased use of emergency powers to curb demand; NEM is already very near the tipping point when blackouts will be unavoidable	Eraring; AEMO dashboard (e.g. for 4/6/24)
10	excessive material requirements	The life-time weight of materials per MWh generated for just the solar panels and steel supports far exceeds that of a fully functioning modern lower emissions HELE, CGCT & nuclear power plant	SOS papers previously supplied to IPCN
11	increase in grid vulnerability	Fires, hail damage, heavy rain & lightning strikes have reduced the output of solar works; component failures & inability to regulate output have restricted some solar works. Extreme temperature fluctuations such as across the region (-5C to high 40C) impacts efficiency of solar panels and batteries; crowding of so many solar & wind works into REZ's and elsewhere will potentially knock out multiple works when a big disaster ultimately occurs.	Not just weather dependent but weather vulnerable. Also a national security risk
12	not having social licence or community consent to proceed	Over 93% objections from the communities for the proposal. Nearly all such proposals across Australia have had similar results.	Why are the impacted people being ignored?
13	inconsistency with similar projects	Proposed PV solar & BESS projects using the same technology to produce a single standard product (AC electricity) have widely varying lives, outputs, footprints, vehicle movements, emission reductions yet no apparent comparisons are made or required.	Every project has unjustified claims, which SOS & others often challenges to no effect.
14	a poor use of resources	Compared to modern alternatives the massive footprint per MW of capacity and huge amount of land & materials consumed and wasted to produce a MWh of energy is unsustainable; the billions of dollars in subsidies & other benefits to solar and wind developers increases the debts of governments and places a great burden on future generations; reduction in food production will impact current & future generations, both in Australia and overseas consumers of our produce.	SOS papers previously supplied to IPCN and again shown as Attachments to this submission.
15	huge amounts of waste	Hundreds of thousands of solar panels & hundreds of tonnes of batteries - the waste from this project will be significant from start to finish let alone the cumulative waste of multiple projects & an influx of out of town construction workers within kms of the small local town.	Virtually no local employment involved but local jobs will be lost. IPA report.
16	low Australian content	The Australian content of these massively expensive projects, which sit idle most of their life, has been estimated at between 12 and 15%	NREL report. SOS papers previously supplied to IPCN.
17	the extent of subsidies provided	No skin in the game then no responsibility; the applicant gladly takes the taxpayers' money through subsidies & higher electricity prices but has no willingness to post a bond for when decommissioning, rehabilitation & disposal occurs in a couple of decades.	SOS papers previously supplied to IPCN. Recent estimate is already $15.6 billion pa and growing. See article Appendix B.
18	End of life impacts	Unclear who is actually responsible for decommissioning, land rehabilitation & disposal of	Confidential agreements hide responsibilities. Onus

#	Issue	Points	Comment
		the waste; potential the then operator of the solar works, the host landholders or ratepayers, if the land is contaminated.	is on hosts to decommission, rehabilitate; etc. NSW EPA law places ultimate contamination cleanup on the local authority (e.g. Council/s)
19	ignoring real life experiences with existing similar projects	Lack of screening, road damage; vehicle accidents; fires; visual impact even at 8 - 10kms or more; lack of response from authorities; flooding; erosion; natural damage; loss of value of solar works; failure of works to achieve originally claimed output. Output degradation.	Presentations at IPC public meetings. SOS and others submissions.
20	negative cumulative impacts	All of the proceeding multiple times plus others as projects accumulate in a condensed areas within and outside REZs.	

