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From

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> **"Nuclear is the perfect antidote to the energy challenges facing Britain - it's green, cheaper in the long term and will ensure the UK's energy security for the long-term.**
>
> **This is the right long-term decision and is the next step in our commitment to nuclear power, which puts us on course to achieve net zero by 2050 in a measured and sustainable way.**
>
> **This will ensure our future energy security".**
>
> - **Rishi Sunak,**
>   **Prime Minister of Great Britain**
>   **(at launch of the document "CIVIL NUCLEAR: ROADMAP TO 2050" January 11, 2024)**

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1.SUMMARY RESPONSE TO QUESTION 1.

In its "*Draft 2024 Integrated System Plan*" AEMO called for submissions from the public and listed the following as the first of the ISP submission questions:

> *1.Does the proposed optimal development path help to deliver reliable, secure and affordable electricity through the NEM, and reduce Australia's greenhouse gas emissions? If yes, what gives you that confidence? If not, what should be considered further, and why?*

The answer to this question is a resounding NO.
The reasons for this response are many. Some relate to the inherent characteristics of the component technologies that make up the Australian electricity grid as envisaged by the "optimal development path". Some of these characteristics demonstrate serious inadequacies.

With regard to **reliability**:

Solar is not reliable other than it may be available about 8-10 hours from dawn to dusk. Its peak is in the middle of the day when there is often excess electricity available from other solar plants and from rooftop solar. The excess of availability at this time is reflected in the price at this time which is often extremely low or even negative.
Solar is dependent upon the weather. A cloudy day and a cloudy season will generate less electricity. It can't be relied upon to generate a stable electricity supply.

Wind: Turbines cannot be relied upon fully for consistent power generation.
The wind blows according to differences in atmospheric pressure. It's variable, intermittent and viably generates electricity onshore about 30% of the time, offshore higher probably 40% of the time. Thus, both wind and solar are "never-fully-reliables".

Further, both wind and solar require vast tracts of land and and/or sea to accommodate the millions of panels and thousands of turbines which will be required. The higher the penetration of these "renewables' into the grid the more chance there will be of major breakdowns of, or damage to, these square miles of technology. Can such widely distributed technologies be cost-effective over a significant time-frame?

With regard to **security**:

Australia has no local manufacturing capability to produce **wind turbines** and **solar panels**. We are almost completely dependent on China. Is it intelligent national security policy to knowingly, and continuously, put "all our eggs in one basket" over which we have no control, in a domain -electricity production and distribution – which is absolutely crucial to the continuing functioning - and even existence- of Australian civilization?

How do we characterize thinking which at the same time, undertakes to spend billions of dollars on the AUKUS project to provide nuclear powered submarines to protect Australia from any 'adventurism', let alone outright war, by China and at the same time with full awareness, commit ourselves to complete manufacturing dependence on China for the components of a renewables-led electricity grid?

Further, the capital equipment for wind and solar will need to be replaced in approximately 15 -25 years. That is, after we have invested billions and built millions of pieces of technology, we will have to do it all over again..... in the pious hope that China will still remain a secure and reliable trading partner and will continue to be so until we have completed the subsequent round of re-building.

The technology to provide **stable, reliable** and **secure** back-up or "firming" for solar and wind is not available nor economically viable. Large scale grid batteries are not commercially available or too expensive, pumped hydro power "batteries" such as Snowy 2 are too expensive and gas, although readily available in Australia is expensive. Use of back-up power always begs the question why not solely use reliable, low-cost base load power such as coal or nuclear!

Affordability

The paragraphs above are in the nature of broad generalisations in relation to the security and reliability of our electricity grid. This document however will concentrate on the third characteristic identified in the request for comment, **affordability.**

The ISP makes a very great deal of the claimed cheapness of renewables. At the second paragraph of the Executive Summary, the ISP states:

> *"….renewable energy, connected with transmission, firmed with storage and backed up by gas-powered generation is **the lowest cost** way to supply electricity to homes and businesses throughout Australia's transition to a net zero economy".*

Such words are then repeated, like a mantra, many times in the document, commencing at the beginning of Part A (p.21).

