New South Wales Government
Independent Planning Commission

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Attachment:	*Save Our Surroundings Submission to the IPCN 22 March 2024.pdf*		

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Please refer to the SOS pdf attachment of 22/03/2024

Submission to the IPCN by Save Our Surroundings 22 March 2024

[redacted]

Introduction
We have several concerns with the Thunderbolt Wind Farm State Significant Development Assessment Report (SSD 10807896) February 2024.

We believe the assessment, which recommends approval for the Thunderbolt Wind Works Stage 1, to be flawed and misleading in several respects. These include the:

1. Making claims for the project that are clearly not supported by actual experience, such as: resource sustainability; ensuring a secure, reliable and affordable energy supply; powering 99,000 homes; replacing coal-fired energy generation, being a suitable high wind site; reducing emissions; cumulative reduction in local biodiversity.

2. Taking a narrow view of how the project will be in the Public Interest by ignoring the impacts the project will have business costs, jobs, energy and national security.

Key project parameters
Little attention, if any, is given in the Assessment to the impacts on quality of output, sustainability of resource used, embedded greenhouse gases emissions, non-equivalence of capacity, decline in capacity and risks of failure.

Key project parameters taken from the assessment will be used to expand on these impacts and other aspects. The parameters are:

- Capacity: 192 Mega Watts (MW)
- Annual output (initial): 570,000 MW hours
- Homes powered claim: 99,000 or average of 570,000MWh/99,000 = 5,758 kWh/annum
- Initial capacity factor (calculated): (570,000MWh x100)/(192MW x 24 hours x 365days) = 33.9%
- Project life: 25 - 30 years (say 27.5 years)
- Average wind turbine generator capacity: 192MW/32 WTGs = 6MW
- Average wind speed 7.6m/s = 27.4kmph
- Project site area: 5,918 hectares (ha)
- Project disturbance footprint 215ha
- Native vegetation clearance 162ha
- Capital investment value: $373,000,000.

Resource sustainability
The methodology at Appendix A for calculating just the tonnes of materials (steel, composites, concrete, etc.) per MWh generated over 60 years (two lifetimes) for the 32 wind turbines and their concrete bases is 1,044,395 tonnes, which is a minimum of 6.1 times more than a HELE and 13.3 times more than a nuclear plant for the equivalent MWh outputs over 60 years (refer Table1).

All these extra materials only provide intermittent electricity generation less than 30% annually on average. With a first year capacity factor of 33.9% the Thunderbolt Wind Works will NOT provide any electricity 66.1% of the time, on average, over its first 12 months. By 25 years its capacity factor will likely decline by 31% (from Hills of Gold WW EIS) to only 23.4%.

Table 1 summarises the weights of direct materials required for each electricity generation type.

Table 1. 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**
Thunderbolt WW^^^	1,193,438	71,606,280	389,575	0.005441	**951,738**	**1,044,395**
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**

* ^^^Thunderbolt NSW; 32WTG x 6MW (at 2665t total each turbine & 750m3 average concrete base) = 192MW; 67WTG = 402MW and 178,555 tonnes; 178,555t x 60/27.5 years = 389,575t over 60 years

This excessive consumption of materials by the project is unsustainable and environmentally damaging just to produce the same product, that is, alternating current to specification. Any other electricity generating source can produce a electricity at a very much less requirement of materials per MWh.

In addition, the tonnes of turbine blades and the reinforced concrete bases will become landfill. Condition B45 only requires the concrete pads to be covered with soil and/or rock, which will not rehabilitate the land for future cropping or pasture development.

There is no requirements for the 600 - 900m3 of reinforced concrete bases, which are additional to the concrete pads, to be removed or reduced to be below ground level or the 90 metre turbine blades to be removed and not buried onsite or elsewhere.

As no bond or fund is required at anytime for the project then the risk that the decommissioning, proper disposal and land rehabilitation will not be done is significant, especially as the Planning Secretary can limit the application of the weak condition, for example if the owner of the wind works or the host landholder cannot afford to do all the work required.

Ensuring a secure, reliable and affordable energy supply

The Assessment uses the terms secure, reliable, affordable or similar many times in support of the project proposals. SOS contends that the proposal does not contribute to any of these objectives.

