Sunshine Hydro Response to Draft 2024 Integrated System Plan (ISP)

Australian Energy Markets Operator (AEMO)
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(lodged by email to isp@aemo.com.au)

Date 16 February 2024
Subject: Feedback on the Draft 2024 ISP

Dear AEMO ISP Team,

Sunshine Hydro welcomes the opportunity to comment on the Australian Energy Market Operator's (AEMO) draft 2024 Integrated System Plan (ISP). We commend the ISP as a widely accepted and referred model of the future state of our energy system and note the heavy responsibility that such a key document bears in shaping the future.

The Draft ISP invites response to 5 questions and we wish to respond to question 1 and 3 in the following ways.

> *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?*

We believe the proposed ODP can deliver a higher confidence level by considering the value of sector coupling with hydrogen, and the imperative of close alignment between policy and techno-economic essentials. We also wish to challenge the role of gas and ask for more clarity on the language around it.

> *3. Does the Draft 2024 ISP accurately reflect consumers' risk preferences? If yes, how so? If not, how else could consumers' risk preferences be included and what risks do you think are important to consider?*

We wish to discuss consumer risk preferences and in particular consumers such as export industries and industries exposed to strong social licence imperatives. In particular we refer to the need for 24/7 traceable carbon-free energy and its role in protecting Australia's exports. We expand on these topics in our submission attached.

Yours faithfully
Chris Baker

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To put these comments into context, we will start by providing some background about us and our solutions.

Sunshine Hydro - developer of pumped hydro for 24/7 CFE and green fuels

Sunshine Hydro is a developer of long duration storage projects which are financially coupled with hydrogen production and contractually bound to real-time wind and solar contracts, and contracted with customers using PPAs designed to deliver 24/7 carbon-free electricity. When the various contracts between entities are structured in the right manner it can result in delivery of 24/7 carbon-free electricity even through the most difficult conditions expected in a 100% renewable energy grid. We call this group of contractually bound assets a Superhybrid and we provide more detail of this proposition in the appendix.

24/7 carbon-free electricity is a term that refers to energy delivered from local renewable sources for every hour of every day. The 24/7 carbon-free energy compact is a global community dedicated to decarbonisation of the electricity system. A recent member of the 24/7 CFE Compact is the United States Government which announced its membership on 5 Dec 2023. Other key members include Microsoft and Google who are seeking to have all their energy delivered from 24/7 CFE. Sunshine Hydro is a member and we design systems that can deliver 24/7 CFE without having to wait until the entire grid is decarbonised.

Hydrogen production is included in this asset ecosystem because it supports the electricity grid. It is used to provide a flexible load and this role is critical in helping to shape the profile of VRE and to avoid curtailment of valuable resources. Hydrogen is then converted to methanol or other green fuels or ammonia, depending on the market needs. In this submission we refer to methanol quite often, however in most cases it can be substituted with other hydrogen derivatives such as Sustainable Aviation Fuel and Ammonia.

The Risk of not using 24/7 carbon-free electricity

Both the EU and the USA intend to require that products not using hour by hour balanced green energy for their production will be penalised with a border adjustment mechanism. If Australian goods are not produced by traceable 24/7 CFE then they will be penalised. We believe it's important to design a system today which can produce what is needed without having to wait until the entire grid is decarbonised.

The value of hydrogen production as part of the electricity grid

A primary role for hydrogen production in our model is to provide services for the electricity grid, and the hydrogen produced can be considered as a secondary benefit.

The Draft ISP does not seem to value the role of hydrogen as a key participant in the electricity grid. **From our modelling we see many benefits and we believe these benefits should be more deeply integrated into the ISP.**
Currently we believe that the best value for hydrogen is to make e-methanol from it. When hydrogen is stored as methanol it can help provide the means for seasonal time-shifting of energy to deal with the “winter problem” of low energy and high demand.

When hydrogen production is an integral part of providing 24/7 CFE to the market, it can earn additional revenue by offloading the electrolyser at times when grid prices are high. This makes the grid more resilient because the grid has additional dispatchable energy available. Typically this kind of offloading would occur each day in line with the evening peak demand - or with the aid of pumped hydro, in anticipation of such peak.