Not in the Public interest

The final statement in the Executive Summary of the assessment report states " The project would result in benefits to the State of NSW is therefore in the public interest and approvable". In what way is the public interest served when:

- no measurable impact on global temperatures can be attributed to this project
- the net benefits of the project and the full impact on the electricity network are not considered, which in our opinion are a negative cost to the network and the NSW and Australian economies and results in ever-increasing electricity costs
- higher electricity costs are shown to be a significant contributor to our current inflation and hence interest rate increases
- hundreds of thousands of households are already struggling to pay the ever-increasing energy bills
- tens of thousands of businesses are closing at an increasing rate, such as cafes and small businesses that cannot recover the increases in their electricity costs
- the AEMO and others have raised concerns of wide-spread blackouts as soon as this next summer
- the NSW government is now paying hundreds of millions of dollars to keep the Eraring coal-fired power station operating as the ruinables fail to live up to the hype
- inter-generational equity is ignored so that future generations of Australians will be paying off the forecast trillions of dollars that the energy transition is forecast to cost them

- the misallocation of resources directly impact the quality of life as fewer funds are available

- the 83% of submissions from the impacted communities over-whelming do not want the project and so there is no social licence for this project.

Conclusion

The proposed Middlebrook project in not fit for purpose and should not be consented to by the IPCN. No number of mitigations required of the Applicant can satisfactorily address the all these very significant short-comings of this project. Mitigation is not elimination! Cumulatively the negatives are prohibitive.

Just the example of zero solar and 1% wind electricity generation and zero BESS output for the whole of the National Energy Market grid during evening peak electricity demand on the 4 June 2024 proves beyond any doubt that more solar, wind and BESS projects cannot overcome the vagaries of wind and solar droughts. Without adequate base-load power generation there is zero system reliability.

In addition, more solar, wind and BESS projects only result in continually increasing electricity retail prices, as experienced throughout the world. South Australia has Australia's highest penetration of solar, wind and BESS grid capacity (over 60%) but also has the highest retail electricity retail prices. This proves beyond any doubt that more solar, wind and BESS projects do not result in cheaper electricity to consumers.

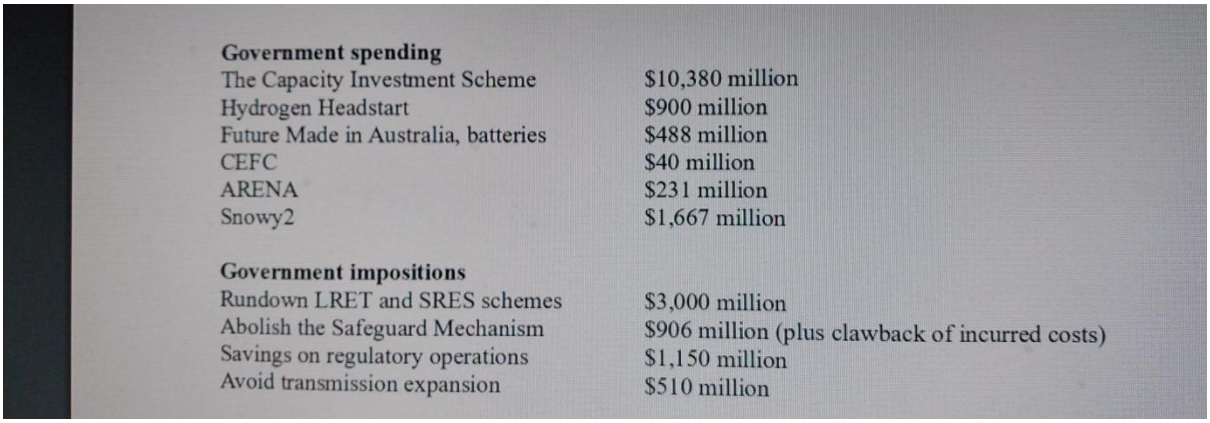
If the IPCN consents to this project they must justify their decision by actually addressing the issues and evidence provided by all the people opposing the project and stating why such evidence was dismissed. To date, both the Department and the IPCN are failed to even acknowledge the issues raised, particularly by Save Our Surroundings, which has invested many thousands of hours in research over several years by drawing on both overseas and Australian experiences, research by others, analysis and experiments by academics, industry consultants, research bodies (e.g. IEA, IPA), governments, government bodies, proponents and manufacturers.