The problem is that this claim that renewables, including transmission, firming, storage, and gas-powered generation, are the cheapest form of electricity generation is **demonstrably false.** The majority of this submission will be devoted to demonstrating this assertion.

AEMO bases its claim for the cheapness of renewables on the GenCost document which it produces with CSIRO. As noted on p.44 of the ISP: "*AEMO projects this mix based on capital and operating costs from GenCost".* However, GenCost suffers from a number of crucial inadequacies. In summary, the main problems with GenCost are[1]:

1. The omission of any detailed consideration of the **true cost of the large-scale nuclear base-load reactors. Such costs are available from the countries already using nuclear generation.** The GenCost material, in assessing the

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1.Some of the problems with GenCost have been detailed in articles and follow-up discussion in the press. See the Letter to the Editor in The Australian dated 26/7/2023 from Paul Graham, Chief Energy Economist, CSIRO in response to an article in The Australian of the previous day, by Claire Lehman quoting several 'expert' commentators who strongly queried the CSIRO 'methodology.

comparable costs of nuclear as against renewables, chooses to make observations **only** about Small Modular Reactor (SMRs) which are nowhere in production on the planet, at an industrial scale. It instances one model which has yet to be developed fully but registers some reservations about the use of available data.

It then briefly wonders if nuclear reactors at scale "**may**" not be suitable to Australia and therefore their relative costs can be ignored. Farcically, this gives no credit to the actual costs of large scale reactors successfully built and operating over the last 10-15 years.

2. The time frames over which comparisons are made should include **the actual expected time the technology or plant will be in productive operation**. It is fallacious for GenCost to declare nuclear is financially non-competitive when it declares 2050 is the cut -off point for any costing comparisons. It fails to calculate the productivity of nuclear over its standard life which is currently 50 -60 years and which if built now would last well beyond 2050.

3. The "capacity factor" of each technology or plant should be clearly identified and the actual capacity - as distinct from the 'plated capacity' - required to generate and deliver a stated quantity of electricity should be included and identified in the cost calculations. Thus for wind and solar, the actual capacity (expressed in MW) needed to generate the 'plated capacity' of the plant will be substantially more than the plated capacity. [See Section 4.3 below]

4. The GenCost documentation makes no reference to other methodologies being used internationally to calculate the **full** costs for the production of electricity over the **total actual or expected life-cycle** of technologies already operating.[See Section 2 below]

These issues will be treated more fully below. To place them in a broader context of the costings of electricity generation in countries which are key, large-scale generators and users of electricity, this submission will:

- firstly, look at some examples of different methodologies for costing and
- secondly, by way of comparison with a different approach to the design and operation of a large-scale electricity grid, the submission will report on the more recent decisions to achieve a "renaissance of nuclear" in Great Britain.

The final section will examine in more detail some of the issues summarized in points 1 to 3 above, in particular the costing of constructing and operating a large-scale nuclear power plant.

2. RESEARCH STUDIES ON "FULL COSTS" METHODOLOGY.

A very significant amount of analytical research work on the full costings of electricity generation has been carried out overseas, drawing on the **actual performance** and **full costs** of renewables and fossil fuel plants and nuclear. Here are just two very recent articles devoted to costs:

- Dr. L. Schernikau, Prof. William Hayden Smith, Prof. Emeritus Rosemary Falcon : **"Full Cost of Electricity 'FCOE' and Energy Returns 'eROI'** in **Journal of Management and Sustainability** Vol.12, No. 1 June 2022. (Published by Canadian Centre for Science and Education).
- Robert Idel: "**Levelized Full System Costs of Electricity**" in **ENERGY JOURNAL** Vol. 259, 15 Nov., 2022. (Published by Elsevier)

Full copies of these articles are attached.

