Cultana Pumped Hydro Project

Knowledge Sharing Report

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ARUP

THE UNIVERSITY OF MELBOURNE

EnergyAustralia
LIGHT THE WAY

Australian Government
Australian Renewable Energy Agency

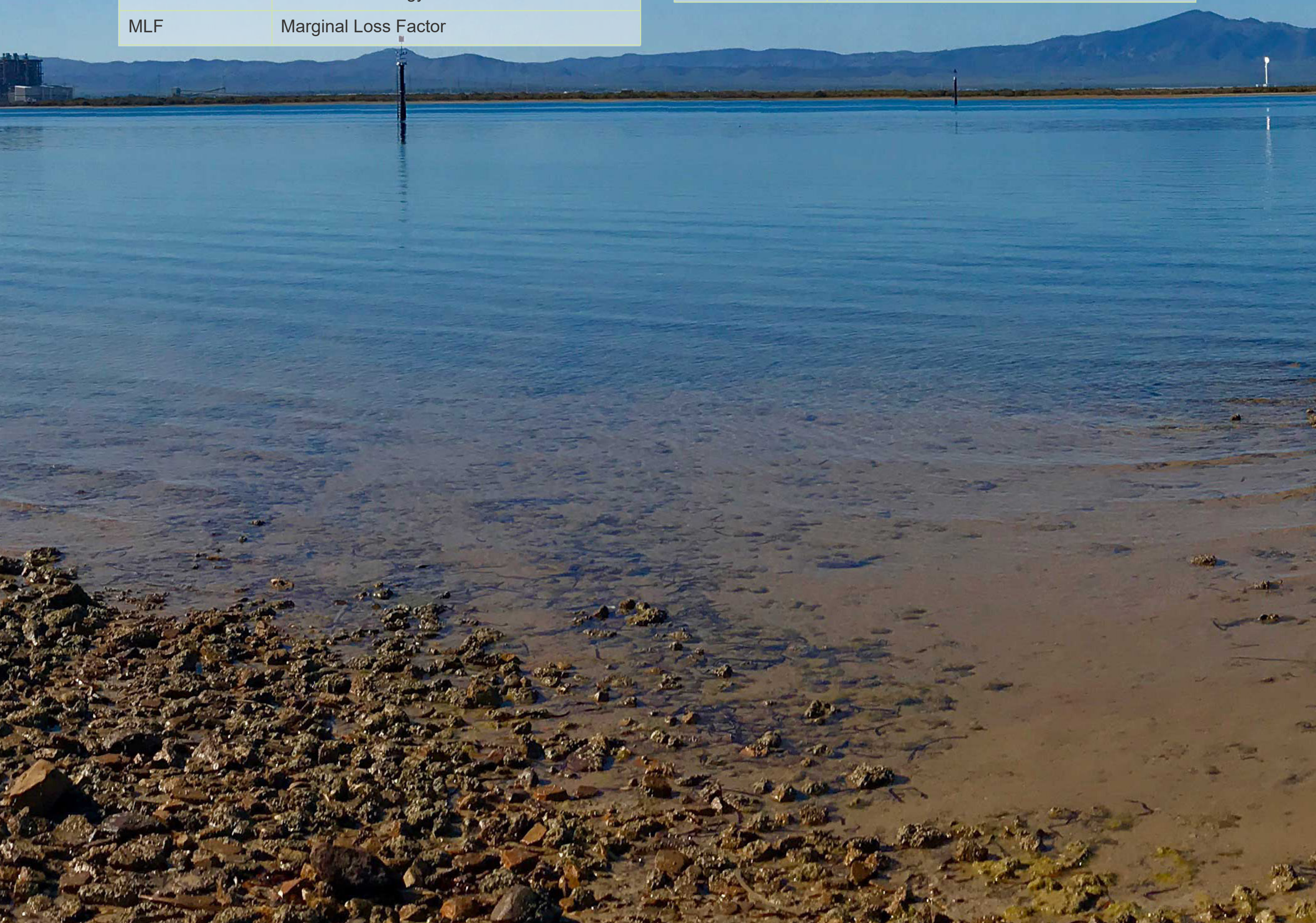
ARENA

CONTENTS

ABBREVIATIONS

AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
ARENA	Australian Renewable Energy Agency
CEFC	Clean Energy Finance Corporation
CER	Clean Energy Regulator
CoAG	Council of Australian Governments
CTA	Cultana Training Area
DoD	Department of Defence
EPA	Environment Protection Agency
EST	Energy Security Target
FCAS	Frequency Control Ancillary Services
GL	Gigalitre
GRO	Generator Reliability Obligation
IPO	Indicative Pricing Offer
IRR	Internal Rate of Return
kV	Kilovolt
kW	Kilowatt
kWh	Kilowatt hour
LGC	Large-scale Generation Certificates
MEI	Melbourne Energy Institute
MLF	Marginal Loss Factor

MVA	Megavolt Ampere
MW	Megawatt
MWh	Megawatt hour
MWs	Megawatt seconds
NEM	National Electricity Market
NSW	New South Wales
OPEX	Operating Expenditure
PHES	Pumped Hydro Energy Storage
PV	Photo Voltaic
QLD	Queensland
RET	Renewable Energy Target
RIT-T	Regulatory Investment Test – Transmission
rpm	Revolutions per minute
SA	South Australia
SPHES	Seawater Pumped Hydro Energy Storage
SRAS	System Restart Ancillary Services
SRES	Small-scale Renewable Energy Scheme
STC	Small-scale Technology Certificates
TUoS	Transmission Use of System
VIC	Victoria
VoLL	Value of Lost Load



EXECUTIVE SUMMARY

One of the main challenges faced by the Australian energy sector is integrating a growing share of renewable energy sources in the electricity generation mix, while preserving the security and affordability of energy supply. Grid-scale energy storage is expected to play a key role in the gradual transition from dispatchable fossil-fuel fired generation to intermittent renewables by supporting the reliability of electricity supply and stability of the grid.

Many renewable energy developers are considering options for coupling battery storage with solar and wind power plants to effectively provide dispatchable energy. In addition, solar and battery hybrids are already becoming a viable alternative to reduce the dependence on diesel-fired generation in off-grid locations. However, at current prices, battery storage does not appear to be financially viable to firm up large scale renewable energy supply into the electricity grid.

Pumped hydro energy storage (PHES) is expected to provide a viable solution for firming up intermittent renewables – it offers large capacity storage with longer hours of energy supply, and a long asset life. PHES utilises electricity at times of low demand or excess supply to pump water to the upper reservoir and returns the power to the grid through the turbine at times of high demand. In addition, PHES can provide a range of ancillary services critical to grid stability, such as inertia, voltage, frequency support, and system restart capabilities.