Regards
Save Our Surroundings (SOS)

Attachments: SOS - CO2 in Chinese panels 231205 V1
SOS - Wind and Solar Resource Requirements are Unsustainable V2

Appendix A: Current Subsidies

From the Spectator article 9/09/2024, "*A great many savings both to the budget and to consumers by withdrawing from the multitude of expenditures and regulatory measures in place for electricity. These measures mean an annual cost to the economy that could allow annualised savings:*



Government spending	
The Capacity Investment Scheme	$10,380 million
Hydrogen Headstart	$900 million
Future Made in Australia, batteries	$488 million
CEFC	$40 million
ARENA	$231 million
Snowy2	$1,667 million
Government impositions	
Rundown LRET and SRES schemes	$3,000 million
Abolish the Safeguard Mechanism	$906 million (plus clawback of incurred costs)
Savings on regulatory operations	$1,150 million
Avoid transmission expansion	$510 million

These estimates indicate an availability of some $15 billion a year in budgetary savings that would actually bring a bonus in additional benefits by causing a return to lower cost electricity supply sources."
(https://www.regulationeconomics.com/_files/ugd/b6987c_3a1c4876a52d4f19b171191a9f00b0bd.pdf)

Appendix B: Definitions

In any discussion about electricity generation it is essential that the various terms used are fully understood as some people mislead others, either accidentally or deliberately, by their incorrect use. The main terms and their acronyms used in this paper are:

- **Megawatt (MW):** A megawatt (MW) is equivalent to 1,000 kilowatts or 1 million watts of electrical energy e.g. a 1MW ("nameplate capacity") wind turbine can, under ideal conditions, produce a maximum of 1MW of electricity at an instant in time. MW and MWac (ac = alternating current) are usually synonymous but MWdc (dc = direct current) is sometimes used as it gives a higher nameplate capacity value, i.e. output before conversion to ac, which involves energy losses.

- **Gigawatt (GW):** A gigawatt (GW) is equivalent to 1,000 megawatts or 1 billion watts.

- **Megawatt hour (MWh):** A megawatt hour is equal to 1,000 Kilowatt hours (KWh). It is equal to 1,000 kilowatts of alternating current electricity used continuously for one hour e.g. a **1MW** wind turbine may only produce over a year **3,240 MWh** of electricity depending on the average strength of the wind. The theoretical maximum annual electricity output for a **1MW** system is **1MW x 24hours x 365 days = 8,760MWh**.

- **Gigawatt hour (GWh):** A gigawatt hour (GWh) is equivalent to 1,000 megawatt hours.

- **Capacity factor:** The net capacity factor is the **ratio of an actual electrical energy output over a given period of time to the maximum possible electrical energy output over that period e.g. a 1MW wind turbine may produce 3,240MWh in a year out of a possible 8,760 MWh, therefore its capacity factor is 3240/8760 = 37%, which is a typical value for modern wind turbines. For solar panels the typical capacity factor is less than 28%. For new coal, gas and nuclear power stations the typical capacity factor is 90% or more, which is why they are the backbone of most of the electricity systems throughout the world.**

- **Artisanal:** Made in a traditional way by someone who is skilled with their hands; in this paper it refers to Cobalt mining done by hand.

Appendix C: Changes required to properly assess renewables projects

SOS suggests that our governments

1. Create a level playing field for all forms of electricity supply.
2. Stop all subsidies to the renewables industry in Australia within 12 months.
3. Require all 'renewables' projects to contribute to access electricity network infrastructure or build/pay for infrastructure specifically needed for the project, or NSW Renewable Energy Zones, to connect to the grid.
4. Ban the use of Sulphur Hexafluoride (SF6).
5. Require truth and completeness in project documentation when promoting their projects for assessment.
6. Require that all risk events that occur be publicly reported.
7. Require projects to lodge upfront bonds upon project approval for decommissioning, disposal and land rehabilitation.
8. Require at least a five years warning by a project that it is to be decommissioned so as to give time for its replacement to be planned, approved and built.
9. Place a limit on the size and location of an industrial solar and wind plants so as to preserve land for agriculture, and the attractiveness and ambiance of the surroundings of regional towns.