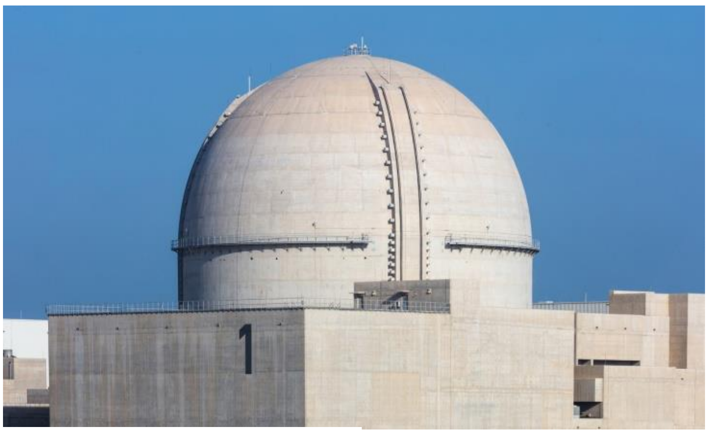
The first article is particularly extensive in its coverage of relevant experts and organisations (especially the major international groups in energy policy such as the IEA). It presents the arguments for what it calls the Full Cost of Electricity (FCOE). After a considered assessment of all of the relevant data, the authors conclude:

> *Using FCOE or the full cost to society, wind and solar are **not cheaper than conventional power generation** and in fact become more expensive the higher their penetration in the energy system….. If wind and solar were truly cheaper – in a free market economy – they would not require trillions of dollars of government funding or subsidies or laws to force their installation.*

This conclusion is firmly based on the inherent characteristics of "variable renewable energy" (VRE) systems such as solar power and wind, the authors' point being that these elements are essential aspects of VRE and no amount of over-building or backup/storage will compensate for their short-comings. They reference the OECD NEA 2018 study: "The Full Costs of Electricity Provision"(p.39) to illustrate their claims:

> *"When VREs increase the cost of the total system….. they impose such technical externalities or social costs through increased balancing costs, more costly transport and distribution networks and the need for more costly residual systems to provide security of supply around the clock".*

These inherent characteristics are summarized in Figure 1 below, summarizing the relevant sections of the paper.



Reactor No 1 at Barakah, United Arab Emirates

Figure 1.

INHERENT SHORTCOMINGS OF VARIABLE RENEWABLE ENERGY FOR RLECTRICITY GENERATION.

1. CAPACITY FACTOR	**Low capacity factors due to site characteristics (resulting in intermittency and unreliability) of wind and solar.**
2.ENERGY DENSITY	**Low energy densities, i.e low availability of wind and solar irradiance per m^2. This results in large space requirements increasing 'territory' costs.**
3. ENERGY EFFICIENCY	**Low energy efficiencies and resulting economic losses from power generation, conversion, conditioning and transmission. (Note this statement applies to electricity generation at grid scale).**
4.CORRELATED WIND/ SOLAR RESOURCES	**Continental sized areas of highly correlated wind speeds and solar**
5. LIFETIME	**Short lifetime of wind and solar installations, becoming shorter because of "repowering".**
6.BACKUP / STORAGE	**Critical requirements for, and under-utilization of, backup up power stations or long-duration backup energy storage systems that needs to equal essentially 100% of solar and wind installed capacity.**
7. MINERAL RESOURCES	**Natural resources and energy demand for mining, transportation, manufacturing and re-cycling of wind and solar installations and required backup/storage systems.**
8.RECYCLING	**Increased recycling challenges due to complex chemistry and short lifetime affecting economics and the environment.**
9, eROI AND MATERIAL EFFICIENCY	**All the above translates to inadequate energy return on investment and low material efficiency when accounting for all embedded energy of the total energy system**

The article by Schernikau et al.is most notable for the detailed list of required costs that have to be calculated to produce a comparison of cost-effectiveness across types of electricity generation which is complete, which can be applied to non-dispatchable types of generation, and which covers appropriate time-frames. The authors provide a detailed explanation and example of each of the costs and references other authors on relevant aspects. They point out that the IEA in France, the International Energy Economics Institute in Japan, the OECD and the US Energy Information Agency have all demonstrated many times the incompleteness of the Levelised Cost of Electricity (LCOE) (the most commonly used system), but it continues in use including by the GenCost team. Figure 2 presents a summary list of the key elements of the FCOE (Full Cost of Electricity) proposed by the authors.

