The Status Of Energy Storage Technologies And Demonstration Projects In Australia

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Australia has a long and rich history in developing energy storage technologies. For example, much of the flow battery technology has been developed in Australia, in particular the vanadium redox battery (University of NSW) and the zinc-bromine battery (ZBB Technologies and Murdoch University). Australian researchers have also developed supercapacitors (CSIRO and cap-XX Pty Ltd), advanced lead-acid batteries (CSIRO and Battery Energy Pty Ltd) and high temperature thermal storage (Lloyd Energy) as well as chemical storage systems for solar thermal power (CSIRO, Australian National University and Wizard Power Pty Ltd).

Australia has been slow to embrace these and other electricity storage technologies largely because of Australia's very low electricity prices and generally high power quality, especially in the urban areas. There is a new interest in storage technology however, arising from a now widespread acknowledgment that renewable energy sources will likely form a more significant component of Australia's electricity supply in the future, and that they will require storage to deliver grid-like dispatchability. The Australian Federal Government has recently provided almost AU$18 m (US$15 m) over 5 years to assist in demonstrating advanced electricity storage technologies (AEST) when combined with renewable power sources. The five projects awarded funding under the AEST program are:

1. $7.4 million to demonstrate a solar energy storage system based on ammonia dissociation into hydrogen and nitrogen. Four 400 m^2 solar dishes will be installed near a regional town (Whyalla) to concentrate sunlight and provide the heat required to split ammonia into nitrogen and hydrogen for storage. When power is required, the gases are recombined, which gives off heat to produce steam and generate electricity through a steam turbine (to Wizard Power).
2. $5.0 million to demonstrate a solar energy storage system using graphite blocks. A high concentration tower solar array will be installed in Cooma and, once proven, a 16-tower solar array system will be built in western NSW (to Lloyd Energy Systems).
3. $3.1 million to demonstrate an integrated 500 kilowatt hour zinc-bromine battery at CSIRO's National Energy Centre at Newcastle (to ZBB Technologies).
4. $1.8 million for demonstration of vanadium-redox batteries with photovoltaic solar panels and wind turbines at a remote fishing community (to Cougar Energy Limited, formerly Pinnacle VRB).
5. $0.26 million for demonstrating innovative vanadium-flow batteries with photovoltaic solar panels and a wind turbine on an island in Sydney Harbour (to V-Fuel Pty Ltd).

Wizard Power

The Wizard Power project combines concentrating solar dish technology with chemical storage of solar energy. The storage system uses ammonia dissociation to store heat (from concentrating solar dishes), and ammonia synthesis to release heat. The heat is used to raise steam and run a conventional steam turbine. The project builds on over 100 years of industrial ammonia production and should be able to provide an indefinite storage time - from minutes to days to months. The storage efficiency can be over 90%, with only minor losses from heat exchangers and liquid/gas pumping.

As an indication of scale, to provide storage sufficient to meet a 10 MWe output for 24 hrs would require approximately 1500 tonnes of ammonia synthesis. This scale of ammonia plant is commercially available and used for fertilizer manufacture. Electricity is produced using standard steam cycles directly from the dish, or from heat generated during ammonia synthesis. The AEST demonstration project will be 1/20th of this scale, delivering 0.5 MWe peak power with 24 hr energy storage. It will use 4 "Big Dishes" and a 110 tonne/day ammonia synthesis reactor. The project aims to show that the intermittent nature of solar energy is not a barrier to large-scale dispatchable solar power, and will establish a baseline configuration and cost basis for future large scale plants. A schematic view of the basic concept is shown in Figure 1.