Among all the regions in the National Electricity Market (NEM), South Australia (SA) has achieved the highest share of non-hydropower renewable energy in its generation mix. Based on the current status of planned and committed new solar and wind farms, the State's renewable energy target of 50% by 2025 is likely to be met, having already achieved over 42% renewables penetration to date. However, this rapid deployment of new intermittent renewable energy has presented significant challenges for the stability of the grid and the reliability of electricity supply in SA. There is an important balancing act between meeting renewable energy targets, at the lowest possible cost to the consumer, while ensuring that security of supply is not compromised as coal and gas-fired generation is retired from the system. PHES has the potential to make a significant contribution to improving electricity supply security in SA and in other States.

A consortium of EnergyAustralia, Arup and the University of Melbourne's Melbourne Energy Institute (MEI), has undertaken a feasibility study, with funding assistance from ARENA, for a seawater pumped hydro energy storage (SPHES) project at a site on the Cultana Training Area (CTA) near the north-western tip of the Spencer Gulf in SA. Seawater pumped hydro was studied due to the lack of freshwater resources in SA and limited freshwater catchments outside of environmentally sensitive areas. The CTA site was selected based on the elevation, proximity to the coast, proximity to grid connection and minimal environmental and cultural impacts.

The aim of the feasibility study was to determine:

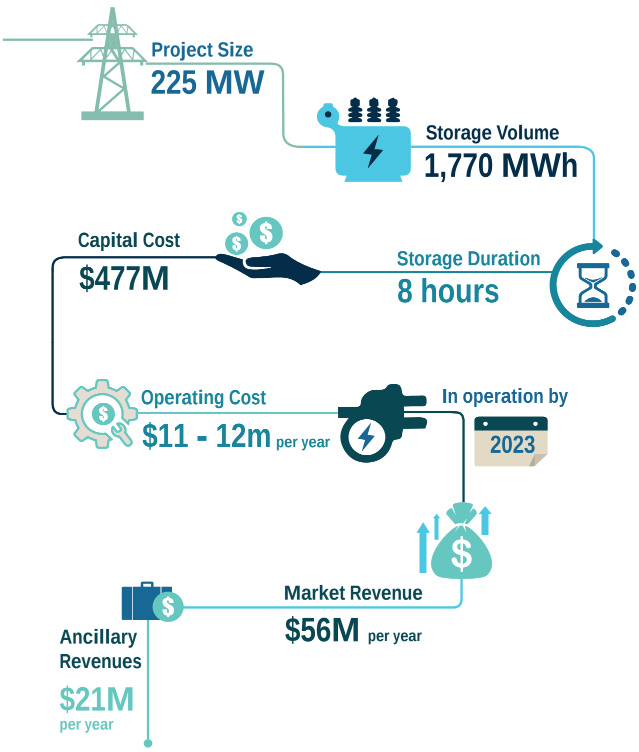
- the optimum sizing of the project, within the range of 100MW to 250MW;
- the capital and operating costs anticipated for the project;
- the commercial model for the project including sources and quantum of revenues;
- the likely cost of grid connection;
- land access, environment, community and stakeholder issues;
- potential regulatory and market changes that may impact the project;
- potential financing solutions; and
- the overall technical and economic viability of the project.

There are many precedents for freshwater PHES in Australia and globally, and the technology is considered mature. However, there is only one international precedent for large-scale seawater PHES, a 30MW facility in Okinawa, Japan.

> "PHES has the potential to make a significant contribution to improving electricity supply security"

Compared to freshwater PHES systems, the use of seawater is associated with potential challenges such as biofouling, the potential for corrosion and additional construction costs associated with marine environments. These issues can be effectively managed with careful material selection and a variety of biofouling prevention mechanisms which are widely used in desalination plants and the cooling cycle of large coal-fired thermal plants. However, this is directly linked to an increased capital cost and likely to also lead to higher operating and maintenance costs over the life of the plant.

This study has demonstrated that, subject to further detailed engineering design, the technical challenges in the application of PHES technology to seawater can be addressed. The study has concluded that an optimal capacity for SPHES at Cultana is 225MW with a storage capacity of 1,770MWh and an overall round-trip efficiency of 72%. An infograph displaying key outputs of the study is shown below.



The Cultana SPHES project has been shown to be technically viable, with a capital cost at just over $2.1 million per MW of capacity or $270 per kWh of storage. Although this storage cost is around a third of the cost of batteries, it is somewhat higher than reference pumped hydro projects due to the relatively long penstock pipelines (3km) and the significant structures to exchange water between the powerhouse and the Spencer Gulf. Operating costs of the Cultana SPHES have been estimated at about $11 million to 12 million per annum.

The main sources of revenue of the proposed Cultana SPHES project are:

- spot price arbitrage, i.e. buying electricity to pump water to the upper reservoir at times of low prices and dispatching water from the reservoir to generate electricity at times of high prices;
- selling cap contracts, i.e. hedges against extreme price events, where the cap buyer pays the seller a premium upfront for protection against electricity prices exceeding the cap strike price;
- firming contracts (as an alternative to caps and arbitrage) used to reduce the volatility of earnings, by purchasing non-firm energy from renewable energy suppliers at a fixed price and selling into the firm baseload or peak markets at a fixed price; and
- ancillary market revenues such as contracts with network or market operators for the supply of inertia, voltage support and/or system restart services.

Based on these revenue streams, the project has been found to be economically viable with a post-tax nominal rate of return of 8% to 12%, depending on a range of scenarios involving capital costs and revenue outcomes. The return is broadly comparable to a benchmark project hurdle rate commensurate with technology and market risks of a private sector investment in a project of this nature.

The project proponents believe that there is merit in investigating the project further to validate and enhance the project returns. Options for further analysis include:

– investigating an alternative project concept that may involve lower capital cost;

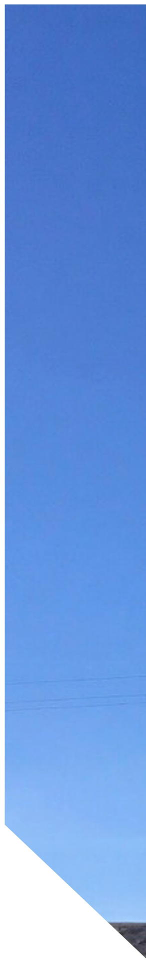
– further engineering work to improve accuracy on the project cost estimates;

– firming the revenue potential from energy market and ancillary market opportunities, including those arising from the implementation of the Finkel Review recommendations and the SA Government's Energy Plan; and

– the potential for government funding support.