FIGURE 2.

ESSENTIAL ELEMENTS IN A FULL COST ANALYSIS OF ELECTRICITY GENERATION.

- Territory. Cost of land (sea) 'footprint' or the space required for the generating facility. Renewables have a much greater footprint per unit of energy produced.
- Building/ Constructing the generation equipment/facility.
- Material input per unit of service. ie. the use of raw materials (steel, concrete, glass) per unit of electrical capacity. Coal, gas and nuclear are superior to renewables.
- Fuel - including transport to the site of the facility
- Operating the generating equipment, including maintenance and repairs
- Transportation and transmission systems to the end user, including high volume power lines, grids, stations, load balancing, inverters etc
- Storage – e.g pumped hydro, batteries, hydrogen. Full cost of storage will include building, operating, recycling, installation of new storage at life's end and volume high enough to cover at least medium time spans of non-production from VREs.
- Backup, redundancy, overdesign as well as backup conventional systems, such as gas. **Each variable renewable system requires 100% back-up and/or storage**.
- Emissions. Particulate matter, sulphur and nitrous oxides, greenhouse gases. Should include the benefits of CO2
- Lifetime, length of use. Solar and wind require replacement with decommission or recycling every 20-25 years. Nuclear runs for 60+ years.

And a further measure of cost-effectiveness is **Energy Return on Investment (eROI),** which calculates energy generated per unit of energy input. Eg. Solar and biomass in Northern Europe 2-4 to 1; **nuclear 75 to 1**; coal & gas~30 to 1.

3. COMPARISON OF THE UK'S APPROACH TO NUCLEAR WITH AUSTRALIA'S

Australia's Energy Security is under threat. Minister Bowen's proposals for an electricity grid comprising 82% renewables by 2030, and devoid of any nuclear capacity are inherently flawed and advocated by no other country in the world. Australia is the only country among the G20 which legislatively bans the construction or use of nuclear technology for generating electricity!

By way of comparison we can summarize the most recent initiatives by the Government of the UK. In September 2023 Prime Minister Rishi Sunak gave a major speech covering several key policy areas, among them energy. He stated:

> "*we're building new nuclear power stations for the first time in thirty years. Just this week, we took a significant long-term decision to raise funding for Sizewell C - putting beyond all doubt our commitment to decarbonising our power sector.*
>
> *And later this autumn, we'll shortlist the companies to build the new generation of small modular reactors*".

Then on 11 January this year his government released "**CIVIL NUCLEAR: Roadmap to 2050**". It referenced the UK's

> " *modern understanding of nuclear power as* ***the only current form of reliable, secure, low carbon electricity which can be deployed at scale in the UK and as a key component in the drive for net zero.*** *Accordingly, the government has taken the decision to reverse decades of under-investment and to recover the UK's global leadership in civil nuclear.*
> *This Roadmap sets out the pathway to a UK resurgence in civil nuclear…*
> ***There is no credible pathway to net zero nor energy security without nuclear power and now is the time to act".***

In his speech launching the Roadmap PM Sunak made the following telling remarks which underline the vast difference between the UK's approach to calculating costs for electricity generation and Australia's current beliefs and hopes:

> *Nuclear is the perfect antidote to the energy challenges facing Britain - it's green**,*** ***cheaper in the long term*** *and will ensure the UK's energy security for the long-term. This is the right long-term decision and is the next step in our commitment to nuclear power, which puts us on course to achieve net zero by 2050 in a measured and sustainable way.*
>
> *This will ensure our future energy security".*

The hi-lighted words are a dagger at the heart of Australia's adoption of the mantra "renewables are the cheapest form of energy". Although there is a group of engineers and technicians who have experience in the operation of the reactor at Lucas Heights used for the production of nuclear medicines, our political and bureaucratic planners have little or no actual experience of running a nuclear- powered plant, nor of the costs incurred nor of the planning for "the long term" management of the asset and ultimate de-commissioning of the plant…. And place all their faith and trust in one CSIRO costing analysis, which is manifestly inadequate!