There’s also another kind of offloading that is still in response to high prices in the grid but instead of being in response to the daily demand cycle, as mentioned above, is in response to seasonal or unexpected shortages of energy. There are various examples of this, and when we modelled the years 2018 to 2022 in Victoria we found that the main offloading would have occurred due to an unexpected failure of generating plant at Callide power station, and the various impacts in 2022 including the global effect of the war in Ukraine. Both of these events pushed up prices in the NEM and the Superhybrid system responded by offloading hydrogen production.

When the hydrogen is converted to methanol it is possible to cheaply and easily store vast quantities of it. This is a stark contrast to hydrogen as a gas or liquid which is extremely difficult and expensive to store, even in small quantities. Therefore methanol can become a very useful way to deal with seasonal variations to energy availability, as discussed further in this submission.

Alignment of market rules to techno-economic necessities

Sunshine Hydro believes that a strong alignment between policy and market rules with techno economic essentials can result in a better grid. The Renewable Energy Target RET is an example of such a misalignment.

While RET was a well-functioning policy when first implemented, the proposal to continue it in the current form into the future incentivises generation at the wrong time of day. For example, solar farms are still being built even though the price in the market is largely less than zero at the time they will generate. The compensation they receive from LGCs encourages generation at any time.

The Energy-only dispatch market does not properly represent the cost of generation of power, which it is intended to do. Most of the energy is sold off market and the 5-minute market is really used as a dispatch mechanism to ensure proponents can deliver the amount of energy they need to defend their contracts, while also supporting technical limitations of the plant.

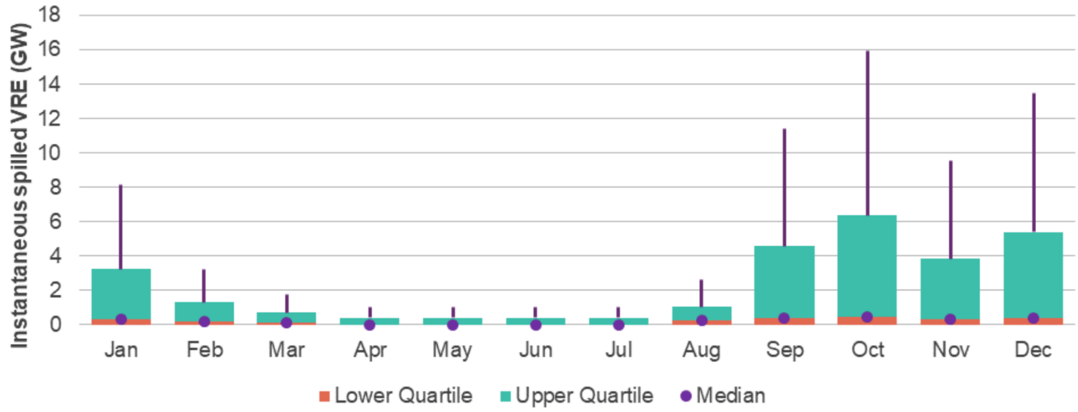
If we have a mismatch between the narrative — we will be 100% renewable — and the reality — we net the generation and consumption annually — the policy is not helpful to achieve the goal. **ISP, as an expert document, needs to help people and policy-makers to see these problems and call for policies that will support the grid to deliver the narrative**. For this example the policy narrative could be: “we will be 100% renewable every hour of every day”, leading to an hourly matched RET.

In our view it is critical that any renewable energy certification, such as the proposed REGO and GO must be time stamped with sufficient granularity to allow proper valuing of the time of generation.

The value of sector coupling

According to the ISP draft there will be significant spill of renewable energy particularly in spring and summer. (see figure 7 below taken from the ISP draft)

Figure 7 Forecast NEM frequency of spilled VRE capacity in 2039-40, *Step Change* (GW)



The large majority of spill is projected to occur during daylight hours on sunny and windy days, with much more VRE spilled in December than in June. The reduced solar resource in winter may lead solar developers to target winter yields in their solar farm designs. The seasonal trend of VRE curtailment also indicates long-duration storages could have a key role shifting energy on a seasonal basis to provide strategic energy reserves. AEMO views this as an important role to be performed by deep-reservoir hydro (see Section A4.6, Figure 18 and Figure 19).