What SOS want Renewables Applications to contain

To enable transparency and proper community and DPIE evaluation of a solar, wind and storage projects, the Proponent/Developer Application (EIS or DA) must provide:

1. That each "Independent Report" included in an application to include a declaration of any financial interests the consulting firm or their owners have in the Proponent/Applicant company or their owners.
2. The comparison with generation alternatives must be against all alternatives of similar capacity (e.g. rooftop solar, CCGT-CC, modern coal-fired plants, modern nuclear plants) on a total life-cycle basis of the longest life alternative. Comparisons to include land space required, total types and tonnes of materials required, and nature of output over each 24 hour period.
3. Details of how and where, if not a standalone electricity generating works, the electricity supply will come from when the solar, wind or storage plants are not supplying sufficient electricity to supply electricity consumers.
4. The life-cycle CO2 equivalents embedded in their specific project once installed.
5. The payback period for life-cycle CO2 equivalents deficit embedded in their project
6. The payback period for life-cycle energy in/out deficit once operational.
7. Evidence for claims that their output is enough supply 'x' households with electricity on a 24/7 basis to ensure the public are not mislead.
8. Soil analysis pre, on and post installation to establish a benchmarks for future comparison
9. Annual testing of soil for contamination, reported to the Council and government departments
10. Confirmation that the project site is not within 10km of the closest boundary of a town, national park, dam or reservoir.
11. Minimum setback from all roads with embankments and vegetation as screening, as for coal mines e.g. 200 metres.

12. The Australian content ($ and %) of their project, separated into labour, transport, materials, taxes and services.
13. The gross value of the project
14. The value any initial and ongoing subsidies, favourable loans or other benefits provided by all levels of government to the project.
15. Details of any Power Purchase Agreements (PPAs) and any Voluntary Payment Agreement (VPA), including duration, price received, and contingency if term is not renewed, penalties for non-delivery of supply amounts.
16. Full details of a decommissioning and disposal plan, including safe-removal and disposal of toxic elements and the full rehabilitation of the land within and around the project site, including resources and estimated times and costs to complete the works.
17. Amount of decommissioning/disposal bond to be lodged with an appropriate government body and the conditions for release.
18. Value of any direct contribution to transmission and distribution networks and associated infrastructure necessary for the project to operate.
19. Value of any contribution or fees to access to the electricity network/infrastructure.
20. Total amount of materials required for the project by type (steel, PV panels, copper wire, etc.) and by weight (tonnes)
21. Type of fire suppression methods to be installed, including type (e.g. water sprinklers, gas,) and the alert methods to fire-fighters (water bombers).
22. Water use plan (source and quantities) for construction and operation, including methods of use.
23. Confirmation that no part the project is within 200m of any waterway (surface and underground)
24. Risk event reporting plan e.g. when any panels or equipment is damaged by fire, storm, hail, etc, including notification to the local community.
25. Extent of compensation to be paid to nearby property owners who incur a reduction in land value as a result of the project or due to fire or contamination.
26. The value of any contributions made to independent research bodies who scientifically study life-cycle "renewables" pollution, resource requirements, impacts on the environment, wildlife and food chain and on humans.
27. Evidence that their product does not include materials obtained from the use of child labour, human rights abuses, and unacceptable impacts on the environments in overseas countries.
28. A risk analysis of the project be included (safety, obsolescence, vulnerability to damage, economic vs. physical life, etc).
29. A chart showing the decline in energy output efficiency each year and projected physical and economic life-time of the project, supported by evidence.
30. Maintenance plan to identify component deterioration on a regular basis (e.g. soil testing if cracking, de-lamination, weather-related damage, turbine blade insect build-up, etc. occurs).
31. Written confirmation from all landholders who lease their land to renewables developers that they fully understand any liabilities they have to remove infrastructure at the project's end-of-life should the then current plant owner not be able or not obligated to do so (e.g. due to bankruptcy or agreement conditions).