Contrast this with the UK:-

- The Hinkley Point C project is nearing completion. It consists of two 3.2GW reactors. It will supply enough "always-on", affordable electricity to power some 6 million homes!
- The Sizewell C project has been approved by the Government and 700 million pounds have been committed as the Government's initial contribution to the joint venture with EDF of France. A court challenge was defeated. A Development Consent Order allowed construction to begin this month, January 2024. It is of the same magnitude as Hinkley Point C, two 3.2GW reactors. Its nominated productive life is 60 years. It is scheduled to be constructed by 2030, based on "learnings" from the Hinkley Point Project.
- The Civil Nuclear Roadmap contains the proposal that :

> *For longer-term clarity we are also now committing to:-*
> ***Exploring a further large-scale reactor project (of the same size as Sizewell C)*** *and setting out timelines and processes this Parliament, subject to a Sizewell C Final Investment Decision.*
> *Aiming to secure investment decisions to deliver 3-7GW every five years from 2030 to 2044.*

- The Government is moving to create or strengthen supply chains across the complete uranium/nuclear cycle. The Roadmap states:

> "*To ensure access to a secure and resilient supply of nuclear fuel….we will deliver UK High Assay Low Enriched Uranium(HALEU) enrichment and deconversion capability by investing up to UK300million pounds alongside industry*".

- The Government has announced a new National Policy Statement *"which can facilitate the rollout of SMRs and Advanced Modular Reactors (AMRs) (alongside GW-scale projects), to meet our ambition for up to 24GW by 2050".*

In summary, the UK Government is committed to some major GW-scale projects at very considerable cost **precisely because they will be economically viable and affordable over the long-term planning horizon**. Along with these major projects, they are pursuing vigorously the design and development of modular reactors of varying sizes and capacities.

Lest the reader might be tempted to regard these decisions by the UK as "a-typical" or "one-off", it is worth recalling that France (as reported in November 2023) has committed to building **six (6) new European Pressure Reactor 2 plants, each with 1670 MW capacity,** which are scheduled to come on-line in 2035 and have an operating life of 60 years. They have announced that a further eight (8) are under consideration. These will be additional to France's current 56 reactors.

4.DETAILED CONSIDERATION OF ISSUES IN GENCOST.

4.1 EXAMPLES OF BASE-LOAD NUCLEAR REACTORS BUILT ON TIME TO BUDGET.

GenCost at section2.4.4 makes some brief comments about large-scale nuclear plants and whether they could be used in Australia. It states:

> *Australia's state electricity grids are relatively small compared to the rest of the world and planned maintenance or unplanned outages of large scale nuclear generation would create a large contingent event of a gigawatt or more that other plant would find challenging to address. In the present system, it would take two or more generation units to provide that role. As such, large scale nuclear plants which are currently lower cost than nuclear SMR* ***may*** *not be an option for Australia, unless rolled out as a fleet that supports each other which represents a much larger investment proposition*.

And then, regardless of the fact that wind farms and solar arrays may well be subject to "planned maintenance" or "unplanned outages" with similar need for significant remedial action, GenCost concludes:

> "*given overseas nuclear electricity costs* ***may*** *be referring to technology that is not appropriate for Australia….. there* ***may*** *be no meaningful comparison that may be made to Australia's circumstances*."

Given the information about the UK presented above at Section 3, we may well wonder what the British would make of this somewhat off-handed dismissal of a technology that they are now investing further billions in!!

