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Submission to ISP 2024

Thank you for the opportunity to contribute to AEMO's Draft 2024 ISP consultation.

Rondo Energy is a supplier of electric thermal energy storage (ETES, or "heat batteries"), for industrial heat decarbonisation.

Transmission

We are pleased to see more detailed development of actionable and future ISP transmission projects, in particular the larger New England REZ to accommodate more generation and to act as a connection point for QNI2, as well as the QLD SuperGrid and Gladstone upgrades.

From a risk perspective, we would be more comfortable if the actionable projects were brought forward, but we understand this is easier said than done. Our main concern is another fossil fuel supply related market shock such as sudden coal power plant failure, or fuel supply issues. Such a risk is both likely and high impact.

Issues with the "planting" method

A feature of the ISP is the use of external forecast outputs as inputs, without equilibration between related components. This means that AEMO's modelling has to mould around quite potent external components, skewing the outcomes for AEMO modelled components.

DER is one example of this absent equilibration. The growth of rooftop solar is likely to suppress further growth if tariffs are brought into line with prevailing market conditions. Home batteries rely heavily on the differential in price, which implies they are made viable by the decreasing viability of solar. Some equilibrium exists where customers may prefer to simply install a smaller solar system and forego the cost of home storage. The forecasts for DER seem out of line with the expectations of consumers, that is, mandated control of batteries, substantial rooftop solar curtailment, and zero export value are likely to discourage the continued phenomenal growth of DER. This is a difficult segment to bring into equilibrium because customer's DER decisions are not always about economics, but it seems clear that uneconomic investments are not going to be undertaken by the majority of households.

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Hydrogen is another major planted component in the ISP, one whose assumptions are rather heroic and in need of review. Most hydrogen forecasts are looking at potential market size for Australian hydrogen assuming:

a) Absolute, global requirements for decarbonisation
b) No other competing technologies or substitution with respect to hydrogen demand sectors
c) Australia's preeminent competitive advantage in the supply of green hydrogen

All three are likely to underperform compared with expectation, because:

a) Decarbonisation using hydrogen is likely to slip due to economics that are far from viability. This is evident in the large number of hydrogen projects either not proceeding, or proceeding as sub-economic trials, and large government budgets for hydrogen projects lying idle globally.
b) Hydrogen's poor economics in general relegate it to specific hard to abate sectors where alternatives cannot be found, such as ammonia. In all other sectors it will experience competition from other equivalent technologies, or from substitution at the end use.
c) Australia has excellent renewable energy resources but is not unique in this regard. Australia also suffers from high labour & construction costs which act against renewable energy deployments and the location of industrial loads here.

Rather than looking at the total addressable market, we should look at the obtainable market. Where is hydrogen viable today and at what volumes? What deployment rates are being realised, and at what installed cost? What size increases are being developed for electrolyser modules? Where will component costs move with inflation and mineral demand? Where is the demand for green commodities, and what price are buyers willing to pay? Rather than picking hydrogen as the winning path to energy intensive exports we should explore conversion of domestic resources, particularly minerals where Australia holds a dominant position such as iron, lithium, and aluminium. This conversion does not explicitly require hydrogen.

Australia's significant advantage in renewable energy resource quality does not guarantee our dominance of as yet unestablished markets for green commodities. Optimism is warranted but should be tempered considering we are behind on decarbonising our existing economy and lack the protectionist policies that support industrial deployment in other regions.

On a more optimistic note, there are bright spots where hydrogen is already gaining a foothold, in particular in liquid fuels such as biodiesel and sustainable aviation fuel (SAF). Hydrogenation of biological inputs into saturated hydrocarbons is one pathway used. This sector may not require gigantic electric inputs, but it has real demand thanks to government mandates or carbon pricing in Europe and California.

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Heat is a segment which also requires further study. In the ISP it seems that a substantial part of the "other hydrogen use" for industry is for heat, and we will discuss in more detail why this is not likely to occur.

Previous ISP work indicated approximately 10 GW of continuous demand from industrial electrified heat. This is a good starting point, but better outcomes can be achieved with thermal storage providing flexibility, and heat pumps reducing electricity demand.

The review of the aforementioned inputs is important because we believe that a more realistic assessment of supply & demand is likely to lead to reduced output costs in the ISP, and greater confidence in its deliverability.