Secure: The Webster's New World College Dictionary defines "*secure*" to mean "*free from or not exposed to danger, harm, or loss*"; it *"also can describe something that is dependable, firm, or not liable to fail or become displaced"*.

The proposed Thunderbolt project already states that it will:

- cause harm and loss to the environment by removing native vegetation, destroying wildlife habitat and killing bats and bird species; the clearing of 162ha of native vegetation and incurring of 4,337 biodiversity offset credits indicates an extensive impact on the local environment; the area to be cleared is 75% of the disturbance footprint and therefore substantial; taken with many other projects planned for the region means a substantial loss of local wildlife.

- expose increased dangers and harm to fire-fighters, aircraft, the environment and others from wind turbine fires, toxic smoke release from turbine and other equipment fires, collision risks to aircraft and flying animals; despite mitigation efforts they will not eliminate such increased risks; risks which will only materialise if the project proceeds.

- transform 59km2 of rural landscapes into a huge industrial estate resulting in wide-spread visual harm and loss of amenity; screening off some peoples view, usually why they built their home where they did, as mitigation is a poor substitute for losing the expansive views they now can enjoy. In addition, even at night most of the turbines will be visible due to the requirement of obstacle lighting.

- only be capable of generating electricity when the natural conditions of wind strength and consistency exist; this dependence on variable weather makes the project not dependable, subject to failure and will in time be replaced by better existing or future electricity generating technologies.

Clearly the claim that the project will provide a secure supply of electricity is false and misleading.

Reliable: As the generation of electricity is solely dependent on the wind strength and availability throughout the year it can never be relied upon to deliver electricity to the NEM grid at the quantity, quality and standard required when needed. The project does not even include a BESS to help produce alternating current to the grid at the correct standard of frequency and voltage.

The AEMO repeatedly intervenes in the market as the NEM becomes less reliable and unstable. The AEMO has warned governments and consumers that wide-spread brownouts and blackouts are increasingly likely during peak demand periods in Summer and Winter.

Clearly the claim that the project will provide a reliable supply of electricity is false and misleading. In fact it will increase the unreliability of the NEM, as is occurring in the electricity systems many other countries. Wind and sunshine droughts, individually or simultaneously, results in little electricity generation from wind or solar generators.

Affordable: Australia's retail electricity prices are no longer inexpensive or reasonably priced when compared to nearly all countries globally. The increasing penetration of wind and solar capacity into the NEM grid over the last decade to now being over 30% of total NEM capacity coincides with ever-increasing retail and business electricity costs. This follows the experience of every jurisdiction in the world where wind and solar constitute 30% or more of their electricity system's capacity mix.

The recent very steep Increases in NEM electricity prices are already causing hardship to households and businesses, resulting in direct relief from government and retail energy providers to some households. Multiple businesses are struggling to survive, going broke, closing down or leaving

Australia for cheaper alternatives in which to operate, which is mirroring the trends in many jurisdictions globally.

The AER this week announced the draft Default Market Prices for 2024-25. For Essential Energy residential and business customers an increase between $22 and $41 is indicated. In addition, a 147% increase to the NSW REZ levy, first introduced in 2023-24,to fund the nearly $500m in the approved REZ costs so far, including $138m towards funding seven regulatory bodies. The increase will add another $25 to the average NSW residential household bill. [Daily Telegraph 22/03/24 p8].

If the Thunderbolt wind works project was to proceed it would just increase the already unaffordable cost of electricity.

Power 99,000 homes

"The project would have the capacity to generate 192 MW of renewable energy, sufficient to power around 99,000 homes per year." [page iii], is nothing but a marketing statement and has no truth in fact and is misleading.

The project will only produce intermittent electricity sometimes, but most of the time zero electricity, due to its weather dependency and at best only 33.9% of the time over the first 12 months of operation.

No modern household can function with an available energy supply of only 8 hours a day on average. Even worse hit is manufacturing plants and businesses that need continuous electricity supply to operate. In particular, alumina smelters, some of which have already announced they will be closing down operations in Australia.

The omission that the claimed 570,000MWh annually is in fact for the first year only and, according to the Hills of Gold Wind Works proponent, will decline to about 23.4% by year 25, i.e. output from the project will decline annually to only generate 393,300MWh by year 25, if the project lasts that long.