In summary, the analysis completed to date demonstrates that the Cultana SPHES project is technically and economically feasible under a range of plausible scenarios and can address the market need for energy firming to facilitate the growth of renewable energy in South Australia.

The seawater pumped hydro storage technology could be deployed widely across Australia, especially where freshwater resources are limited, to support the growing share of renewable energy in the generation mix.



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Overview of Pumped Hydro Energy Storage

1.1 International experience in PHES

Hydropower is one of the oldest and most commonly used renewable energy sources in the world. Since its first introduction, there are now hundreds of Pumped Hydro Energy Storage (PHES) systems in operation around the globe. This includes systems of modest size up to significantly large capacity, such as the 1,728MW Dinorwig Power Station in Snowdonia National Park in Gwynedd, North Wales. Pumped hydroelectricity storage makes up 97% of all large-scale energy storage and has a strong history of reliable performance over long time periods.

Seawater hydroelectricity is more commonly found in the form of tidal turbines or wave energy, where there are plants that have run reliably for some time while immersed in, or using, seawater. There is an increasing global interest in these technologies, although the long-term operational performance and economics of such systems are yet to be fully demonstrated.

The principal use for a pumped hydro system is to store energy by pumping water to an upper reservoir when energy is abundant and then to generate electricity during peak times. In a market context, pumping occurs during low price periods and generation during high price periods, taking advantage of the volatility in the spot market. As illustrated in Figure 1.1, for a seawater pumped hydro project the sea acts as the lower reservoir.

The 30MW Yanbaru Power Station, on Okinawa Island in Japan, is the only seawater PHES (SPHES) plant with considerable operational history and this plant was used as a benchmark for the Cultana SPHES study. Using the Philippine Sea as its lower reservoir, the Yanbaru power station has an effective head of between 132 and 152m. The pipelines and pump turbine are installed underground in tunnels lined with grouted fibre reinforced plastic pipe. Fibre-reinforced plastic tubes are also adopted for the penstock and the tailrace instead of steel tubes to avoid seawater corrosion and reduce adhesion of barnacles. The pump turbine runner is made of austenite stainless steel which is more resistant to seawater corrosion. The artificially excavated upper reservoir is approximately 600 metres away from the shoreline, 150 metres above sea level, has an effective storage capacity of 564,000 cubic metres and was lined with an impermeable liner to prevent seawater from leaking and damaging the surrounding vegetation. Figure 1.2 is an aerial photo of the facility.

The Yanbaru plant was commissioned in 1999 and, after being tested for four years, operated commercially for over twelve years before being decommissioned in 2016 due to commercial reasons related to a change in the network requirements. The important point to note is that, during a major maintenance overhaul undertaken after ten years of fault-free operation, only low signs of material erosion were observed, with no corrosion and little adhesion of biofouling found in the system. That said, the design that led to this high level of performance came at a cost of around $10 million per MW installed capacity. As this was the first seawater PHES system in the world, it was considered as a research and development undertaking, built by a utility that was fully government-owned at the time, which has been subsequently privatised as J-Power.

Figure 1.1: SPHES SCHEMATIC PROFILE

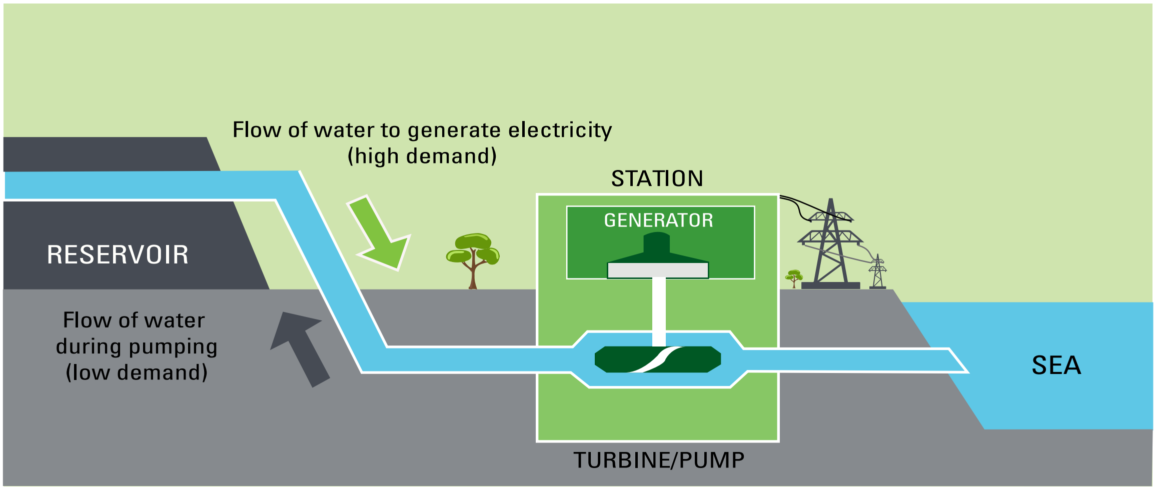


Figure 1.2: Yanbaru SPHES power plant, Okinawa, Japan

1.2 Australian experience in PHES

Australia has extensive experience in freshwater PHES. There are currently three PHES plants operating in Australia – including Tumut 3 (1,500MW), Wivenhoe (2 x 250MW), and Shoalhaven (two schemes with 240MW capacity in total). Note, however, that these facilities were developed with water management as a key consideration, with hydroelectricity and pumping capability developed in parallel. New entrant greenfield PHES systems will differ from these legacy assets in that they will be off-river and have energy storage as their primary purpose.

Historically, freshwater PHES systems would have been located on existing water catchment or river systems. In Australia, there are limited opportunities for developing new freshwater PHES in existing water catchment or river systems due to environmental and sociological impacts.

As an alternative, freshwater sites with inherently lower environmental value have been identified for further investigation, such as the Baroota reservoir near Port Pirie and the Bendigo goldmine system in Victoria. In terms of capacity, these sites are comparable to the Cultana SPHES seawater site, although detailed assessments of them are yet to be completed. The HydroTas vision of being the "battery of the NEM" using freshwater illustrates the potential that large scale pumped hydro storage could bring, but would require a second submarine interconnector and significant national transmission network upgrades for reliability purposes. Similarly, the proposed Snowy Hydro 2.0 project has the potential to provide very significant energy storage capacity to the NEM and has the benefit of utilising a site where the two reservoirs are already constructed and in use. Again, significant transmission infrastructure will be required to export new pumped hydro capacity from Tumut into the NSW grid. The Australian National University has explored the potential for off-river freshwater pumped hydro across the NEM regions.