And instead of letting the word "*may*" slide by unchallenged, we here in Australia may well expect that the GenCost authors could have spent some useful time in discovering what technology was actually being referred to and what are the actual costs of building and operating it. After all, the information is available ! (See below at end of this Section).

Base-load Nuclear power plants are consistently dismissed by Australian Government politicians as being "impossibly expensive" and taking "decades" to build a plant. Such comments seem to refer mostly to projects in the North Atlantic countries (such as the UK, the USA, Canada and the EU). They focus on projects such as Hinckley Point C in the UK or the two Vogtle Plants in Georgia, USA, the first to be built in the USA for more than three decades. This habit of quoting relatively recent "builds" in only the USA or Britain (while ignoring China, India, Japan and South Korea) to "prove" cost and time unacceptability, overlooks examples such as the very successful achievement of the United Arab Emirates (UAE) where South Korean contractors have built and commissioned four APR 1400 MW reactors at Barakah in just over 10 years (2012 – 2023). During that period, the South Korean contractors also built and commissioned four more reactors in their own country!

The cost was reported as just in excess of US$20b, far cheaper than the costs – disclosed to date- for the Australian "renewables transition" described in the AEMO ISP. This is before the full costs to the tax-payers for the enlarged Capacity Investment Scheme, which are currently ‘suppressed’, (allegedly for “commercial in confidence” reasons) are actually revealed!

The publicity given to nuclear at the COP28 conference in Dubai and the opportunity for delegates to learn first-hand about the recently constructed four reactors at Barakah has made this feat much better known but it is worth providing the detail which demonstrates that **Australia could at the present time contract South Korea to build a series of these APR 1400 reactors as the back-bone of Australia’s electricity grid. They would provide the guarantee of always-reliable and available electricity at an affordable cost for decades into our future.** The key details are these:-

- The APR1400 MW reactor is a “Generation three plus” reactor developed from the earlier model 1000 around 2010. It was carefully adapted after the Fukashima incident in Japan by measures such as strengthening the foundations, converting all doors to waterproof models, strengthening the containment dome etc.
- This model has been “accredited” in the EU by obtaining in 2017 the European Utilities Requirements (EUR) Certification that it is an evolutionary Advanced Light Water reactor fully complying with the EU requirements and European codes and standards.
- It has also received, in August 2019, Design Certification (DC) of this model from the Nuclear Regulatory Commission (NRC) in the USA, which confirms that it meets the relevant safety requirements.
- The brief history of the project at Barakah is that construction of the first plant commenced in 2012. Construction was completed in 2018, within six years! Testing and commissioning followed and the plant was connected to the grid in 2020. The second plant was commenced in 2013 and completed in 2020 and connected to the grid in 2021. The third plant was commenced in 2014 and began commercial operation in 2023. The fourth plant’s construction was completed in July 22 and was connected to the grid in 2023. In summary, four plants were constructed and entered service to supply around 25% of the country’s electricity needs in a period a little over 11 years.

  It achieved this from a position in which the country had no previous experience with nuclear operations and needed to educate a large technical and engineering workforce, many of whom were taken to South Korea for training. And the working language for the whole project was …English!

  Australia on the other hand has been actually operating a nuclear reactor at Lucas Heights for decades (albeit not generating electricity), has a small cadre of trained and experienced technicians and has extensive experience, as a major producer of uranium, in the production and transfer of uranium for enrichment and with the international protocols which govern the uranium cycle, including the treatment of waste at all levels.

These details point to the opportunity for CSIRO to obtain the relevant financial data from the UAE and South Korean Governments, along with the World Nuclear Association, to adapt their GenCost methodology to show what the relative cost-benefits are for base-load, large scale reactors in comparison to wind and solar.

4.2 CRUCIAL IMPORTANCE OF LIFETIME OF TECHNOLOGY OR PLANT

The GenCost report clearly sets a time deadline on the costing process which it is presenting. This is 2050, presumably because that is the year when Australia, along with a number of other countries, aspires to have reached 'net zero' in CO^2 emissions. This is an artificial and arbitrary decision in the methodology and ignores some major factors in the comparison of the costs of various technologies.