Clearly a claim that the project will generate enough electricity to supply 99,000 homes is false and very misleading.

Material contribution to replacing coal-fired generators

Another marketing statement in the Assessment that is not based in fact. The project's 192MW capacity, because of its low capacity factor and relatively short life, has a starting capacity equivalent of a modern High Efficiency Low Emissions (HELE) power plant of 40MW (192MW X 0.339CF X 27.5 yrs / 0.9CF x 50 years).

In addition, the wind project will only produce electricity intermittently with no ability to match output to demand as changes occur. A HELE or the current operating coal-fired and gas-fired power plants can and do operate to supply both base-load power and match increased demand when necessary.

Hundreds of HELE plants have been recently built, are under construction or have been approved globally, but particularly in Asian countries where the majority of wind turbines, solar panels, lithium batteries and electrical vehicles are made. These countries are benefitting from a secure, reliable, affordable and readily available source of energy.

Clearly, the project will not make a material difference as existing coal-fired power plants are forced to prematurely retire. Its contribution is minuscule at 40MWe (1.4%) compared to the base-load 2880MW Eraring power plant. The project's intermittent output will only displace not replace it a small fraction of the on-demand output of Eraring.

Suitable Site

The Assessment states an average wind speed of 7.6m/s (27.4kmph) for the site. This supposedly makes the suit a high wind area. Yet a capacity factor of 33.9% indicates that over 12 months the wind speed rarely is sufficient for the wind works to achieve its 192MW maximum output.

Last year the DPE put out a map showing the Central West of NSW as not particularly suitable for electricity generation wind turbines. A subsequent amendment changed the map to be more favourable. An initial capacity of 33.9% for the Thunderbolt project and 29.9% for the larger Hills of Gold wind works also in the Tamworth LGA indicates the original map was probably the accurate one. These low capacity factors (CF) for wind works do not compare favourably with the greater then 90% CF of modern HELE, gas nuclear or even a 50 year old Liddell power station, which finished at over 54%CF.

The DPE appears to be contradicting itself by proposing that the Thunderbolt site is a high wind resource site and therefore suitable for the project.

Reduces emissions

The Assessment claims that the project when operational will contribute an annual reduction of 550,000 tonnes of Greenhouse Gas emissions. Even if true it is only for the first year. Thereafter, output declines and so does any emissions offset against any still operating coal and gas-fired power plants.

No consideration was given to the embedded GHG emissions created by the project and all the other infrastructure specifically necessary for the construction and operation of the wind works. Where the wind works components are manufactured has a significant bearing on the extent of embedded GHG.

SOS has previously demonstrated to the IPCN that just solar panels manufactured in China are unlikely to offset their embedded GHG emissions in the works lifetime, let alone all the other direct and indirect emissions involved.

Other infrastructure, equipment and actions for the Thunderbolt wind works will also have significant embedded GHG emissions, including vegetation removal, construction and use of specialised transport vehicles and cranes, massive concrete footings and pads, replacement turbine blades, hundreds of litres of specialised oil per oil change for each turbine, electricity used to rotate blades during low/no wind periods, etc.
In addition, the project only produces electricity intermittently less than 34% of the time annually on average, so that there must be additional transmission, generating capacity and storage built elsewhere. A proportion of the embedded GHG emissions "firming" infrastructure must be apportioned to the project as it is not stand alone but part of an integrated electricity network.

The end result is a massive over build of the NEM grid to make up for not just the low capacity factors and intermittent supply, but also for when wind droughts across the Eastern states occur at times of low/no sunshine.

There being no requirement for the project to account for scope 1, 2 and 3 emissions means that any statements about the project reducing Greenhouse Gas emissions are unsupported. Yet, the fundamental justification for the project is claiming a significant reduction in emissions and so contributing to the net-zero targets. Just stating a saving of 550,000 tonnes annually is without context and is therefore both misleading and inaccurate.

Disturbance footprint

A disturbance footprint of 215ha seems at odds with a project site of 5,918ha. With wind turbines the height of 260 metres (m) and over 180m wide, it is the airspace required that matters. Each turbine produces turbulence when the blades are spinning. Therefore, every turbine must be a sufficient distance from every other turbine so as not to interfere with each other.