This reinforces the notion that the need for deep energy storage has a seasonal requirement. AEMO states that

> *The seasonal trend of VRE curtailment also indicates long-duration storages could have a key role shifting energy on a seasonal basis to provide strategic energy reserves.*

Pumped hydro projects, with what is considered deep storage (more than 12 hours), can deal with time shifting energy within a day, or even moving energy from day to day. However the need is to be able to time shift energy over months and much deeper capacity is required for this.

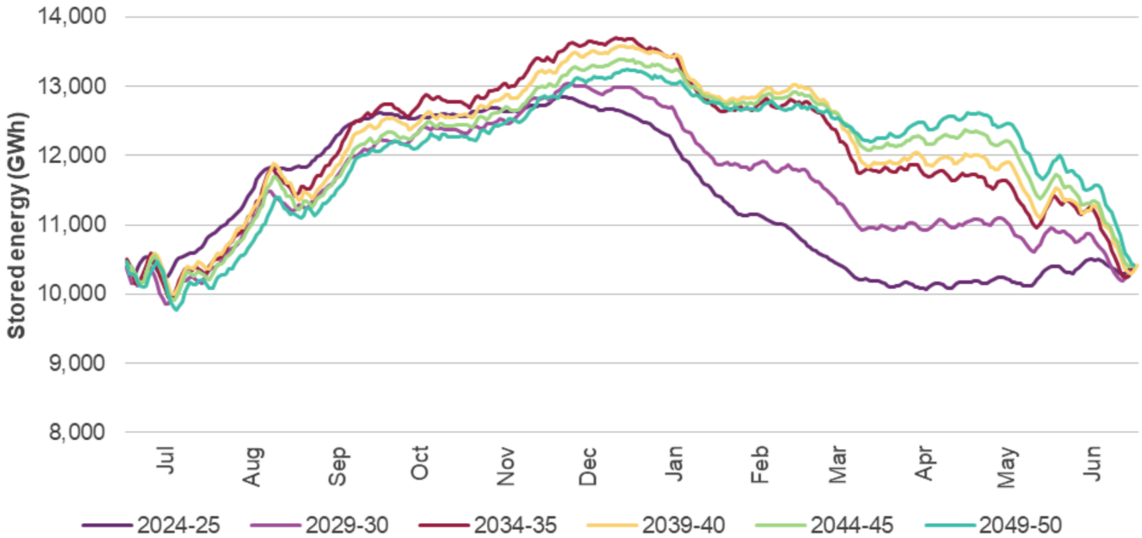
Methanol storage as an ultra-deep electricity storage

We propose that methanol storage can fulfil a similar role to that currently done by deep storage hydro reservoirs. A key difference is that the methanol storage can be replenished by utilising what would otherwise be spilled energy from variable renewable resources. However, what is needed is a functioning methanol market - which is fast developing - and conscious coupling of these two markets in the optimisation task of the asset ecosystem.