Wind and Solar Works Resource Requirements are Unsustainable

Summary

This paper by Save Our Surroundings (SOS)highlights the extent of resources required by various types of electricity generation. It considers the comparisons from the same stated nameplate capacity (e.g. 400MW) but more importantly from equivalent electricity generation over a 60 year time period, which is a much better assessment of resource requirements.

An overseas study by Sovacool (2010, 2020) of the tons of materials required, based on a capacity of one gigawatt (GWe), for installed industrial wind, solar and nuclear plants concluded that solar (169,363t) and wind (410,530t) required 0.78 and 1.89 times more materials respectively than does a nuclear plant (217,101t). Current proposed solar and wind works are more recent and much larger in Australia than in the Sovacool study.

SOS has assessed the tonnes of materials required based on actual results derived from Australian installed or proposed projects for rooftop solar, industrial solar and wind, High Efficiency Low Emissions (HELE) and Combined Cycle Gas Turbine with Carbon Capture and Storage (CCGT-CCS). The Nuclear plant figures are from the Sovacool study.

When compared to the same 400MW capacity HELE power plant, just the average materials requirements for installed industrial solar and industrial wind electricity generating works are 1.2 times and 2.8 times respectively more than for an installed HELE plant (refer to Table 1). However, capacities of solar and wind works are in no way equivalent to base-load power plants.

All generator types output a single product - alternating current electricity. SOS puts forward a superior method to just capacity comparison that is based on output equivalence over a given time-frame. While the methodology used grossly understates the materials required by industrial solar and wind works it still exposes a massive resources demand difference just for the basic components when compared to fully installed and operating HELE and Nuclear plants.

SOS chose to compare industrial solar and wind works with HELE and Nuclear works as the latter are being installed in increasing numbers globally and are 24/7 base-load electricity generation plants. When compared to the same electricity output over 60 years of an installed HELE plant, just the average materials requirements for industrial solar and wind electricity generating works (average) are 3.8 times and 7.8 times respectively more than for the same electricity output of a HELE plant (refer Table 2).

Stubbo Solar (NSW), Wind Works 1 (Bowmans Creek NSW) and Wind Works 2 (Winterbourne NSW), which only include the solar panels and steel supports for Stubbo, and Wind Turbines and the concrete bases for the wind works, provide an Australian context. The results for two wind works, based on information included in their Environmental Impact Statements (EIS,) are 5.0 and 8.1 times more tonnes of materials than for the same output of an old supercritical HELE (Kogan Creek, Qld). Stubbo Solar Works is 3.1 times more materials than for the HELE.

The very significant additional materials and land requirements of solar and wind technologies has very serious implications for the global and local environments. More mining of a wider variety of minerals, more toxic processing, more manufacturing, more sea and land transportation, more land clearing, more land withdrawn from original use, more construction, more impacts on wildlife, more waste disposal, and more frequent replacement are all leading to greater destruction of local environments and more creation of greenhouse gases. In addition, energy security and national security are significantly diminished. This unsustainable!

The capacity equivalence (Ce) of solar and wind electricity generating works compared to a 400MW HELE is 56.6MW for solar and 53.5MW for wind. That is, to match the electricity output of a 400MW HELE plant at least seven or more 400MW wind and solar works have to be built as well their required high voltage, energy storage and other infrastructure. This unsustainable!

1. Comparisons based on Capacity

The 400MW Stubbo Solar Works currently under construction near Gulgong in the NSW Central West Orana Renewable Energy Zone (CWO REZ) was evaluated against actual and published figures for Industrial Solar (average), Rooftop Solar (actual in the CWO REZ), Wind Turbines (average), High Efficiency Low Emissions (HELE) coal fired plant (actual), Combined Cycle Gas Turbine with Carbon Capture and Storage (CCGT-CCS) plant (proposed) and, a nuclear power plant (average). The Stubbo solar works result aligned well with the industrial solar averages. The results are summarised in Table 1.