It is the requirement for airspace that creates the demand for huge areas of agricultural and wilderness land to be accessed and damaged for some of the largest and most prolific structures in Australia. Structures that require:

- very significantly more tonnes of varied materials and resources per kilowatt of standardised alternating current electricity supplied to the NEM grid than any other electricity generating type, as detailed previously.

- huge distances between each of the 32 wind turbines and six 170m tall metrological towers resulting in 50kms of internal access roads, 100kms of cabling and the destruction of at least 162 hectares of wildlife habitat.

- visual pollution of rural amenity and landscape character for decades with the potential to be abandoned at the project's end-of-life due to cost of decommissioning, removal and disposal or premature obsolesce as more efficient technologies compete with the ageing and falling efficiency of the wind works.

Capital Investment Value and Subsidies

Both the Wind works and the HELE sell the same product to the required specification to the NEM. Comparisons based on generated megawatt hours are therefore valid.

The capital investment value (CIV) of the project is stated as $373,000,000, most of which will be for imported components, materials and shipping. An estimate of the Australian content of 12% - 15% results in an capital investment of less than $56m. Even less if many of the workers are temporarily from overseas.

Over its 27.5 years life span (mid-point of 25 - 30 years), the project is expected to generate about 13,323,750MWh, assuming a starting capacity of 570,000MW that drops 30% to 399,000MWh by year 27.5.

Thus, excluding financing costs, just the recovery of the CIV over 27.5 years is $28/MWh. By comparison a new HELE CIV capital recovery cost is about $6.85/MWh.

Clearly, a major increase in electricity costs would result by proceeding with the project, even before considering the related costs of new transmissions lines, back up energy sources when insufficient wind blows and the replacement of these, and large scale decommissioning and rehabilitation costs.

Also, the Thunderbolt project would be subsidised by taxpayers and electricity consumers through free Large Scale Renewable Energy Certificates (LSREC) at a government guaranteed surrender value of $40/MWh, NSW minimum wholesale floor price and the proposed Federal government Capacity Investment Scheme underwriting of a minimum wholesale price for any electricity produced by wind and solar works. The LSREC subsidy alone will be worth more than $22.8m for the first year of generated output.

Therefore, Australian taxpayers and electricity consumers are effectively funding the CIV of the project and also substantially funding the operation and the additional infrastructure, such as BESS works, necessary to integrate the project into the NEM grid.

Because of the subsidies and other benefits afforded to the project, the claimed financial benefits to host land holders, Councils and the local and State economies are largely illusionary. The claimed benefits are just partial return and redistribution of taxpayers' and consumers' money.

The DPE Assessment fails to include the impacts of subsidies, the decline in output and the short lifetime and so grossly overstates the financial benefits claimed for the project.

Inadequate Sound Assessment

The definition of "noise" is undesirable sound, which causes disturbance or damage to receivers".

The Assessment acknowledges that the wind turbines will create noise, but only partially considers the affects of audible sound in the human hearing range. However, infrasound is omitted in the Assessment, even though infrasound may be even more detrimental to the health and well being of humans and animals than audible sound.

There are 27 residences within 5.1kms of one or more massive wind turbines. Dozens of humans may be impacted, especially from infrasound, which is known to travel up to 13kms from much smaller wind turbines (<120m). Larger wind turbines greater greater infrasound noise. [M Villey-Migraine Dec 2004], [J Punch, R James Oct 2016], [E Zou Sep 2020], [Uren v Bald Hills WF VSC 250/22]

The project stated it will remove 162ha of flora and fauna habitat. However, the remaining habit and ecosystems will be subjected to construction noise for two years of construction and decades of audible noise and infrasound pollution from the wind turbines and other infrastructure.

Publications by several bodies, including the CSIRO and the Environmental Evidence Journal, state that livestock and many native animal have a hearing range much greater than humans, as do many pets. They further state that such animals can become very distressed by sudden loud or high pitched noises. This stress can cause aggressive and other negative behaviour in cattle as well as affecting weight gain and quality of the meat. (CSIRO). Noise pollution from man-made machines, including wind turbines, "can mask and inhibit animal sounds and/or animal audition and it has been shown to affect communication, use of space and reproduction." [9781486301614_Chapter4 (csiro.au)]' [Evidence of the impact of noise pollution on biodiversity: a systematic map | Environmental Evidence | Full Text (biomedcentral.com)], [Human noise affects animal behaviour, studies show | Animal behaviour | The Guardian, [BBC - Earth News - Noise pollution threatens animals

Months of frequent loud and sudden noise from the operation of large machinery during construction could cause prolonged stress in the animals. Years of both audible and inaudible noise from the operation of wind turbines has been found to have ongoing negative consequences for residents, domestic and native animals. Such consequences may include humans and animals being driven from the site and the areas around the wind works.