Furthermore, a frank reassessment of hydrogen's potential in Australia is needed to encourage governments to redeploy billions in hydrogen funding towards technologies that can deliver greater value for money.

Two new major sources of controlled load

With the increasing momentum of decarbonisation in the electricity sector, we must turn our attention to the next sectors for decarbonisation because they rely heavily on electrification and will impact the electricity market. Transportation and heat are the major sectors of interest because they are large-scale, have available solutions, and the economics do not require exorbitant green premia.

AEMO has already commissioned excellent studies on residential electric vehicles, and modelled EV charging behaviour. Further study of the potential for commercial EVs and freight would be a valuable addition as they are nascent but substantial segments. We do not consider the inclusion of fuel cell vehicles realistic at this stage, given the absence of available vehicles or refuelling infrastructure, and the economic disadvantages of expensive vehicles, expensive fuel, and poor electron-to-wheel efficiency. Planning for this technology should be reconsidered only if it demonstrates more traction.

However, our main focus is on the industrial heat sector, so we will leave transport to others.

Heat as a sector

Heat is one of the largest segments of primary and final energy consumption, and of this about a quarter of global primary energy is industrial heat. This share is likely to increase as electrification of transportation and heating buildings also implies a substantial increase in efficiency due to electric motors and heat pumps respectively.

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Australia is unusual for both a low amount of building heating relative to industrial heat, and the mature use of heat pumps for heating buildings. Outside of Victoria, reverse cycle air conditioners are the most common form of home heating, putting Australia ahead of the rest of the world in preparation for low carbon homes. It wasn't exactly clear how the transfer of gas heating to reverse cycle AC was expected to occur in Victorian homes and commercial customers, but we infer from the ISP that this should decrease total energy consumption and not increase peak demand given the preexisting air conditioner peak in summer.

We agree that there will not be any use of hydrogen in homes.

Industrial heat is primarily delivered by gas today, with substantial proportions of coal and biomass. Decarbonisation of this sector has several potential pathways, many of which will be used to some degree.

Biomethane/biogas

Biogas is the product of fermentation of biological wastes or crops and contains large amounts of impurities such as carbon dioxide, water, and sulphur compounds that make it unsuitable to inject into pipelines, but acceptable for direct combustion with minor cleanup. Biomethane is a purified version of biogas suitable for pipelines.

The high cost of purifying biogas means that biomethane is rarely used or competitive at scale. This also means that biogas tends to be used locally. The vast majority of biogas tends to be burned in gas engines to produce electricity or combusted simply to earn carbon credits. Where biogas is used in industry it is typically associated with industries that are able to ferment their own waste products and have applicable heat demands, e.g. meat processors with adjacent manure/waste digesters.

We do not expect any significant use of biomethane in Australian industry due to the price differences noted in the ISP inputs. Biogas has only modest scope for expansion for industrial heat given that many of the best waste sources with collocated heat demand are already making their own biogas. The relocation of industry to places with biogas is also unlikely as it creates significant costs on the heat user and requires idealised matching of supply and demand that is impractical to coordinate.

Biomass

The original fuel, and already a substantial portion of Australia's industrial heat due mainly to its use as a byproduct of sugar and primary paper production. As a byproduct, biomass is generally the cheapest source of heat and likely already fully consumed. Expansion of biomass use usually implies the expansion of industries that produce their own waste biomass. However, conversion to biomass

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heat may occur where concentrated sources of biomass are available at a reasonable price such as regions with forestry plantations, or with continuous agricultural processing. Due to the high cost of transportation, as well as variation in both local and regional production, biomass is not likely to be used in industrial heat outside of the above examples. Nonetheless it will remain a substantial fraction of industrial heat delivery.

Hydrogen

Hydrogen is oft touted as an ideal replacement for gas given the minimal integration costs within a process. This advantage is appreciable at very low rates of decarbonisation where integration costs would dominate for other technologies, however at full scale having the highest capital cost and highest operating cost rules out hydrogen in all circumstances. Industry is more likely to shut down, than convert to hydrogen.