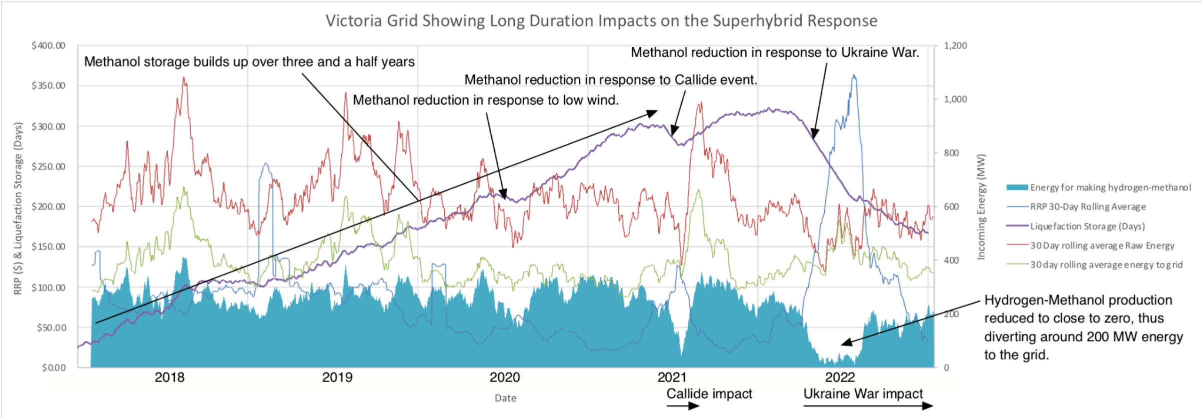
We are not proposing to convert electricity into hydrogen and then methanol, store it and then use methanol to generate electricity when needed. We are proposing to couple the methanol storage with long-term on-going methanol supply contracts on the market. While these contracts are normally supplied from the processing facilities, the methanol storage enables these facilities to be turned off even for extended periods, thus acting as a flexible load on the electricity market. This is demand management on a very large scale.

Deep hydro reservoirs are able to provide seasonal availability of extra energy by virtue of their ability to store vast amounts of energy and make it available on demand. Below is figure 19 from the Draft ISP and it shows the energy stored in hydro reservoirs over typical years. This is the sum of all deep hydro reservoirs in the NEM and the variation amounts to 3000 to 4000 GWh each year.

Figure 19 Daily energy forecast to be stored in deep storages and traditional hydro reservoirs over a year, *Step Change* (GWh)



Below is a trace of a modelled methanol storage as though it was operating in Victoria during the period 2018 to 2022. The purple line shows the level of methanol storage over that time. The biggest variation in storage occurs during 2022 and amounts to approximately 150 days at 200 MW per day. During this period hydrogen and methanol production is reduced to very low levels, and the energy that would have been used in normal production is made available to the grid. This extra energy is significant. The total energy involved is 720 GWh and is about double the energy that Snowy 2.0 intends to store as dispatchable energy.



However, other proponents should be encouraged to develop their own models for coupling the electricity sector with other markets where-ever the end-product creation is energy intensive and storing it is economic in comparison. This represents an opportunity to add flexible loads that we have not seen included in the ISP models to any significant degree, and hence **we propose to mention storage opportunities through sector coupling alongside with the traditional deep storage solutions like hydro storage**.

The Role of Gas in Australia's future grid.

We question the role of gas as presented in the ISP and wish to put forward the view that with the right combination of storage and the use of sector coupling there is no need for fossil sourced gas. There is certainly a role for peakers, but this should not be confused with a need for gas. We note that the ISP states that gas as mentioned in the ISP also notionally may include peakers running on hydrogen, but throughout the document, gas is playing a vital role in the future energy mix.

The ISP states:

During longer periods of low VRE generation the system will rely on transmission to deliver resource diversity, as well as on deeper storage technologies, hydro and gas-powered generation (GPG)

GPG provides critical support but gas supply can be constrained

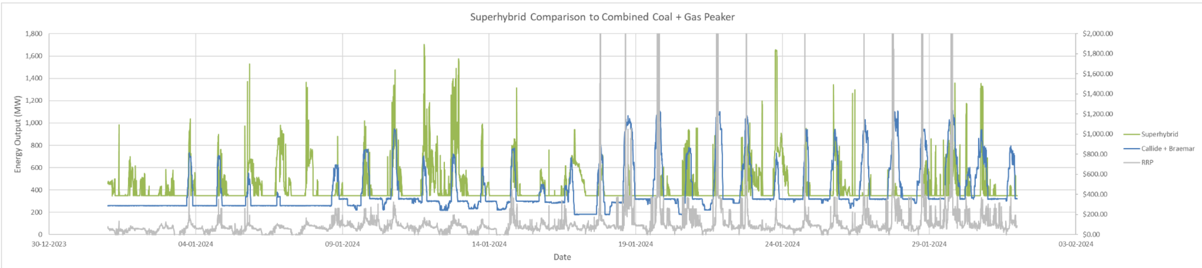
GPG is not defined in the Glossary of ISP but is fleetingly defined as gas powered generation in the document without the nuance of whether this gas can be non fossil fuel sources.