Compared to freshwater systems, the use of seawater has potential challenges associated with marine biofouling and corrosion, environmental, tidal and storm protection costs, which increase both the initial capital cost as well as operating and maintenance costs over the life of the plant. However, the risks associated with seawater operations can be effectively managed, as has been demonstrated by other marine assets including desalination and power plants, and a major advantage of seawater PHES is an abundant water supply in arid and semi-arid regions and no need for a lower reservoir.

In summary, there is enormous potential for new entry pumped hydro storage across the NEM, both freshwater and seawater, to bring both firming capacity for renewables as well as locally-sourced inertia to improve grid security and reliability.

1.3 Site selection

The Cultana SPHES site is located near Port Augusta in South Australia, on the north-western edge of the Upper Spencer Gulf, partially within the Cultana Training Area.

The main criteria for selection of an appropriate PHES site include:

- large elevation difference between reservoirs;
- proximity between reservoirs to limit piping distance and costs;
- terrain that allows reservoir construction costs to be minimised, for example, dam-able valleys, existing reservoirs, etc.;
- proximity to the high voltage transmission grid, in an unconstrained location;
- no significant concerns around securing land access;
- minimal environmental and social impact;
- access to the required volume of water;
- favourable geology; and
- low risk of hydrogeological and surface water impacts.

In 2014, MEI and Arup performed an analysis of the South Australian coastline and found that there were many sites with good elevation near the coast. These coastal sites could utilise the sea as a lower reservoir, reducing construction costs of a potential SPHES system.

The Cultana SPHES site was selected for this study as it provided the best match to all the criteria listed above. The site has the highest elevation among all the options considered, as well as the closest proximity to the transmission grid at a strategic location (ElectraNet's 275kV Davenport substation), is associated with relatively low environmental impact and the upper reservoir will be situated on non-arable land. The main disadvantage is the greater distance of the upper reservoir from the coast.

2 TECHNICAL DESIGN

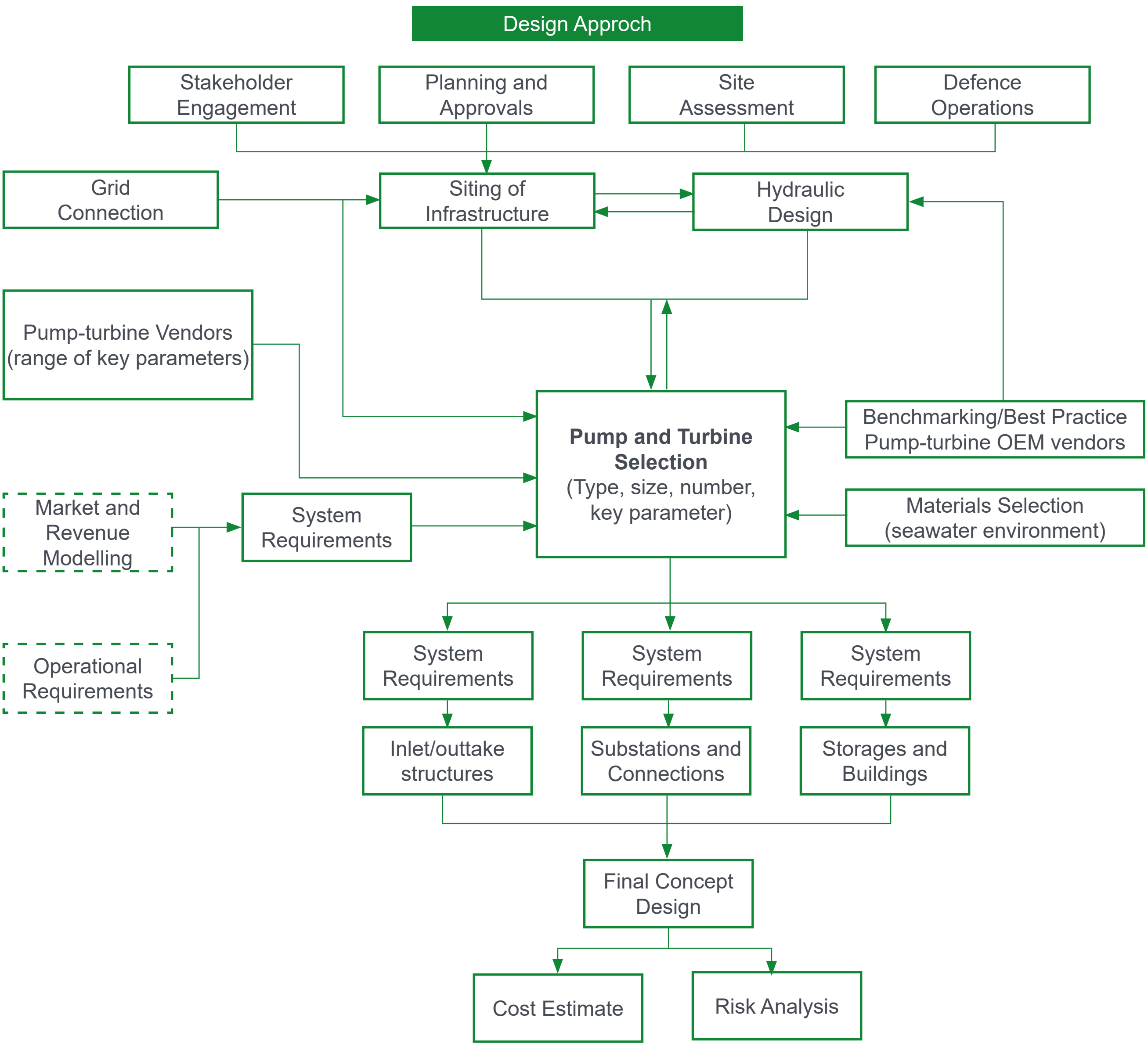
2.1 Technical design basis

The concept design was driven by an iterative process with inputs from a range of stakeholders and reviews, which helped inform the final pump and turbine selection, as illustrated in Figure 2.1. The main objective of the technical design was to ensure that the Cultana SPHES facility could meet the following operational requirements:

– quick response time from all system states to full output in either direction (standstill, direction change, load increase and decrease); and

– minimum operational and unit capital costs, within the limits of safety and the operational requirements detailed below.

Figure 2.1: Overview of iterative concept design development process



The progress of the feasibility report was greatly assisted by strong collaboration and assistance from the stakeholders identified in this figure. Defence facilitated multiple site visits, including for substantial geotechnical drilling and test excavation pits, SA government departments provided approvals for drilling on Crown land and advice on planning and environmental issues, and the local community was engaged and is supportive of the process. Stakeholder issues are further elaborated on in Section 8.