A pertinent example is the recently announced Townsville hydrogen hub; a $137m project with a $70m grant from the Australian government and further $27m (€16.4m) funding from the German government. The level of grant funding suggests electrolyser deployment cost needs to be three times smaller to be cost competitive.

Featuring a 17.6 MW_e electrolyser, the annual output of 800 tons of hydrogen equates to roughly 3 MW_t of continuous heat at theoretical efficiency. With such a high capital cost this is clearly not even remotely viable for any industrial application, even before input electricity is considered. An electric furnace would have similar or better operating costs at one-thousandth the capital cost.

The capital cost of the Townsville project is over three times the estimates used in academic literature (including the CSIRO basis for the ISP), suggesting substantial underestimation of items such as civils, electrical, labour, land, and inflation.
The UK's recent hydrogen auctions (HAR1) have a delivered price of A$465/MWh, more than 10 times the cost of fossil gas in Australia.[1] The average install cost is 4 times higher than the CSIRO electrolyser assumptions for 2024.

The learning rate for electrolyser deployment is also likely exaggerated, there is no indication that electrolysers (a hundred-year-old technology) have a learning curve rivalling PV. We recommend undertaking component level analysis and applying learning rates to components separately. We expect scale benefits of larger electrolysers units to apply non-uniformly across components. A high power electrolyser requires a larger active surface area and this has no scale benefits, whereas the balance of plant for a larger electrolyser module is proportionally cheaper. Unlike semiconductors or

[1] https://www.gov.uk/government/publications/hydrogen-production-business-model-net-zero-hydrogen-fund-shortlisted-projects/hydrogen-production-business-model-net-zero-hydrogen-fund-har1-successful-projects

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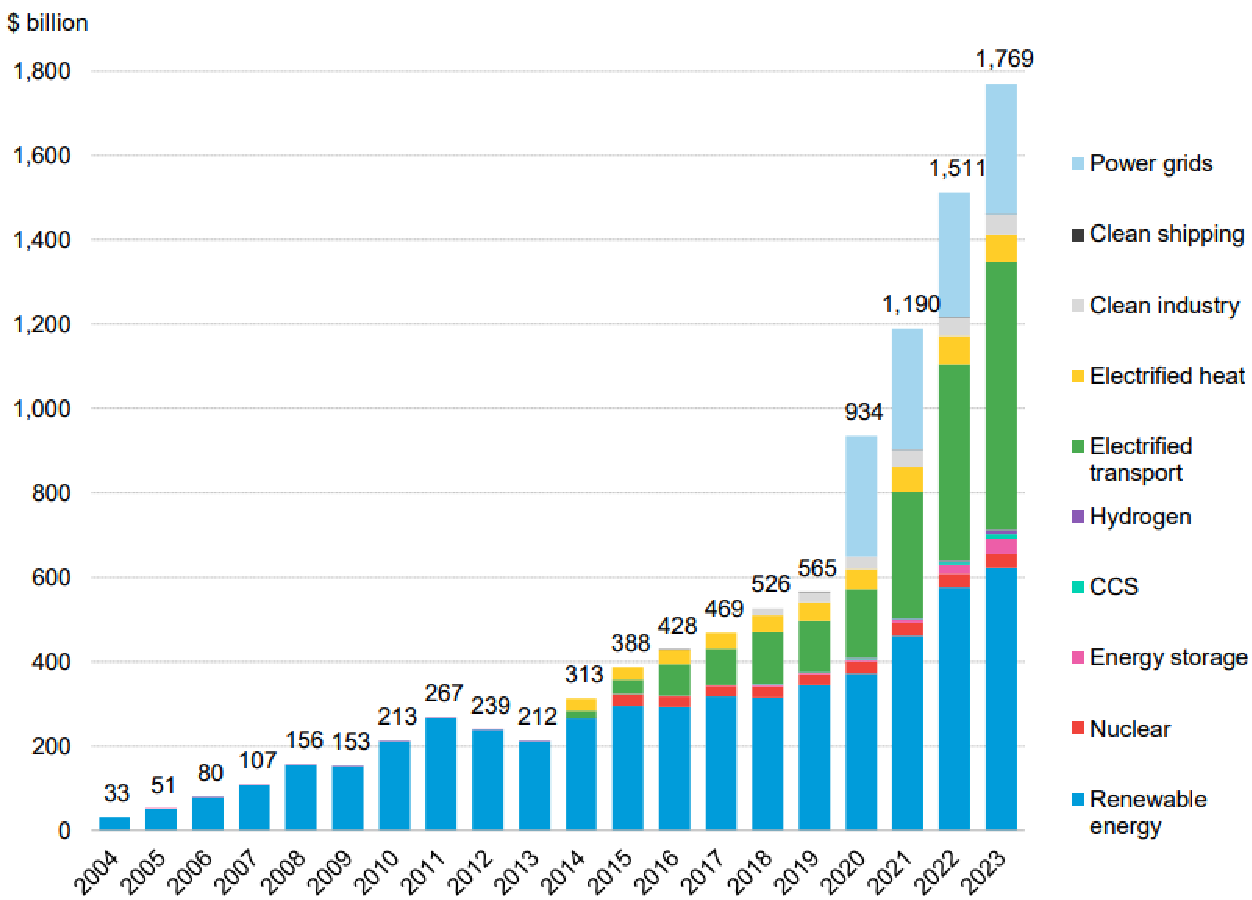
rotor blades, electrolysers cannot expect to have a multiplicative improvement in productivity per unit of material.

