Thermal Long Duration Energy Storage

"...At Macroeconomics Advisory, we have estimated that the cost of replacing existing thermal power with solar and wind and back-up will be in excess of $150 billion. That impost is likely to be borne by governments/taxpayers.

But there is a way to avoid most of these transition costs and perhaps restore some of our old manufacturing base sourcing cheap, emissions-free, reliable energy.

The thermal option

One little known option that is apparently ready to go is long-term thermal storage. It is a scalable and compact way of storing energy that provides relatively cheap, very-long-duration back-up for intermittent systems. Even better, it is a leading-edge Australian-based technology.

The technology sources flake graphite locally to manufacture energy storage blocks that are fitted within energy storage cells. The critical breakthrough is that these cells operate at a very high operating temperature range with virtually unlimited cycles and can be charged and discharged simultaneously.

This unique capability enables them to drive the large-scale turbines used in coal-fired power stations. Heating cells with solar and wind generation and then using this heat to drive these turbines means it can deliver dispatchable power through the existing infrastructure in the Hunter and La Trobe valleys.

The technology fits Angus Taylor's far-sighted plan to support technologies even if the execution of the strategy is floundering.

Who would have thought risk-averse bureaucrats would use it to dole out big dollars to foreign-sourced solar (including solar thermal), wind and now, hydrogen?

Why not just back the thermal option that appears to require no assistance whatsoever? It may just offer the good folks at the Energy Security Board the level of energy security to allow them to sleep nights."

Dr. Stephen Anthony, Contributor
- Australian Financial Review, 28 March 2022

Dr. Anthony's comments follow Macroeconomics Advisory's study in which it undertook an independent assessment of the requirements for long duration energy storage (LDES) within the NEM as part of the AEMO Net Zero by 2050 Plan. This study examines in detail the deployment of large scale thermal LDES by retrofitting existing coal fired power stations with TES technology. The findings in this study also form the basis for Macroeconomics Advisory's submission to AEMO on 11 February 2022; see Attachment 2 for study highlights.

Energy Ministers' Meeting

Hon. Angus Taylor
Chairman
Energy National Cabinet Reform Committee
Via email: Angus.Taylor@energy.gov.au; EnergyMinerals@industry.gov.au

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Mr. Daniel Westerman
Australian Energy Security Board
Via email: daniel.westernman@aemo.com.au

("Members")

30 March 2022

Dear Members,

Long Duration Energy Storage (LDES)
Sunlands Co. Thermal Energy Storage (TES) Systems

I The Technology

Sunlands Co. is an Australian company that has patented TES technology utilising flake graphite-based thermal storage media (FGSM) to be manufactured locally by the Quantum Sunlands Partnership (QSP). Details of the technology are set out in Attachment 1 to this letter and www.sunlandsco.com.

The purpose of this letter is to introduce the Sunlands Co. TES technology to Members, provide suggestions for regulatory reforms considered essential to supporting investment in LDES and highlight the findings of the independent Marcoeconomics Advisory study on the deployment of thermal LDES within the NEM to support the AEMO Net Zero by 2050 Plan.

The Sunlands Co. technology has been the subject of a commercial feasibility study by leading thermal process engineers ProTherm Systems. ***This technology is the only LDES technology that operates at temperatures capable of driving utility scale turbines and consequently, the only technology that can be deployed as a retrofitting solution for existing coal fired power stations***. The pairing of TES cells with conventional utility scale turbines and utilisation of associated power plant and transmission infrastructure has far reaching implications for the relatively cost-effective provision of mass storage which is critical to decarbonisation of the grid.

II Recommended Reforms to Support Investment in Thermal Long Duration Storage

Like any market, the market for storage responds to market need and commercial opportunity – this is generally derived from a number of factors including market structure/ dynamics, revenue opportunities, price and supply risk management and managing regulatory obligations.

In Australia, market dynamics to date are manifested in:

- Private sector investment in storage predominate in the fast start, short duration space to provide FCAS-type services and or meet short term supply shortfalls, hedge against or exploit high wholesale prices;
- Announced future private sector investment in medium duration storage of up to 4 hours; and
- Very limited private sector investment in LDES, noting Kidston pumped hydro was only made possible with significant government subsidy/funding support including massive new transmission infrastructure investment by State-owned Powerlink.

Deficiencies in market structure underpinning lack of private investment in LDES including thermal LDES, are likely to be substantially addressed if the measures outlined below are adopted.

Potential of Thermal LDES to be Retrofitted to CFPS to Restore Dispatchability and Inertia

Major coal fired power stations (CFPS) are slated for retirement including Eraring (2025), Yallourn (2028) and Bayswater (from 2030). The resulting loss of 'base load' dispatchable generation and valuable system inertia threaten energy security and grid stability.