2.2 Site selection and layout

The following conditions had to be met in selecting the final project location:

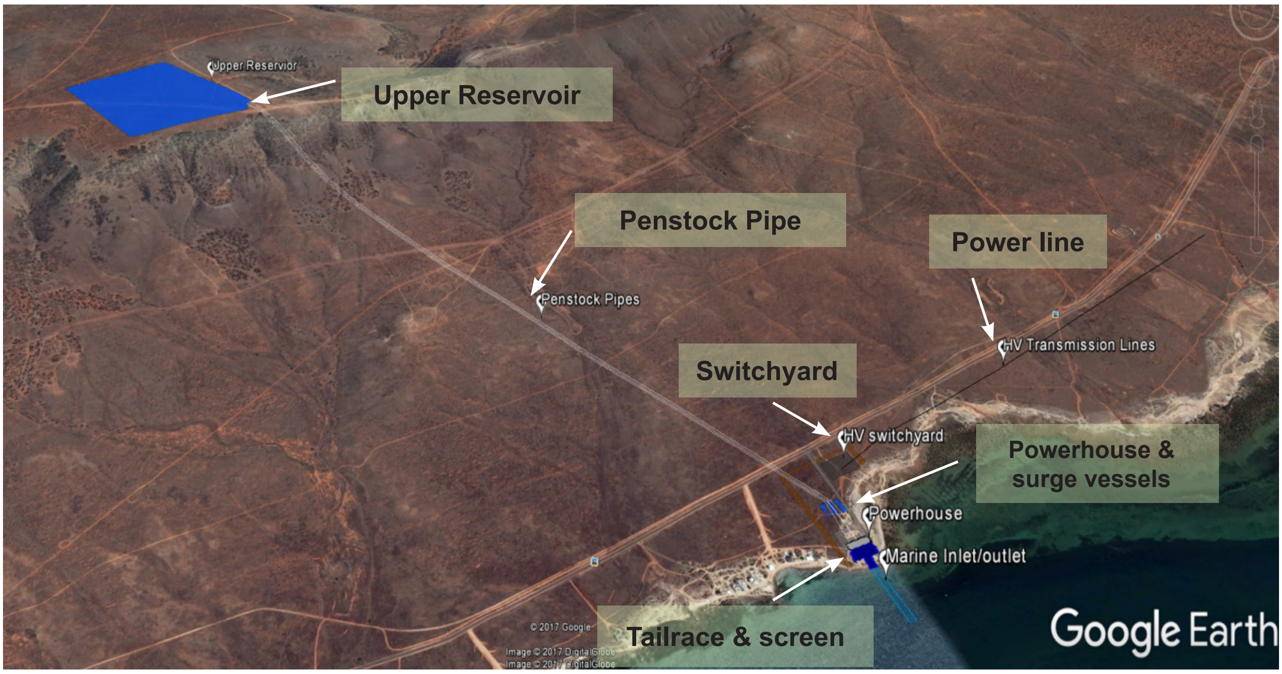
– the Department of Defence (DoD) advised that locating the powerhouse in the CTA was not preferred and, therefore, it has been located east of Shack Road on Crown land;

– the DoD further required that north-south vehicular access not be impeded on the coastal plain between the foot of the escarpment and the boundary fence along Shack Road and, therefore, the penstock pipes have been buried for all but the first kilometre from the upper reservoir;

– the SPHES scheme would need to be at least 300m from the nearest house on Shack Road, based on good practice in acoustic design and the estimated noise output level of the facility; and

– in accordance with SA Environment Protection Agency (EPA) requirements, the environmental impact at the coastline would need to be minimised, including the removal of shoreline mangroves and impact on the benthic seafloor environment.

Figure 2.2: Satellite image of the Cultana site showing key infrastructure locations



Further technical considerations in finalising the plant layout shown in Figure 2.2 were the required plateau area for the upper reservoir, minimising the distance to deep water and high voltage transmission lines, and minimising the geotechnical and civil works. The nominated area for Cultana SPHES is of approximately 120 hectares of land, most of which is owned by the DoD; however, the powerhouse, intake/outlet and tailrace will be located on Crown/Local Council land.

The marine intake/outlet structure location in the Spencer Gulf was preferred as the distance to deeper ocean is minimised and there are no residences in the immediate vicinity. The nominated area is expected to minimise environmental impact on the coastline, minimise project cost, and based on preliminary stakeholder engagement, appears acceptable to all relevant parties.

2.3 Concept design

2.3.1 Overview

The study considered a capacity envelope of between 100MW and 250MW. Below 100MW it was expected that the fixed costs of large civil construction would be too high to yield a viable project due to lack of economies of scale while, beyond the upper limit of 250MW, roughly equivalent to one of the coal-fired Northern units recently retired, there is a risk that the storage capacity would be too large for the SA market and the larger the capacity the lower the expected market revenue per unit of capacity. This relationship is explored further in Section 5.4 and illustrated by Figure 5.7 in particular.

Within this range, the proposed 225MW nameplate capacity of Cultana SHPES was determined based on the maximum scale that could be achieved while avoiding any significant incremental changes in cost. Based on consultation with pump/turbine vendors, the largest available pipe diameter that could be readily transported and meet the hydrostatic test pressure requirements of 40bar gauge is 3.3m internal diameter steel pipe. This ultimately restricted the overall system capacity at 225MW. Additional system parameters are shown in Table 2.1

Table 2.1: Key system parameters of the 225MW Cultana SPHES plant

System Parameter	Value
Plant Nameplate Capacity	225MW
Pumping Load	250MW
Energy Storage	1,770MWh
Turbine Type	Reversible, Fixed Speed Francis Pump-Turbine
Number of Units	3
Round-trip Efficiency	72%
Storage Type	Upper Reservoir: ‘Cut-and-place’ construction Lower Reservoir: The Spencer Gulf
Storage Volume	2.9GL
Penstock	3 Pipes x 3.3m internal diameter
Maximum Flow rate	110m3/s
Design Head	260m
Working Fluid	Seawater
Economic Life	30 years
Plant Capability	NEM Arbitrage, 60sec and 5min FCAS, SRAS, Grid Stability, Synchronous Condensing
System Inertia	680MWs

2.3.2 Plant capabilities

The Cultana SPHES would support intermittent renewable energy penetration in the SA electricity market by providing a large volume of daily energy storage that can be dispatched quickly and flexibly on demand. The facility could go from standstill to full output within 90 seconds on a single unit and to full load on the entire station within 150 seconds. The plant would also be able to provide a range of ancillary services to the NEM in South Australia. These services include black start capability, a significant contribution to inertia as a synchronous generator, and fast system response capable of responding to major load and generation imbalances including in the 60 second and 5min FCAS markets. This is consistent with the operation of other hydro facilities, such as in Tasmania, which provide a range of frequency control services, but not the 6-second response.