For VREs such as wind and solar, the expected life-span for their operations is somewhere between 20 and 25 years. Thus, some of the facilities constructed in the mid nineties in the first round of close-to-grid-scale build-outs are now being de-commissioned, de-mounted, and either recycled (for the small amount of componentry for which it is feasible) or treated as scrap in waste-fill.

The de-mounted facilities will then have to be replaced with new equipment. At the current level of VRE technology, this process will have to be repeated each 20-25 years. So the cost of providing VRE electricity at scale must incorporate these costs. In Australia's case, the large quantity of wind farms and solar arrays that have been built in recent years - and which will be built up to 2025 - will all have to be de-mounted by the designated year of 2050… and then we will have to start the re-building!

The (obvious?) comparator for cost purposes is base-load nuclear plants many of which have a life-span of 60 years, such as the reactors being constructed in the UK. But existing fleets of reactors (e.g in France and the US where Diablo Canyon reactor in California illustrated the process) can have their life-spans extended, in some cases, by up to a decade. In short, if we build a grid from renewables and batteries and gas back-up and a grid from base-load nuclear, than after 60-70 years each nuclear plant will be chugging along, still with a capacity factor of around 90%, while the VREs will be heading for their third or even fourth builds and re-builds!! Will GenCost tell us at what total cost?

GenCost follows the convention, in costing electricity generation, of using the metric of 'dollars spent per MW produced'. So to employ a costing indicator that accounted for the time the facility was producing electricity over its total life span, we might use

> Total costs **over life-time** divided by total number of MWs produced = cost per MW

Such a cost would be an indication of the actual cost that had to be paid whether the facility was owned and operated by the government, or by a commercial corporation or by a public-private consortium. (GenCost places significant emphasis on their perceived need to get costings mainly for commercially owned/operated plants). Depending on ownership, the cost of capital would be expected to be factored in.

In addition to the issues raised above about the actual wind turbines and solar panel arrays, a complete costing process would have to factor in the costs of:-

- replacing the storage batteries (including waste disposal of 'flat' batteries) required by a high penetration VRE grid and
- building, maintaining and up-grading as required the thousands of additional kilometres of high strength transmission lines that will be required to convey the electricity from the production sites to the areas of need.

4.3 CONSEQUENCES OF DIFFERENT CAPACITY FACTORS FOR DIFFERENT TECHNOLOGIES IN RELATION TO COSTS

The term "capacity factor" is used in energy production to indicate the proportion of time that a facility or generator is actually producing what it is designed to produce. In daily language we comment that something is "operating at full capacity" and mean that it is producing all that we can expect it to.

In electricity generation, many facilities have an actual production capacity which is lower than the "plated' capacity or amount that it can theoretically produce if operating constantly at its full strength. For VREs the actual capacity factor will never be at the peak of its possible performance. The capacity factor for solar power is below 50% simply because the sun goes down each night. It is even lower because cloudy or rainy weather will additionally curtail the hours of sunshine.

The capacity factor for wind turbines will be affected by any period where there is little or no wind, or in some cases by the presence of such high winds that they have to be shut down to prevent damage. Figures of around 50% are quoted for wind turbines. Thus VREs inescapably experience "intermittency" in their performance.

The practical conclusion in relation to the full cost of electricity generation is that the size of wind farms and solar panel arrays will have to be significantly larger than their 'plated' capacities. If for example the solar panel array has been built with the aim of providing 800MW of electricity constantly over a defined period, then because its capacity factor is, say 35%, to produce 800MW of electricity in the time frame required it would have to have available 2.8 times the "capacity factor", so that it could produce enough electricity during the "sunny" hours to supply the immediate needs of users, as well as "over-producing" and then storing in the batteries the electricity needed by the users in the solar array's downtime. .