In the chart below we see that global spending on hydrogen is miniscule as a fraction of total energy transition spending, precisely because of the woeful economics. We believe AEMO has given hydrogen far too much attention and weight in the ISP, and that clean industry and electrified heat are more deserving of that attention.

Global investment in energy transition, by sector



Source: BloombergNEF. Note: Start years differ by sector but all sectors are present from 2020 onwards; see Methodology for more detail. Most notably, nuclear figures start in 2015 and power grids in 2020. CCS refers to carbon capture and storage.

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Direct electrification

The base case for heat decarbonisation should start with direct electrification. It is low capex, reliable, more efficient than combustion, and physically capable of delivering any temperature needed.

The challenge for direct electrification is that baseload electricity costs more than gas.

Conversion to electricity requires substantial refurbishment of high temperature processes (>600°C), which is a barrier, but less so than operating costs. Electric furnaces etc. are available and used where gas is unavailable or would contaminate the product.

Conversion of steam and other fluid processes is straightforward with direct electrification, and steam processes make up around half of industrial heat consumption.

Heat pumps

Heat pumps have a huge efficiency advantage over small temperature deltas, which overcomes the cost disadvantage of baseload electricity.

They are applicable to low temperature industrial heat uses such as hot water, but as temperatures exceed 90°C the capital costs increase, and the efficiency advantage diminishes as temperature deltas increase. The overall heat demand at the lower temperatures is about a tenth of industrial heat use. Additional uses cases for heat pumps (or equivalent) exist where waste heat cannot otherwise effectively be captured, for example with some evaporative processes, and where heating and cooling are required at the same location.

Compared with hydrogen and direct electrification, heat pumps require smaller grid upgrades which can be a barrier for electrification especially at small scale, and in urban areas.

Thermal storage

Adding storage to the electric thermal sources above increases their flexibility, but also their capital cost. Offsetting this cost is access to cheaper electricity. Given the low cost of thermal storage materials, the total cost of ownership is improved with thermal storage in many cases. Australia's high instantaneous penetrations of renewable energy result in a large difference between the average electricity price and the "bottom 8", or the cheapest 8 hours each day. More importantly, the bottom 8 prices are cheaper than gas.

Adequate access to electricity supply is a concern for direct electric with thermal storage given the large multiple of maximum load (not peak load) compared to existing electrical loads at most industrial sites. This can often be mitigated with co-located solar in ex-urban areas.