2.3.3 Storage reservoirs

In the concept design the lower reservoir is the Spencer Gulf, with the upper reservoir located on a 260m plateau in the CTA approximately 3km due west of the coastline.

The upper reservoir will be an open-excavation, balanced ‘cut-and-place’ construction storage dam with a footprint of approximately 37 hectares. A maximum seawater storage capacity of 2.9GL has been allowed for, which corresponds to almost 8 hours of generation.

The proposed reservoir dam wall would be a clay core and sandstone shell, a common approach used successfully many times in Australia for mining pondage and water storage applications. A concrete and sandstone dam was also considered as an alternative. The floor of the reservoir is to be lined using a compacted clay layer, again in line with common Australian applications. Further geotechnical investigation on the clay properties and further design will be needed to ascertain whether a geomembrane (plastic lining) will be needed to reduce the risk of leakage.

2.3.4 Powerhouse

The powerhouse will be located approximately 100m from the coastline directly inland from the intake/outfall structure in the Spencer Gulf, and approximately 3.1km east of the upper reservoir. A buried bunker-style powerhouse was selected based on the geological conditions and utilisation of piped rather than tunnelled penstocks in the SPHES. The powerhouse contains the mechanical and ancillary equipment, site office, amenities building and workshop. There is also a laydown area in the main building hall that allows an improved installation and maintenance schedules.

2.3.5 Pump-turbine selection

The Consortium issued a Request for Proposals to the major vendors of pumps/turbines/generators that have experience with pumped hydro and received proposals from five potential vendors. This enabled the project to confirm the machine selection and identify potential costs. The pump-turbine/motor-generators selected are three fixed speed, reversible Francis type pump-turbine units with 75MW output each at maximum rated load. The main pump-turbine and motor-generator variables are presented in Table 2.2

Table 2.2: Key system parameters of the main pump-turbine and motor-generator

Parameter	Value
Number of Units	3
Nameplate Capacity	86.5 MVA
Pumping Power	84 MVA
Power Factor (generation / pump mode)	0.9 / 1
Synchronous Speed	400 - 500 rpm
Rated Voltage	10.5kV
Operational Range	68 to 83MW
Mass of unit	140 tonnes
Diameter of Unit	7. 5m

KEY CONSIDERATIONS IN TURBINE SELECTION

- Vendors indicated that increasing the number of turbines for the same plant capacity would increase capital cost.
- Australian Energy Market Operator (AEMO) has indicated that variable speed motor-generators, which can only provide synthetic rather than real inertia, could in effect preclude the machines from providing inertia to any future market or procurement process. Given that real inertia is the ancillary service most in short supply, the consortium decided to use fixed speed motor-generators, which also avoids an approximate 20% capital cost premium associated with variable speed.
- Modelling and consultation with vendors indicated that the plant output range may be significantly restricted with only two fixed-speed turbines. Francis turbines with synchronous motor-generators can only operate over a limited range, so more turbines offer more flexibility in plant output. Using three turbines enhances the ability to vary both the pumping and generation range compared to two turbines.

- Pipeline vendors suggested that a two-turbine, piped penstock design (two separate pipelines) would not be possible with restrictions on maximum pipeline diameter and pressure rating (test rig size), therefore a two-turbine design would need to be coupled with a tunnelled penstock option, for which initial cost estimates were not economically viable.