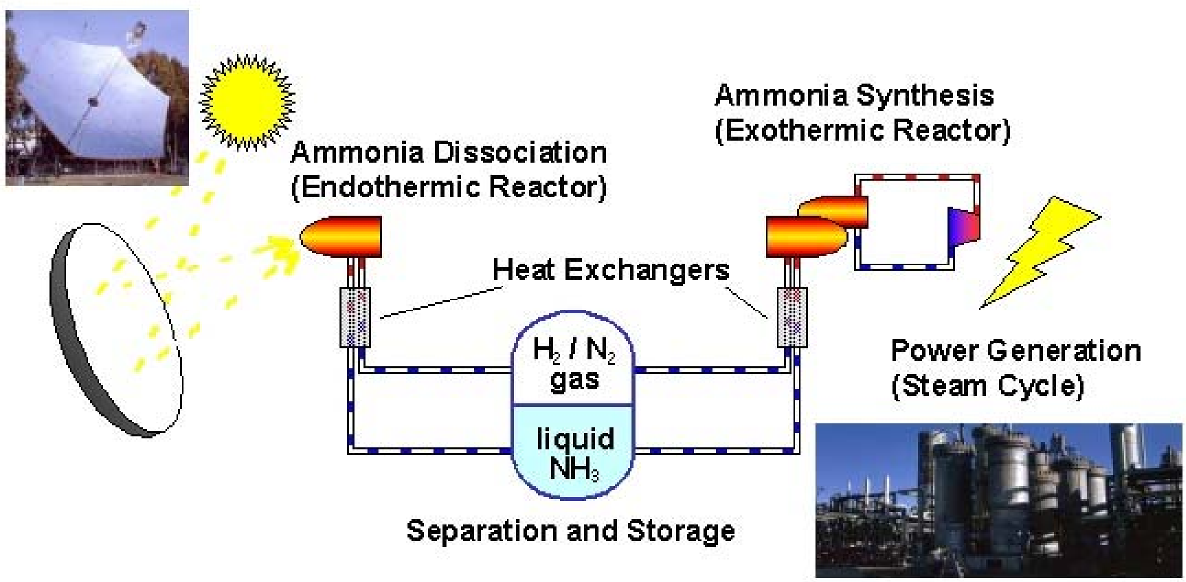

Figure 1: Schematic of Wizard Power's ammonia thermal energy storage system

Lloyd Energy
The Lloyd Energy project is also based on the collection and storage of heat, but uses a novel graphite technology capable of very high temperature operation. The solar energy collection will use 2,200 mirrors providing 16,000 m^2 (172,000 sq feet) of collector area. The solar energy is focused into a cavity that is formed