Table 1: 400W capacity generators material requirements over 60 years

Generator Type	Land Req'ts Ha	Capacity Factor %	Output MWh/Year	Availability	Material Req't Tonnes#	Expected Life Years	Energy in/out Payback %	Materials Over 60 Years t
Stubbo Solar EIS^	1772	25.2	883,008	Daylight Hrs	73,400	30	60	146,800
Industrial Solar (ave)	1280	25.5	893,520	Daylight Hrs	61,457	25	60	184,371
Rooftop Solar (CW)	0	24.5	858,480	Daylight Hrs	13,550	25	>60	40,650
Wind Works (ave)	10,160	30.1	1,054,704	Wind dependent	148,970	20	290	446,910
Wind Works 1 EIS^^	12,734	34.2	1,176,471	Wind dependent	158,472	30	NA	316,944
Wind Works 2 EIS^^^	19,905	35.0	1,226,190	Wind dependent	178,534	25	NA	535,602
HELE (Qld)	30	82.3	2,915,328	24hrs/7days	< 78780	50	3,000	157,560
CCGT-CCS (NSW)	146	90	3,153,600	24hrs/7days	< 78780	25	3,000	236,340
Nuclear (average)	169	91.3	3,199,152	24hrs/7days	78,780	60	7,400	78,780

* Ratios were used to bring to all types to 400MW capacity level
* ^Stubbo NSW estimated by SOS: 16,000T (25kg x 800,000) solar panels, 53,400T steel (40kg/m x 5m lengths X 133,500 piles plus 133,500 cross members) but no allowance for concrete, inverters, wiring, etc.
* no BESS included
* Rooftop solar from CWO REZ resident
* ^^WW1 = Bowmans Creek NSW; 60WTG x 5.6MW (at 2232t total each turbine & 600m3 concrete base) =336MW; 71WTG = 398MW & 158,472 tonnes
* ^^^WW2 = Winterbourne NSW; 119WTG x 6MW (at 2665t total each turbine & 750m3 average concrete base) = 714MW; 67WTG = 402MW and 178,534 tonnes
* HELE = Kogan Creek Qld supercritical 750MW commissioned 2007; assumed weight as for nuclear plant
* CGCT-CCS = AGL proposed Newcastle NSW 250MW dual fuel; assumed weight as for nuclear plant
* Nuclear from Sovacool study 1000MW; design life of 60 years from UK Hinkley C project
* Average hectares for solar based on developers' published figures for Beryl, Gulgong, Stubbo and Wellington solar works
* Average hectares for wind based on developers' published figures for Coopers Gap, Bodangora, Hornsdale & Sovacool
* Materials averages from sciencedirect.com "global environmental change Vol 60 Article 102028 table 1"
* 30/6/20 M Shellenberger "Apocalypse Never" p192 for energy in/out payback

One of the major drawbacks of this analysis is that there is no consideration of the non-equivalence of Solar Works or Wind Works capacity compared with base-load power plants.

SOS has developed a basic indicative formula where Capacity equivalence Ce = generator type (capacity X capacity factor X claimed life)/ base-load (capacity factor X economic life). e.g. for a 400MW solar works generator Ce = (400 x 25% x 25 years)/ (90% x 50 years) = 55.6MWe or seven times less than the 400MW HELE plant. Solar Ce will be even lower if solar panel degradation, solar works likely economic life and intermittency were taken into account. But that is for Mathematicians to work out.

The Ce for a 400MW Wind Turbine electricity generation is Ce = (400 x 30.1% x 20 years)/(90% x 50 years) = 53.5MWe or greater than seven times less than the 400MW HELE plant. Wind Ce will be even lower if wind turbine degradation, wind works likely economic life and intermittency were taken into account. But that is for Mathematicians to work out.

An alternate view of resource demands of each electricity generation type is by equating total alternating current electricity produced over a period to the initial material resources required to create the power plant. The next section provides an analysis using the data in Table 1.