Sunshine Hydro has modelled many years of historical data of actual wind and solar traces and uses a dispatch model which includes only forecasts that are available at dispatch. So we believe it is a realistic approach avoids the potential risk of assuming perfect foresight, which occurs in some modelling . SH has created a digital twin of the proposed Djandori Superhybrid planned for the Miriam Vale area. If the project was running today in the NEM, and being dispatched according to bids created by AESOP, a trace of energy dispatched to the NEM for the past month of January would be as in the chart below.

The 24/7 carbon-free energy trace is shown in green. As a comparison the blue line plotted to the same scale is a combination of Callide B unit 2 plus Braemar gas peaker. The grey line is the market price for Qld (RRP). As the chart shows, the Superhybrid would behave quite similarly and could provide a similar level of service to the combination of these two fossil fuel stations. This model also includes a very strict requirement that the only renewable energy is used which means for example hydro pumping is done only with available contracted energy matched on an hourly basis.

The Djandori Superhybrid is a combination of these assets:
1600 MW nameplate wind generation
200 MW solar generation
600 MW pumped hydro with 11 GWh of storage
300 MW electrolyser producing hydrogen (and methanol)
50 MW peaker running on hydrogen or methanol

When the charting is run for a 5 year period the trace follows quite similar patterns to what is shown here.



As the example shows, peaking capability can be provided by alternative technologies as well as gas. However, the language is again important here. If ISP calls it “gas”, most people do not realise that it doesn’t need to be gas, and certainly not fossil gas.

We suggest to amend the wording throughout the ISP to talk about “peaking generators” rather than “gas” and to include a definition, which includes fossil gas, various green alternatives and other technologies capable of providing peaking capacity.

We also propose that the ISP use the technically correct term of fossil gas when referring to methane of fossil fuel origin rather than the misleading term of natural gas which we believe diminishes general understanding of the impact that this gas has on the natural environment.

Summary of Sunshine Hydro proposals

While we commend the great modeling and consultation effort that has gone into creating the Draft ISP, we want to emphasise the importance of language when communicating the results. The ISP is arguably the most important document in the development of our energy system in such a critical time of human history.

The old wisdom “watch your words, they become your actions” takes a new significance here at communal and sectoral level. The words in this document will shape the actions of policy makers, investors and businesses alike. Therefore, our suggestions are focused on the language, wording and inclusion of solutions within the definitions of the terms used in the ISP.

For ease of reference, below is a summary of the suggestions discussed in our submission.

1. ISP, as an expert document, should clearly point out to the public and to policy-makers where the policy narrative is not aligned with techno-economic necessities of decarbonising our grid.

2. We suggest hydrogen production could be more tightly integrated as a critical part of the electricity grid and as a provider of valuable grid services.

3. We suggest including deep storage opportunities through sector coupling and flexible loads as a possible solution for deep energy storage. We see value in remaining technology agnostic and using a generic term like “deep storage” rather than “hydro storage” for example.

4. We believe that amending the wording throughout the ISP (including the graphs) to use technology agnostic language for “peaking generators” rather than calling it “gas” would improve the impartiality of the document. We suggest to use a definition of peaking generators, which includes fossil gas, various green alternatives and other technologies capable of providing peaking capacity.

Appendix

Pumped Hydro Dilemma

Many pumped hydro projects are not reaching financial close despite having satisfied planning and technical design risks. The conclusion of most regulatory authorities, proponents and industry bodies is that pumped hydro projects are not commercially viable without government assistance. For example, the purpose of the NSW government LTESA scheme and the Federal Government CIS are to underwrite projects to help with their viability. The two pumped hydro projects under construction, Snowy 2.0 and Kidston rely on government support and it is likely that the Borumba project in Queensland will proceed and it is a wholly owned government project (it appears in the ISP as Indicative Pumped Hydro).

Malcolm Turnbull in his role as President of the International Hydro Association reiterates this view that projects need to be incentivised.