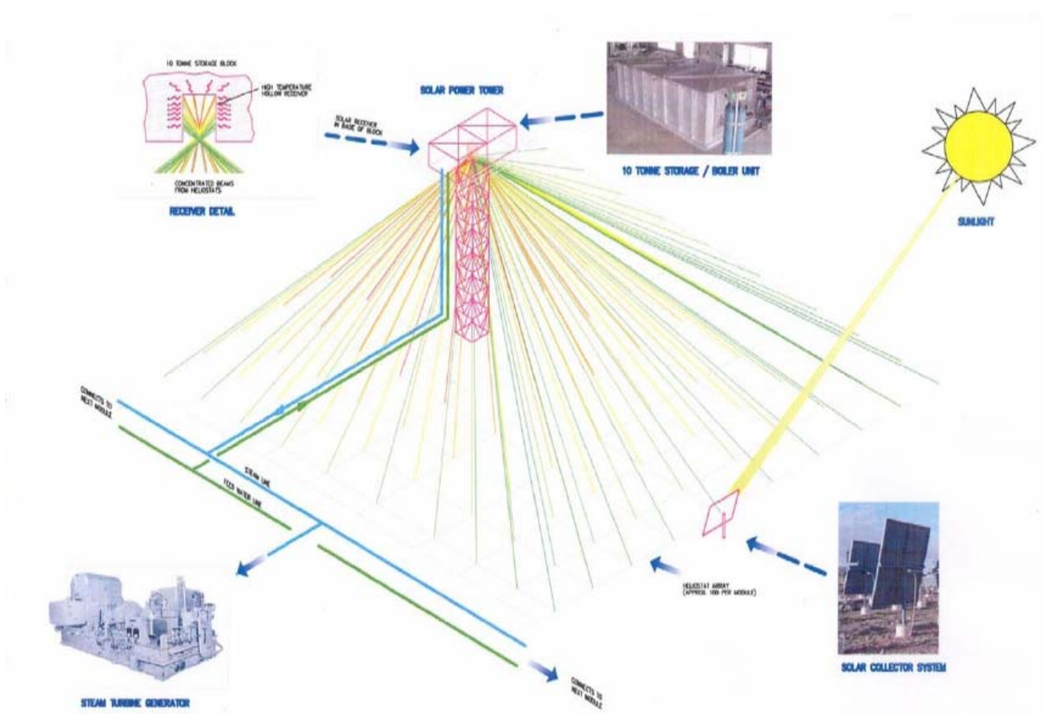

Figure 2: Lloyd Energy solar thermal energy storage concept

in a specially designed graphite block, which can be heated to temperatures above 750˚C (1380˚F) and maintained at temperature for extended periods (Figure 2). The thermal storage system will be composed of 16 such modules, utilizing 160 tonnes of high-purity graphite providing 16 MWh (electrical) storage. Tubes embedded in the graphite block provide steam generation which is fed into standard steam turbines for power generation. The thermal storage capacity will allow for power generation on demand, such as during periods when the existing 66 kV power line is unable to meet the demand from the local community. The electricity generation capacity will be 3 MW for 5 hours in winter and 9 hours in summer. Larger units will be able to provide continuous power production where required. The project will initially demonstrate a single tower array at the company's field site, then once proven, the full scale, 16-tower array will be built and operated in the Lake Cargelligo region of Western NSW, where the power constraint is situated, and which also has much higher quality solar radiation.

ZBB Technologies Limited

ZBB will install a 500 kWh zinc-bromine battery in the CSIRO Newcastle Energy Centre, which is a state-of-the-art energy research laboratory approximately 200 km (125 mi) north of Sydney, shown in Figure 3. The Energy Centre has 3 x 20 kW wind turbines, and 120 kW of photovoltaic panels installed, as well as advanced building energy management and analysis systems.

The project will deliver an integrated 500 kWh flow battery used to store energy from the renewable energy sources available at the laboratory. This energy will then be used to better manage the energy demand of the laboratory, through integration with the existing building management system. The Center already has a purpose built battery room which can comfortably house a 500 kWh battery and associated power conditioning systems. The project will develop new and improved strategies for management of grid-connected renewable energy in combination with flow battery storage and building loads. In addition, the project will address

Figure 4: CSIRO Energy Centre which will house the ZBB battery

Figure 3: ZBB 50 kWh battery modules housed in shipping container

elements of zinc-bromine battery design and construction to further reduce cost and improve reliability and maintenance. A better understanding of the integration and utilization of advanced battery energy storage for renewable sources will help in reducing losses and maximizing usable energy. The battery will be delivered in the form of 10 by 50 kWh modules, as shown in Figure 4 (5 modules visible).

Cougar Energy Limited
The Cougar Energy project is based on vanadium redox battery technology and is focused on providing distributed storage in a number of remote communities, starting with a fishing village on the west coast of Australia. The village currently relies on a mixture of diesel and gasoline generators and PV panels and is not connected to the grid. The aim is to use a number of 5kW VRB battery storage units to integrate PV and diesel generation to provide more reliable and higher quality power while reducing fuel consumption. The first phase of the project will also be used to develop the necessary integration and control systems which will then be applied to later phases of the project. The full project could result in up to 90 VRB units being installed in locations around Australia. The VRB units will be supplied by VRB Power Systems Inc. of Vancouver.

V-Fuel Pty Ltd
V-Fuel has developed a new vanadium redox technology using vanadium/bromide electrolyte coupled with improved membrane technology offering significant cost reductions. According to the developers, the generation 2 (G2) V/Br battery has a number of superior features to the original vanadium battery, including up to double the energy density, a broader temperature range enabling operation in difficult climates and a sealed stack, eliminating a number of operational and safety issues. While the original VRB employs a solution of vanadium sulphate in sulphuric acid on both sides of the cell, the generation 2 V-Fuel V/Br technology employs a vanadium bromide solution in both half-cells. The higher solubility of vanadium bromide allows the specific energy to be almost doubled (to around 50 Wh/kg) and also allows lower temperature operation of the new battery system. The G2 technology is undergoing further R&D and a 5 kW G2 product is expected to be available for field testing by 2008. Current costs are approximately $1,400/ kW for the stack and $210/kWh for the electrolyte, but the target is $400/ kW for the stack and $95/kWh for the electrolyte.

Figure 5: V-Fuel Generation 2 vanadium battery stack and electrolyte tank

Two demonstration batteries will be installed – one on an island in Sydney Harbour and the other in a Sydney environmental research institute. Figure 5 shows a prototype 1-2 kW battery with sealed stack design, which has been verified and laboratory tested, complete with G1 VRB electrolyte and welded components. The intention is for 5 kW stack modules to be available for field trials in 5-100 kW installations by late 2007, and for 25-50 kW stack modules to begin development in late 2007 for large-scale MW size installations.

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In addition to these demonstration projects, a number of other energy storage technologies are being developed, such as the CSIRO UltraBattery, a high performance, high power, lead-acid battery-supercapacitor hybrid. Further information on this technology is provided by CSIRO in their paper.

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