Retirement of CFPS generation is considered inevitable due to the combination of CFPS plants reaching the end of their technical lives and declining CFPS economics due in part to carbon reduction policies. Whilst some efforts could be directed at extending the technical life of certain CFPS, declining economics appear to be an irresistible force, i.e., the impact of carbon reduction policies and average wholesale prices from the influx of zero short run marginal cost (SRMC) renewables.

Both market participants and regulators accept that LDES must be an integral part of the solution to address the loss of energy security and grid stability. ***The advantage of the Sunlands Co. technology is that it can physically restore dispatchable generation and system inertia at a relatively low cost. We recommend that policy makers focus on thermal LDES technologies such as Sunlands Co.'s which can utilise the existing NEM thermal infrastructure***.

Remove Application of Network Charges to Storage

Sunlands Co. strongly encourages policy makers to remove network charges from LDES providers including generators fueled by TES. LDES providers are not the ultimate end-users of generation, whilst storage delivers direct benefits to consumers and networks. The imposition of network charges on storage is counterintuitive.

Develop a Suitable LDES Revenue Model

Sunlands Co. recommends that policy development includes encouraging LDES solutions by developing revenue models that support the following LDES operations:

(i) High frequency operation - LDES storage routinely discharged for overnight and supplementary power; and

(ii) Low frequency operation - Reserve LDES (i.e., deep mass storage) where discharge may be less frequent and designed to address periods of solar and/or wind drought extending from a few hours to several days.

Routinely discharged storage providing overnight and supplementary power has a place in the commercial supply portfolios of energy retailers. The potential revenue streams including those derived from market arbitrage and hedging (cap option) are well established and would need to be factored into any policy response.

In the case of Reserve LDES, these recurrent revenue opportunities are far less prevalent.

As the Marcoeconomics Study found, Reserve LDES is critical to supporting the decarbonisation of the energy grid. Its development is highly unlikely without at least one of the following:

(i) a capacity market;

(ii) state ownership or underwriting of minimum revenues;

(iii) an economic regulatory framework akin to transmission and distribution network assets; or

(iv) regulatory obligations imposed on retailers to underwrite.

Without at least one of these mechanisms, capital investment will not be justified given the lack of recurrent commercial revenue streams.

III Preferred LDES Support Model

Critical to any model(s) selected by policy makers for supporting LDES (both routinely discharged and reserve storage) is adhering to the principle that the model(s) should result in lowest total cost to energy users, taxpayers and the environment. The model(s) should:

- Facilitate access to capital (especially debt) that matches the technical or economic life of the LDES. For example, Sunlands Co.'s LDES generation assets have technical and economic lives that are a multiple of many other technologies. Energy consumers and taxpayers will only benefit financially from this advantage if equally long debt amortisation profiles can be accessed from the debt markets. ***Financiers must ultimately have confidence that the LDES assets will be employed and revenue generated over the technical and economic life of the assets and can look beyond, for example, the term of any foundation offtake contract;***
- ***Take account of both the direct cost of the LDES storage assets as well as all associated costs in connecting them to the grid, including grid connection and new or augmented transmission infrastructure costs***. If these are assessed in silos, the interests of energy consumers and taxpayers will not be protected;
- Take account of the reliability of the LDES technology. We would submit that ***technologies with a history of failure and prolonged outages should not be afforded policy support;***
- ***Take account of environmental costs and risks both during the operating phase and in decommissioning and disposal at the end of use***. Some technologies not only have a history of failure and unsafe environmental discharge during operation, but also face significant environmental risks and costs upon decommissioning and disposal at end of life; and
- ***Take account of the cost advantages (option value) to consumers and taxpayers of future capacity expansion***. For example, technologies such as Sunlands Co. power systems do not require replication of the entire system to increase capacity. Only the TES cells require replication, not the heat exchange and generation components of the power system. Similarly, no additional connection and transmission costs are required with capacity increases to an established Sunlands Co. power system

IV Status of Commercial Deployment of Sunlands Co's TES Systems

In 2020 Sunlands Co. and QSP developed a strategy to accelerate the commercialisation of the TES technology. This strategy comprised 3 key elements:

(a) the completion of (initially) an Australian study evaluating the level of LDES required by the NEM to achieve the objectives contained in the AEMO Net Zero By 2050 Plan;

(b) a pilot plant FEED study which would include high temperature test work on the FGSM at a scale beyond the bench scale work performed in connection with the ProTherm Feasibility;

(c) the construction of a pilot plant.