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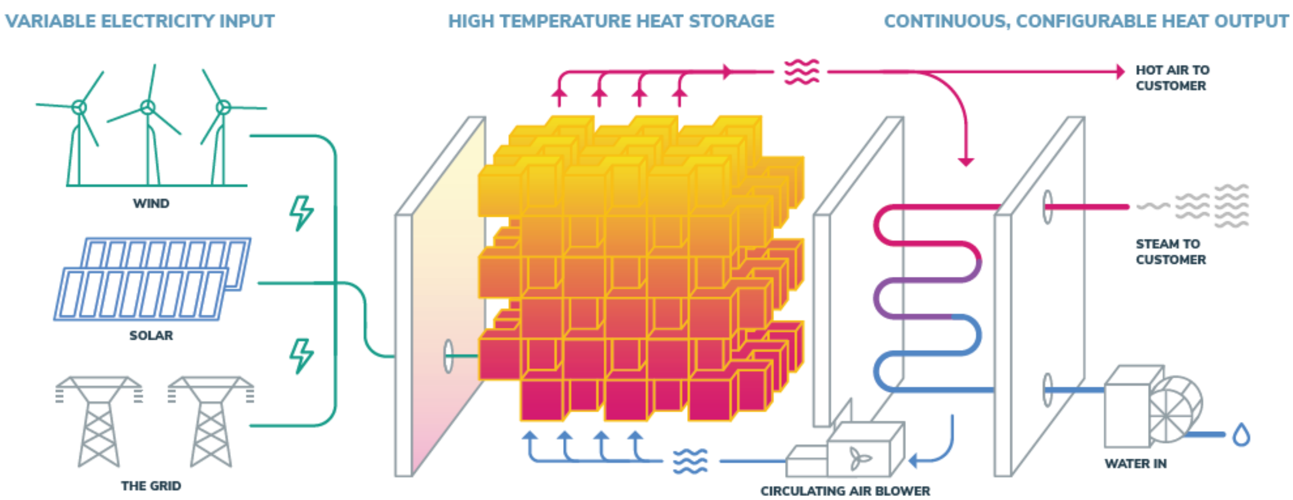
Combinations of technologies are expected to be used to minimise total cost of heat, e.g. using heat pumps for hot water, direct electric thermal storage for bulk steam, and electric boiler for startup/peak operations.

Heat batteries as a controlled load

Rondo's technology, the "heat battery" is a direct electric thermal energy storage system. Ceramic bricks are heated to high temperatures with resistive heaters and the stored heat is delivered on demand to customer processes. Unlike electrochemical batteries, output is expected to be continuous rather than just for peaks, and charging and discharging are independent, that is, charging can occur at the same time as heat delivery.



Rondo Heat Batteries are designed for a typical 8 hours of charging per day with continuous 24h heat delivery. Heat delivery can be turned up and down depending on customer demand, and charging can also be highly dynamic and controlled.

Rondo has three kinds of applications:

Heat only

This makes up about two-thirds of our global pipeline and is the simplest configuration with the widest application. Efficiency is high (98%) due to the lack of conversion losses.

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Combined heat & power

This makes up about a quarter of our pipeline of projects. CHP is the most economical configuration as it gains substantial value from converting offpeak power into baseload power, while still maintaining 95% net efficiency due to the heat load. The heat load must be compatible with a low pressure steam supply which limits its application, although low pressure steam is the most common medium for industrial heat. A fair amount of industrial heat users already have steam based CHP and integration of thermal storage in these cases is simple.

Power only

The remaining fraction of Rondo's pipeline is not related to heat delivery but converts stored heat back to electricity via a steam turbine.

Without a use for process heat, round trip efficiency is only 40% which limits its application as electricity storage. Customer interest is typically due to a need for reliability and long duration storage, or the regular availability of cheap or curtailed power that nullifies the impact of lower efficiency storage. Integration of thermal storage with existing fossil generators is an avenue of interest to some clients.

System impacts

The major system benefit of electric thermal energy storage is the avoidance of growth in peak demand, as charging can occur entirely during offpeak times.

Flexible charging increases the absorption of excess renewable energy, reducing the impact of economic or network curtailment. This improves the business case for greater overbuild of renewable energy, which further reduces the need for firming energy.

Backup fossil heat systems make for a surprisingly effective tool in managing dunkelflaute. By switching to pre-existing fossil systems, electricity demand can be significantly reduced during tight supply conditions. This comes at a lower cost than backup fossil generation as turbines are not required, and the fuel consumption is also much lower than a turbine given that the thermal energy is directly consumed.

Combined heat & power systems contribute to supply during peak demand, again reducing the need for dedicated firming assets. The potential scale of this is some small number of GW_e at today's industrial demand level.

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Please feel free to contact Rondo for further information.

Sincerely,

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Tom Geiser

Head of Australia, Rondo Energy