> *A competitive market mechanism that incentivises developers to build pumped storage hydropower (PSH) capacity is essential to meet the energy storage needs of rapidly changing power systems*
> ***Malcolm Turnbull, President of the International Hydro Association***[1]

GE Hydro summarises the situation well in a submission to the AEMC which reiterates this view that pumped hydro projects aren't viable in the business as usual approach to such projects. Additionally they point out the high value of the benefits that are delivered by pumped hydro projects. They lament the misalignment between costs to the developer and returns which are just a small fraction of the benefits that are created.

> *The overall economic case for pumped hydro is likewise extremely strong, with GE's internal analysis demonstrating that the 'peak shaving' services it provides would save electricity consumers hundreds of millions of dollars annually, enabling an economic payback period of less than 5 years in most cases. Consideration of additional benefits such as avoided transmission investment and regional job creation only serve to strengthen the case for investment in pumped hydro.*
> *Despite this positive context and a wealth of potential sites, many seemingly promising pumped hydro developments have stalled prior to FID. Feedback from investors and developers has primarily attributed this to insufficient size and certainty of the revenue streams available to them.*
> *Our internal analysis supports this conclusion, indicating that current market rules and structures create a misalignment between benefits and costs, in which developers incur 100% of the cost of building their projects, but receive less than 15% of the market benefits their projects create. The remaining >85% of benefits flow as 'positive externalities' to electricity purchasers across the market in the form of lower prices.*
> ***GE Hydro in submission to AEMC***

1 https://www.hydropower.org/news/new-market-mechanisms-key-to-more-pumped-storage-hydro-says-turnbull

Sunshine Hydro became aware of this dilemma many years ago and set out on a research and development journey to study this problem and seek to develop a commercial model that may allow proponents to capture more of the value that they create by developing long duration storage facilities.

We now find that it is possible to do so by making use of sector coupling, design of PPAs that support system wide techno-economic objectives, and the use of software to pull these together.

Our Solution: Superhybrid

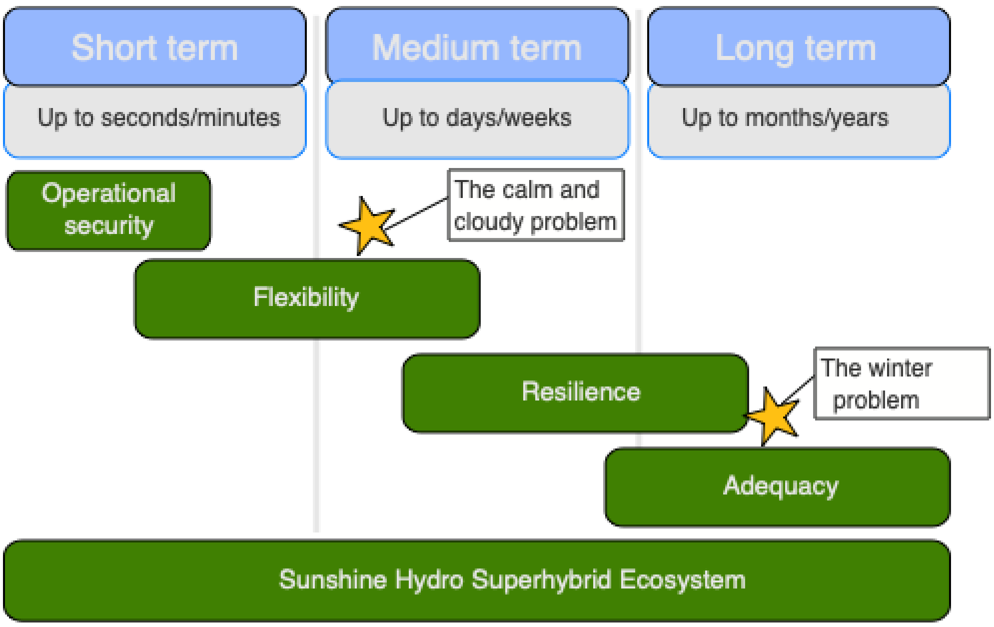
A Superhybrid is a combination of assets all working together to provide a reliable electricity output. This ecosystem consists primarily of three main asset types:

- raw energy production by wind and solar farms (primarily wind),
- a long duration storage mechanism such as pumped hydro, and
- a flexible load such as hydrogen/methanol production.