2. Comparisons based on equal output

The calculations presented here are indicative of the differences in material requirements. The differences are so significant that they do point to a real but often ignored issue about the sustainability of wind and solar works and the associated greenhouse emissions involved in their construction.

Assumptions:

- Only onshore works were considered.
- Maintenance materials used during the works or plant operation are not included.
- A new and similar replacement power plant is built and operating at the time that the previous generating plant is decommissioned.
- No land requirements are included in the calculations, which are in fact very substantial for wind and solar works (refer to Table 1).
- No indirect, but necessary, materials are included that are specifically needed to connect remote wind and solar works to the electricity grid, such as new transmission lines, sub-stations and road works.
- No indirect, but necessary, additional materials associated with works necessary to address the intermittency of wind and solar works electricity generation, e.g. BESS and pumped hydro, are included.
- No degradation of output over time has been included; however, for solar works it is 2% the first year and 0.5 - 0.8% per year over a life of up to 25 years; for wind turbines the efficiency decline varies widely from 0.17% to 1.6% yearly over a life of 15 - 20 years. Declining efficiency results in declining output, which will increase the material requirements per MWh of output.
- The tonnes of materials for HELE and CCGT plants were not available so SOS assumed a worse case by using the Nuclear (average) materials figures.

The exclusion of materials required for connection, backup, and maintenance, as well as ignoring falling output from efficiency degradation favours solar and wind works. That is, solar and wind works create the need for even more materials than base-load power plants to support their operation.

Table 2 summarises the weights of direct materials required for each electricity generation type.

Table 2. Comparison of material needed based on output (adjusted to 400MW)

Electricity Generator type	Output MWh/year	Output Over 60 years MWh	Materials Over 60 years t	Material Tonnes/ MWh	Materials to Equal HELE output t	Materials to Equal Nuclear output t
Stubbo Solar EIS	883,008	52,980,480	146,800	0.002771	**484,673**	**531,859**
Industrial Solar (ave)	893,520	53,611,200	184,371	0.003439	**601,556**	**660,120**
Rooftop Solar (CW)	858,480	51,508,800	40,650	0.000789	**138,044**	**151,483**
Wind Works (average)	1,054,704	63,282,240	446,910	0.007062	**1,235,313**	**1,355,578**
Wind Works 1 EIS^	1,176,471	70,588,260	316,944	0.004490	**785,396**	**861,859**
Wind Works 2 EIS^^	1,226,190	73,571,400	535,602	0.007280	**1,273,421**	**1,397,395**
HELE (Qld)	2,915,328	174,919,680	157,560	0.000901	**157,560**	**172,899**
CCGT-CCS (NSW)	3,153,600	189,216,000	236,340	0.001249	**218,483**	**239,754**
Nuclear (average)	3,199,152	191,949,120	78,780	0.000410	**71,791**	**78,780**

When compared to the same electricity output of a HELE plant, just the materials requirements for averaged solar and wind electricity generating works are 3.8 times (601556/157560) and 7.8 times (1235313/157560) respectively more than for the same electricity output of a HELE plant.

Stubbo Solar (NSW), Wind Works 1 (Bowmans Creek NSW) and Wind Works 2 (Winterbourne NSW), which only include the solar panels and steel supports for Stubbo, and Wind Turbines and the concrete bases for the wind works, provide an Australian context. The results for two wind works, based on information included in their Environmental Impact Statements (EIS,) are 5.0 and 8.1 times more tonnes of materials than for the same output of an old supercritical HELE (Kogan Creek, Qld). Stubbo Solar Works is 3.1 times more materials than for the HELE.

The massive amount of materials required for just a part of the solar and wind works indicates that total electricity grid costs must substantially increase from current levels which will result in ongoing increases in electricity costs to consumers. In addition, the upfront embedded greenhouse gases directly and indirectly created by solar and wind works should not be ignored.

3. Wind and solar only produce electricity less than 30% of the time.

Significant issues with both wind and solar generated power results for their dependency on the weather. Both wind and solar are dilute, inefficient and inconsistent forms of energy conversion. Being only able to initially produce electricity over a year on average 25 -30% of the time and often zero because of wind and irradiance (sunshine) droughts means that electricity must be provided from some other sources at these times.