As part of this strategy, an application was lodged with ARENA in September 2021 in response to an invitation from ARENA which at the time was focussed on LDES that could meet the LETS stretch target of sub $100 MWh despatched. ***The application was made in conjunction with Sunlands Co's partners, QSP, EnergyAustralia, Ausgrid, Siemens Energy, InductoTherm and ProTherm Systems***. The application specifically covered items (b) and (c) above, i.e., the construction of the pilot including a FEED study which would include the high temperature FGSM test work.

The ARENA Panel of Consultants refused the application. ARENA's response was perplexing in light of the LETS objective and the need for market and regulatory reform to stimulate investment in LDES.

QSP is now proceeding independently with the construction of the pilot plant. Due to limited funding, Sunlands Co. and QSP have revised their commercialisation schedule and deployment of the TES technology will be delayed for a further 15 months.

QSP has commenced the FEED study and has recently appointed the Institute of Non-Ferrous Metallurgy and High Purity Materials (INEMET), a research institute of TU Bergakademie Freiberg. INEMET is one of the few western industrial research groups that has the capability of conducting industrial scale high temperature test work. In particular, INEMET will test varying specifications of FGSM at temperatures exceeding 2,000 °C. The test work has been scheduled for late Q2/early Q3 2022.

As part of the FEED study, ProTherm Systems has been appointed to construct the pilot plant and has commenced design of those aspects of the pilot not directly dependent on INEMET's work. A critical feature of the FEED study is obtaining performance data across the various FGSM specifications to ensure that commercial deployment can extend to large scale reserve storage systems.

Yours faithfully,

Sal Catalano
Sunlands Co.

David Trimboli
Quantum Sunlands Partnership

cc. **Hon. Barnaby Joyce MP**
Deputy Prime Minister
Minister for Infrastructure, Transport and Regional Development

cc. **Australian Renewable Energy Agency**

Overview of Sunlands Co. TES Cells

i. utilise FGSM within a refractory lined cell to store energy from any power source, including from the grid or direct from solar or wind generation

ii. paired with conventional turbine generator packages to despatch synchronous power and provide grid strengthening inertia

iii. Sector leading performance – largest operating temperature range, highest maximum operating temperature and uniquely capable of driving large utility scale turbines

iv. Sector leading efficiency – only technology currently available that can sustain reliable inlet pressure and temperatures of more than 150bar and 600°C respectively critical to the use of high efficiency (>50%) large-scale conventional steam turbines

v. scalable, offering short, medium and long duration storage and despatch at any turbine output size, including utility scale turbines

vi. discharge duration scalability does not require duplicating the complete TES System, only the addition of TES cells

vii. are not location or site dependent and can avoid additional transmission infrastructure

viii. are cost competitive and readily capable of achieving the $100/MWh 'stretch target' for 8 hours plus despatch duration as sought by the Federal Government's Low Emissions Technology Statement (LETS)

ix. are safe and do not raise any heat related safety issues, including in hot operating environments

x. benign environmental footprint in construction, operation and upon decommissioning

Regulatory and Market Obsevations

- The need for network plans to place much greater weight on LDES
- The availability of TES technologies offering low/zero emissions LDES with dispatchable capability as a replacement for coal and utilisation of existing thermal infrastructure
- The potential for TES technologies as an important enabler to increase renewables penetration in energy systems as also recently recognised by IRENA and the IEA
- Inclusion within the ISP of a comprehensive analysis of TES systems generation, including an estimate of the benefits to the grid of large scale despatchable generation, the savings in costs avoided to replace transmission and generation infrastructure and option value/benefits of hedging against the uncertainties and risks associated with the current Optimal Development Path
- Consideration within the ISP of a market for medium to long term back up and security services
- The limitations of pumped hydro as a large-scale LDES solution in Australia

NEM Deployment of Sunlands Co. LDES TES Systems

- Unlike most TES technologies, The Sunlands Co's (Sunlands) technology has been developed to operate at high temperatures to drive utility scale steam turbine generators such as those used at coal fired power stations (CFPS). The technology is ideally suited to retrofitting CFPS
- The estimated capital costs avoided of retrofitting CFPS with Sunlands TES technology rather than closing the CFPS is $7.5 billion per GW
- The estimated cost of retrofitting a 1GW CFPS with Sunlands TES technology storing 20GWh of energy is less than $0.8 billion
- At the efficiencies published by Sunlands, the cost of energy delivered to the grid using Sunlands technology is less than the $100/MWh target that forms part of the Federal Government's Technology Investment LETS Roadmap. This includes the cost of new generation plant not required where the technology is retrofitted to existing CFPS
- There are significant benefits to electricity consumers and investors in renewable generation capacity in large scale TES contracting the duck curve's peaks and troughs