A related factor is that for grids composed largely of VREs there will be a requirement for backup from pumped hydro, storage such as big batteries and peak generation facilities such as gas, to provide replacement generation when the VREs are not generating. This will in effect be a 100% replication of the VRE grid! This is an astounding fact little remarked upon, or apparently little known, by proponents of renewables. In short, when you choose to build a grid composed predominantly of renewables, you are choosing to build TWO grids! How can this be an economical proposition?

5.CONCLUSIONS

The “optimal development path” set out in the ISP is inadequate to provide Australians with **guaranteed reliable, secure and affordable electricity**. Australia is faced with a clear and present danger of shortfalls in our electricity supply and paradoxically at the same time, increases in the price of electricity. The higher the penetration of the renewables into the grid the greater this danger becomes and the more costly building the grid and then remediating damage becomes.

The inescapable “intermittency” of wind and solar requires – besides the vast arrays of solar panels and wind farms and transmission lines across our landscapes - additional components in the grid including very large storage batteries of a size and in numbers that Australia is nowhere near installing, some pumped hydro and an unspecified, large amount of gas “peaker plants” to ensure that in periods of “intermittency” there will be an uninterrupted flow of electricity. Ensuring a constant supply of gas will also be difficult in the face of relentless campaigning by activists to shut down gas fields and exploration. Co-ordinating the inputs from each of these sources of supply will be a complicating additional task.

Building the solar panel arrays and the wind turbine farms will be a colossal task, for which we are completely dependent on a foreign power to supply almost all the fabricated components. Thus we have questionable “supply chains” with the possibility of very substantial delays in obtaining construction materials or completely blocked supply. The timetable for all coal-fired power being de-commissioned by 2038 should be urgently re-examined and contingencies planned and implemented as soon as possible. All possibilities including the construction of a HELE (High Efficiency Low Emissions) coal plant on the coalfields at Callide in Queensland should be in the mix of considered candidates.

The demonizing of nuclear power plants should no longer be tolerated. Cool reason should dictate that the first step is to have AEMO contract CSIRO to produce a Special GenCost report which compares renewables with base-load nuclear power plants (leaving consideration of SMRs for another day when the advantages, costs, benefits and special construction processes have been hammered out successfully). In particular the comparison should be over the full life-time of the longest-lasting technology, in this case nuclear. This special costing should include all of the items set out in the paper by Schernikau et al. discussed in this submission. The results of such a comprehensive inquiry might then be expected to show that nuclear over a life-time comparison is the cheapest form of electricity generation. Such a conclusion, confirming Prime Minister Sunak’s claims, would demand debate in Federal Parliament with a view to repealing the anti-nuclear legislation from 1998-99 and developing a compelling and successful approach to Australia’s energy security. The foundation of this could be a “back-bone” of 8 to 10 APR 1400 reactors which would provide guaranteed base-load power in all weather and would reap the benefits in efficient construction and lower costs resulting from being “nth in the series” instead of a pioneer.

Finally, a crucial question remains hovering in the air above the contending view-points in Australia. That question is:-

If Emmanuel Macron the President of France could confidently proclaim in 2022 that

> ‘*the key to producing electricity in the most carbon-free, safest and most sovereign way is precisely to have a plural strategy….to develop both renewable and nuclear energies. We have no other choice but to bet on these two pillars at the same time. It is the most relevant choice from an ecological point of view and the most expedient from an economic point of view and* ***finally the least costly from a financial point of view”***

And if the Prime Minister of Great Britain, Rishi Sunak can declare, in January 2024 that

> “*Nuclear is the perfect antidote to the energy challenges facing Britain - it’s green,* ***cheaper in the long term*** *and will ensure the UK’s energy security for the long-term.*
>
> *This is the right long-term decision and is the next step in our commitment to nuclear power, which puts us on course to achieve net zero by 2050 in a measured and sustainable way.*
>
> *This will ensure our future energy security”.*

………..then when will the decision-makers in Australia acknowledge the obvious truth about nuclear and renewables which Macron and Sunak are proclaiming and introduce an energy security programme in our own country to give life to this truth?