Filling the up to 100% gap in electricity generation is very costly, so resulting in significant price rises as more wind and solar works are built and supported by evermore storage works (e.g. batteries and pumped hydro) and thousands of kilometres of new transmission lines.

A study has shown that a PV solar system only generates **1.6** times the energy that was used leading up to its commissioning. It therefore starts operation with a CO2e and energy deficit. Assuming a 25 year life then the system will only offset its energy deficit at the time of commissioning after 10 years of operation, i.e. at least **40%** of its life before contributing to any global reduction in CO2e. Batteries in a BESS need to be replaced more frequently (10 -14 years), so adding more CO2e to the atmosphere. If the components are manufactured in China the embedded greenhouse gases are very much greater. [ref: https://doi.org/10.1016/j.energy.2013.01.029]

For energy generation, wind is an ancient technology. Solar cells were invented in 1883 by C Fritz and the first commercially viable PV solar panel was developed by Bell Laboratories in 1954.

Both wind and solar are dilute, inefficient and inconsistent forms of energy conversion. The energy density (the amount of energy in mega-joules [Mj] released per kg) of different fuels in increasing order is wood (16Mj/kg), coal (24), oil (45), natural gas(55) and nuclear (3,900,000). The higher the energy density the lower the total demand on all resources and the higher the efficiency in producing electricity. A mega-joule is equivalent to 0.278KWh of electrical energy.
Logically, natural gas and zero emissions nuclear should be the preferred fuels at this time.
[ref: understandsolar.com "Who invented solar panels?"; energyeducation.ca/encyclopedia/energy_density]

A study of Germany's electricity generation found that over their operating life solar and wind have very low energy output compared to the energy used to make and install them. The energy generated by nuclear, hydro, wind and solar was, respectively, **75, 35, 3.9** and **1.6** times greater than the energy required to make them. Wind and solar provide a poor return on an energy in/energy out basis compared with other methods. More energy in means the more emissions created and embedded in the product, especially those sourced from China, which generates the most emissions globally. Up to 90% of Australia's solar panels, wind turbines and batteries are made in China.

Logically, nuclear energy should be preferred for electricity generation as it gives the best energy in/out result, causes fewer emissions in its creation and generates zero emissions during its operation. Also, the imbedded GHG in renewables must be taken into account.
[ref: 30/6/20 M Shellenberger "Apocalypse Never" p192]

Australia is the only country of the top 20 developed countries and the top 'developing' countries (China and India) that does not depend on zero-emissions nuclear power for part of their electricity generation. There are currently about 53 nuclear power reactors under construction, mainly in China, India, Russia and UAE. Australia is being left behind due to its illogical and damaging ban on nuclear energy.
[ref: World Nuclear Association "Plans for New Reactors Worldwide" September 2020]

Conclusion

Even when only taking into account just the main materials required by industrial Solar Works (solar panels and supporting structures) and industrial Wind Works (turbines and concrete bases) it is apparent that they require many more tonnes of materials over a 60 years period than do a High Efficiency Low Emissions coal-fired power plant or nuclear plants of the same capacity. The implications of this considerable materials requirements difference are that:

- Solar works require at least **3.1 - 6.8** times more materials, just for some components, than does a fully installed operating HELE or nuclear plant.

- Wind works require at least **8.1 - 17.7** times more materials, just for some components, than does a fully installed operating HELE or nuclear power plant.

- All these extra materials only provide intermittent electricity generation less than 30% annually on average.

- All the extra materials (transmission, storage, etc) required to build a 100% solar and wind based electricity system must also be added to the tonnes of materials required to create solar and wind operating plants and to fill the 70% plus gap when solar and wind are unavailable.

- Such massive extra tonnes of materials demands of solar and wind electricity generation are not only substantially increase electricity system costs but are highly damaging to multiple environments and are unsustainable.