There is also a small peaker plant using hydrogen or methanol as fuel. This is relatively small compared to the hydro capacity (about 1/12th the size) but when combined with long duration storage can contribute substantial additional energy over multiple days.

The outputs or products from this ecosystem are:

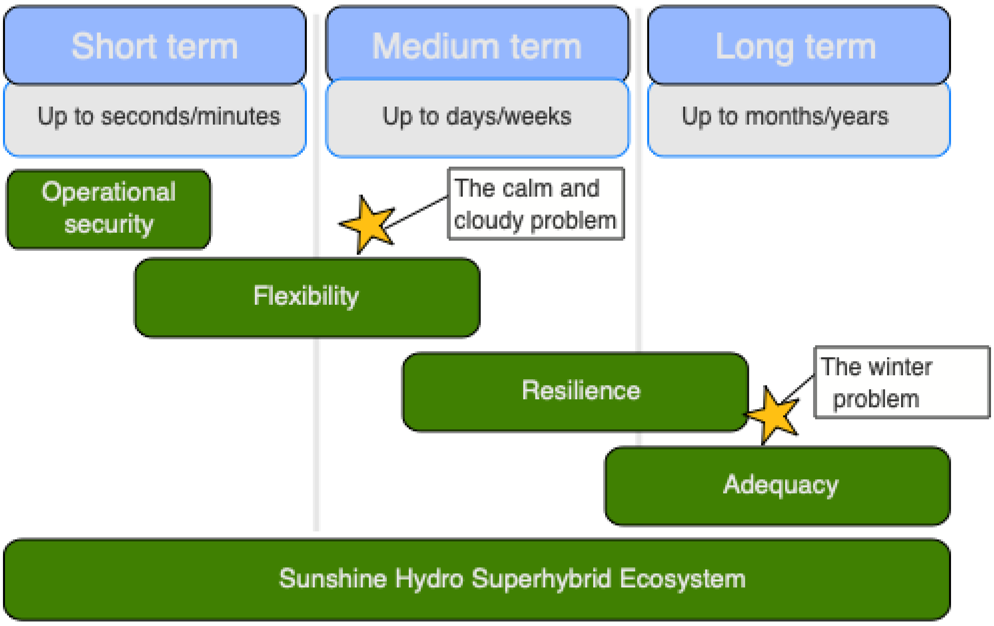
- Green "baseload" (also known as 24/7 carbon free electricity)
- Methanol (or other hydrogen derivatives)
- Peaking power
- Various grid strengthening or capital efficiency services



The ability of the Superhybrid to span all types of storage timescale within the one project is possible because of the inclusion of hydrogen and methanol production as part of the mix.

The timescales of storage requirements

This image shows the various timescales of energy storage that are needed for an energy grid.



Short Term

The very short term response of seconds and minutes is well managed by batteries and in some ways better than the traditional method of using rotating machines which worked by using energy from inertia as well as injecting more primary power to those machines when extra energy is required. These rotating turbines are often powered by steam, which in turn comes from fossil fuels. It's hard to beat rotational inertia to be able to provide an instant response to the sudden loss of power such as when a generating unit fails or a power line is tripped. But power engineers are learning how to do that using batteries and other asynchronous devices, and we see examples of synthetic inertia being provided by batteries. This is also an area where hydrogen production can, perhaps unexpectedly, play an important role. Hydrogen production using PEM electrolysers can be ramped very quickly to respond to frequency changes in the same way that a battery can. The caveat is that the hydrogen production has to be running at the time. Its load setting can be controlled at millisecond response times and provide the same kind of fast frequency response that a battery does.

Hydrogen electrolysers can also be used in partnership with pumped hydro to provide the load to soak up renewable energy when it is plentiful. Hydrogen electrolysers can easily and quickly change their operating level in response to changes in wind or solar generation. Using electrolysers for this role means that the hydro pumps can be fixed speed machines and not need to be the more expensive variable speed devices. Load dispatch needs to

change each 5 minutes to match RE production and in this role electrolysers can have an important place.
The hydro station can also participate in providing extra energy in individual dispatch intervals and even though they can start within a five minute interval, short term injections or reduction in energy are more likely to be managed by changing the output of an already running hydro turbine.