Clearly the wind turbines generate mechanical and aerodynamic undesirable sounds, which cause disturbance or damage to receivers, both human and animal. The lack of a full consideration of these noise impacts are a serious omission in assessing the project and is contrary to the **Federal Legislation - Environment Protection and Biodiversity Conservation Act 1999,** which states at 3A Principles of ecologically sustainable development the principles of:

"(a) decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations;

(b) if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation;

(c) the principle of inter-generational equity—that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations;

(d) the conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making;"

Viability

Modern wind and solar electricity generation has been penetrating electricity systems at significant levels around the world for well over 20 years. They are not a start-up industry, even in Australia. We have the highest per capital penetration of rooftop solar in the world, which currently generates more and cheaper electricity than industrial solar

Wind and solar works are, in virtually all cases, still heavily subsidised through direct and indirect methods. Australia now subsidises wind and solar electricity generation by about $15 billion a year and growing each year. These subsidies not only divert limited resources from social needs, like schools, hospitals, defence, etc., but they add to both state and federal debt as well as reducing our positive trade balance because most of the components are imported.

How viable will the Thunderbolt project, and similar projects, be when subsidies are reduced or stopped or much better generation technology embraced? How can the ever increasing cost of energy, taxes and debt and their impact on reducing economic activity meet the principle of inter-generational equity? The subsidies in all their forms are unsustainable.

Public Interest

Page iii of the Assessment states that the key assessment considerations are energy security, biodiversity and visual impacts. For many of the reasons already presented we believe that this view by the DPE is too narrow.

Therefore, their response at Table J-1 136(2)(e) is not accurate in that they state, "*The Department considers that all information relevant to the impacts of the project has been taken into account in its assessment."*

Page 63, paragraph 172 states that, "*On balance, the Department considers that the project is in the public interest and is approvable, subject to the recommended conditions of consent (see Appendix F*)."

The Thunderbolt wind works project, if consented to, would result in:

- excessive consumption of materials by the project that is both unsustainable and environmentally damaging just to produce the same product that better alternative generating types can do.

- a more insecure and poorer quality supply of electricity.

- little electricity generation from wind during wind droughts and times of too weak or too strong a wind, so that any claim of being a reliable source of electricity generation is false.

- increased electricity costs to consumers with the adverse affects this has on struggling households and businesses.

- insufficient electricity to supply even one household 24/7 let alone supply a claimed 99,000 households

- an equivalent generating capacity of under 40MW, not the apples and oranges comparison of 192MW wind works versus a 192MW base-load power plant.

- a capacity factor of only 33.9%, which indicates the site is not actually a high wind resource as claimed.

- substantial upfront greenhouse emissions that have been ignored in justifying the projct's contribution to reducing.

- a substantial requirement for airspace and hence the ground disturbance footprint is largely irrelevant.

- a capital cost recovery per mega watt than alterative generating types, which is more than subsidised by taxpayers and consumers through higher or misallocated taxes and higher electricity prices.

- potentially damaging infrasound being produced and effecting human and animal receivers over 13kms or more from turbines, but which is ignored in the Assessment.

- the unsustainable need for subsidies and beneficial treatment to support an otherwise unviable project.

Given just the above and the fact that the project requires dozens upon dozens of mitigation actions, many of which will not be finalised until after approval, we fail to see how anyone can conclude that the project is in the public interest. Mitigation is not elimination. The accumulation of all the mitigation actions that are proposed for this project indicate it is a high risk project that will cause harm greater than any claimed benefits.

Conclusion

This submission highlights several of the deficiencies in the Assessment and conclusion. For the IPCN to consent to the Thunderbolt Wind Works project will require it to ignore the facts as presented in our submission. The project is not approvable nor in the Public Interest.

APPENDIX A:
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.