Medium Term

This is the zone where it's hard to beat pumped hydro. Batteries are nipping at the heels of pumped hydro for durations of 4 to 6 hours. But for durations of 15 to 24 hours, which is needed in a 100% renewable grid, the long duration storage offered by water stored in a reservoir makes this the domain of pumped hydro for now. This is the ability to provide extra energy over a period of days when renewable energy is low, such as a few days of low wind, or a few cloudy days.
Hydrogen production can also play a role in when energy is scarce for days at a time by shutting down or reducing production to make sure as much energy as possible is available for the grid. The primary role of hydrogen/methanol in this example is not to be converted back to electricity, but to shut down production as a demand response.

We also model as part of a Superhybrid a secondary role for methanol to be used as a fuel for a rapid start generator which would be used sparingly just as diesel and gas powered reciprocating engines are used now in the grid. This uses a very small fraction of the total methanol produced and can be dispatched to provide additional energy when needed to meet the green baseload target or as a peaking power when grid prices are very high.

Long Term

Long term storage, or long term time shifting of energy, in the range of months to years, is where methanol offers a significant advantage over the cost of other methods of storage. We have begun calling this ultra-long duration storage to differentiate with the long duration storage that can be provided by a typical pumped hydro station. See our discussion article in PV magazine here. Examples of ultra long duration storage include Snowy 2.0 and the now abandoned Onslow scheme in New Zealand, and the cost of these projects is measured in tens of billions of dollars. On the other hand the additional cost to extend the capability of a Superhybrid to include ultra long time shifting is in the order of hundreds of millions. (This includes cost of tank and increases in size of hydrogen and methanol plant. An example of tank cost in 2017 is this tank in Geelong. $50 million for 100 million litres. The energy needed to create 100 million litres of methanol is approximately 133 days at 200 MW = 0.6 TWh of freed up energy) The marginal capital cost of this additional storage is just a fraction of a dollar per kwh.

This method of using offloading for seasonal time shifting of renewable energy is explored for the case of ammonia production in this working paper prepared in a collaboration between Griffith University and Oxford University. The principles are quite similar however in the working paper the method is not coupled with pumped hydro operations which we believe brings much higher benefits to the grid. The use of ammonia for this purpose is quite similar to methanol and also relies on shutting down production of hydrogen, which is operating as a highly flexible load.

The ability of the Superhybrid to span all types of storage timescale within the one project is possible because of the inclusion of hydrogen and methanol production as part of the mix.

Further comments in response to A4.5 Operating the power system during long, dark, and still conditions

Sunshine Hydro has modelled a subset of the NEM for particular regions — this subset includes primary energy production from wind and solar (primarily wind), deep energy storage using pumped hydro and flexible load using hydrogen electrolysis, and backup energy delivery from green fuel storage on a rare basis. The objective of this modelling is to test the reliability of delivery of a flat generation profile 24/7. We are particularly focussed on the difficult times of low wind and solar production.

> *The NEM must be resilient in its capability to provide energy in all weather conditions, including when there is minimal or no sunshine or wind for prolonged periods.*

By scenario testing, goal seeking and learning from failure we have tuned the sizing of various elements and the operation of the forward looking decision making software, AESOP, so that this Superhybrid subset of the NEM is able to delivery a flat profile of 24/7 Carbon Free Energy with a reliability of >99.9% for the Queensland model. This reliability is is a calculation of the ability of the ecosystem to deliver hour by hour balanced 24/7 CFE. At resolutions lower than an hour there can be a greater mismatch between load and generation for particular five minute intervals. However the subsequent five minute intervals are used to correct for the mismatched interval.

Such an ecosystem would offer a similar profile to a nuclear power station however at half the cost. Another significant difference is that a Supehybrid would naturally deliver load at times of high renewable generation and generation when generation is scarce.