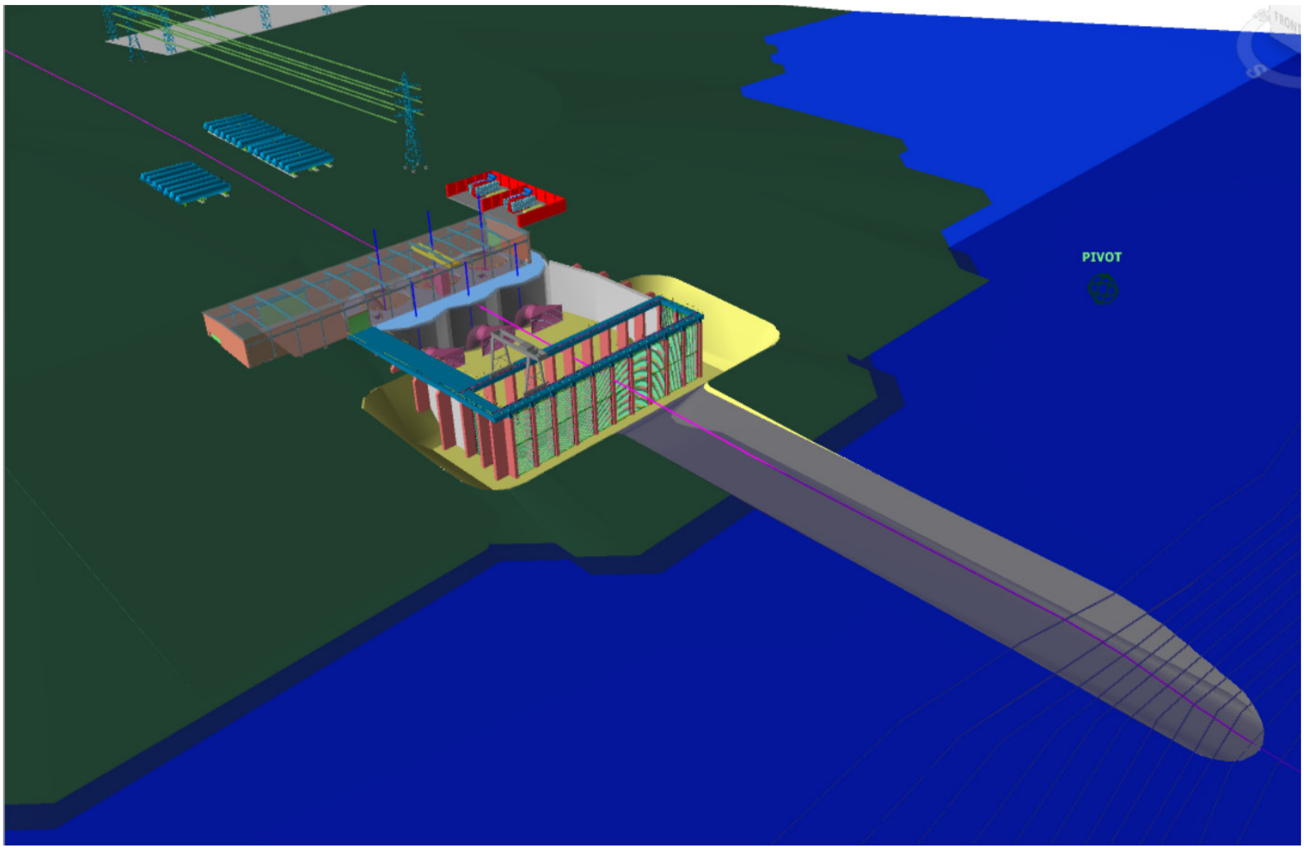
2.3.6 Penstock

The penstock employs three 3.3m internal diameter, high grade mild steel pipelines with a high durability glass-reinforced plastic impregnated, epoxy marine internal lining paint to transfer the fluid in the upper reservoir to the powerhouse for electricity generation. The 3.3km of penstock pipeline is above ground for the first 1km from the upper reservoir, with 45m span pipe support structures and a steel welded stiffening structure for support on the steepest section of the pipeline down the slope off the escarpment. The remaining 2.3km runs underground to the powerhouse structure, ensuring the coastal plain pipeline is covered, avoiding restriction to vehicular traffic flow, as requested by the DoD.

2.3.7 Tailrace and marine intake/outlet

The tailrace and marine intake/outlet design was required to reduce the flow velocity at the outlet to 0.15m/s or less, based on a review of the SA EPA requirements, to allow small marine organisms to swim away from the intake and avoid entrapment/entrainment. The concept design for the marine intake/outlet is shown in Figure 2.3. The tailrace is a rock-lined channel extending approximately 50m from the shore and is approximately 18m wide. The large sluice gate type screens can be raised for cleaning by an overhead gantry crane. The design aims to minimise cost and environmental footprint, whilst maintaining constructability and ease of maintenance in the coastal environment.

Figure 2.3: The marine intake/outlet and powerhouse structure



2.3.8 Valves and surge protection

The facility will consist of three separate streams with common inlet and outlet water bodies. Each stream can be isolated to allow maintenance of one stream whilst the other steams are running. This allows for improved system reliability. To achieve this, nine isolation valves are required, three at the upper reservoir outlets, three at the turbine inlet (main inlet valves) and three on the draft tube between the turbines and ocean area.

2.3.9 Surge protection

There are twenty-one large hydro-pneumatic bladder type surge pressure vessels to maintain the hydraulic pressure of the system. These act as a cushion to dampen water hammer as the turbine changes states and will be used daily as a part of the system.

2.3.10 Biofouling prevention

Biofouling, including the build-up of barnacles in the pipeline and intake screens may require ongoing management. However, the experience of the Yanbaru project after ten years of operation was that no biofouling was observed. If treatment is required, various options could be considered, including hot water dosing and chemical dosing similar to that used in desalination plants, or alternatively, coating the penstock and pump-turbine components with anti-fouling paint in regions where the flow is lower or stagnant.

2.3.11 Grid connection

Cultana SPHES is proposed to be connected to one of the circuits of the existing 275kV double circuit (600MVA each) transmission line (Davenport-Cultana) approximately 2.2km from the powerhouse substation via a double switched 275kV transmission switchyard. The powerhouse substation and switchyard will be co-located at the site directly adjacent the powerhouse, minimising the length of high voltage (HV) lines and/or bus to be owned and managed by the SPHES owner/operator. Davenport is the high-voltage substation that was the connection point for Northern Power Station and supplies large customers to the north, the entire Eyre Peninsula (including Whyalla and Port Lincoln) and has multiple high-voltage lines to the Adelaide load centre. This places the Cultana SPHES project at a very strategic location in the SA grid and also provides a Marginal Loss Factor (MLF) close to unity.

2.4 Comparison of concept design with similar systems

The system flow rate and gross head are typical for pumped hydro systems, although the size of the system is relatively small compared to some of the major facilities under construction in China and elsewhere. Compared with other projects, the proposed Cultana SPHES system is a direct drive with medium runner depth, medium speed and has the ability to ramp up or down when generating or pumping to provide frequency control (60 seconds, 5 minutes).

Interestingly, the three-turbine design is atypical, with most PHES systems globally normally two, four or more turbines. The ratio of elevation to penstock length is within the boundaries of operating pumped hydro systems, but on the lower end of the range. The important thing to note is that each project is designed for the specific circumstances of the market and the topographic and geotechnical configuration of the site.

3 Capital cost

3.1 Reference Case cost breakdown

The current concept design has a total estimated capital cost of $477 million ±30%, which is a level of accuracy typical for a study at this stage of design development. The level of accuracy will be further refined once detailed specifications are developed during the front end engineering design phase of the project. Table 3.1 shows the breakdown on the capital cost.

Table 3.1: Capital cost estimates

Project element	Cost ($million)
Civil	43
Building works	41
Mechanical	103
Electrical and instrumentation	31
Penstock and piping	99
Marine works	25
Balance of Plant	2
Direct cost	**344**
Indirect cost	133
Total	**477**

Indirect costs include design, contractor overhead costs and margin, escalation, preliminaries such as insurance, and a 10% contingency.

3.2 Cost comparison with other PHES systems

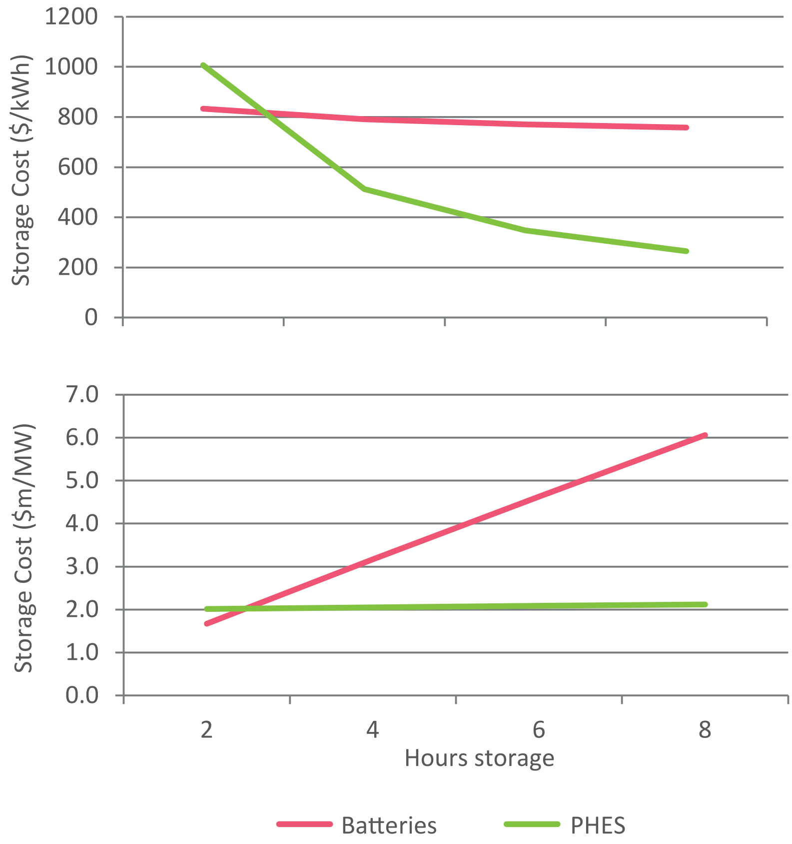
The estimated capital cost of about $2.1 million per MW of installed capacity for the Cultana SPHES is at the upper end of the range of comparable freshwater pumped hydro systems. Costs are higher due to:

- the long penstock pipe of 3.3km;
- the extensive marine screening and tailrace structure to minimise water input and output velocities;
- expensive construction of the powerhouse so close to the shoreline; and
- use of coatings and special alloys to avoid biofouling and corrosion.

3.3 Cost comparison with lithium-ion battery storage systems

The most commonly asked question in relation to the economics of PHES projects is whether battery storage would offer a more competitive solution, since it is quick and simple to install in comparison to PHES and is not associated with the same site restrictions. When making this comparison, it is important to consider both 1) the cost of instantaneous capacity of the system ($/MW) to insert energy into the grid or draw from the grid; and 2) the cost of energy storage ($/kWh). The ratio is the average length of time that the storage system can sustain its full output. Figure 3.1 compares the costs, on both metrics, of the Cultana SPHES project with utility scale battery costs, based on quotes received by EnergyAustralia for such systems, holding the system size at 225MW.

Figure 3.1:Cost comparison of PHES with utility scale lithium ion battery storage systems



The above charts demonstrate that batteries outperform PHES for an average of less than 1-2 hours' storage, whereas pumped hydro is a more economical solution for larger number of hours of storage, since there are significant fixed costs involved in building a PHES, but very minor incremental costs of additional storage (a slightly larger dam). For an 8-hour system, the capital cost of building a battery relative to pumped hydro is roughly 3 times.

This analysis does not include the longevity or degradation over time of the asset, it merely compares upfront cost with capacity and storage volume. The current expected life for batteries is limited by a finite number of cycles and is equivalent to 8 to 12 years with significant degradation in capacity over the term dependent on total energy throughput, whereas PHES has an asset life of over 30 years. The analysis also ignores operational costs, which would be expected to be higher for pumped hydro than for batteries.

It is also worth noting the different ancillary services that batteries and pumped hydro can offer. Batteries can start in milliseconds and also provide fast frequency response (6 seconds or better). Pumped hydro can provide other frequency services (60 second, 5 minute), system restart services and inertia.

Given the above, the Consortium came to the view that batteries and pumped hydro are quite complementary technologies and that the integration of renewables could best be facilitated with both.

> "...hydro is a more economical solution for larger number of hours of storage"

4 OPERATING COSTS

The material operating costs are labour, grid connection charges, and maintenance costs. Table 4.1 shows the high-level estimates for each operating costs category and assumptions related to each cost. Note that costs of pumping are considered in the context of net market revenue and are therefore included in section 5.

Table 4.1: Breakdown of operating costs by category

Cost category	Total operating cost ($million per annum)
Fixed operating costs	
Labour	1.2
Outsourced Cost (e.g. labour, cleaning, admin)	1.3
Grid connection & market fees	3.0
Annual maintenance - planned	4.5
Insurance	0.5
Consumables	0.4
Total fixed operating costs	**10.8**
Variable operating costs	
LRET liability (LGC)	0.6
SRES liability (STC)	0.5
Network charges (TUoS)	0
Total variable operating costs	**1.1**

5 REVENUE MODEL

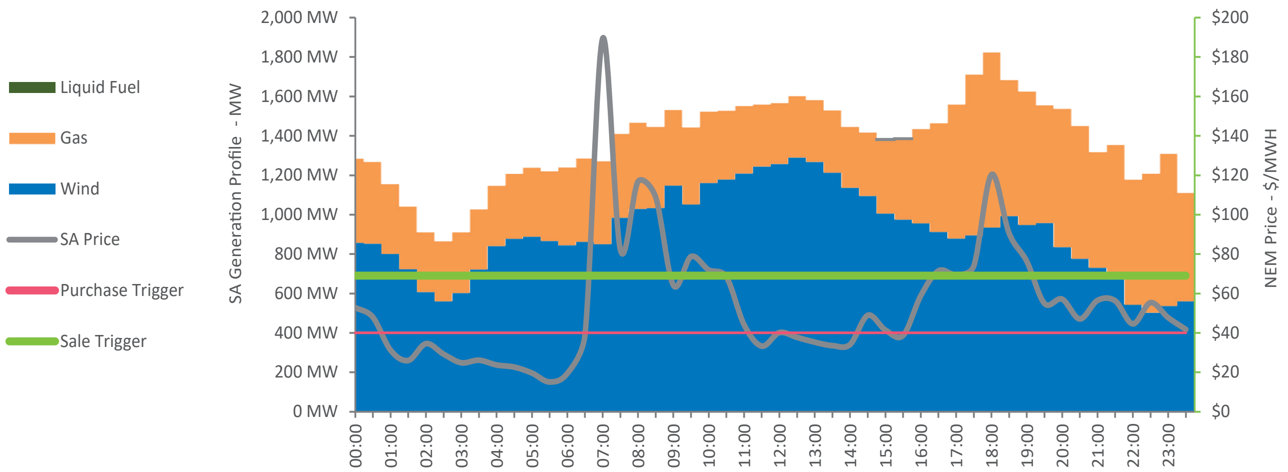
5.1 Revenue from energy storage

A pumped hydro system uses electricity to pump water uphill during periods of low demand and/or when there is strong availability of renewable energy and then to generate when there is high demand and/or a shortage in generation. Pumping times are therefore likely to occur during the overnight periods, from 10pm to 6am, but with the possible exception of the hot water peak (11pm-1am). Generation times will be sculpted to peak demand, such as the morning peak prior to strong solar production and the evening peak once solar production has ceased for the day. PHES might be a critical part of the significant ramp required in the late afternoon to meet rising evening peak demand at the same time as solar production is falling off. With strong solar penetration, PHES may also be cycling diurnally and be in pumping mode during the middle of the day when solar production is at its peak.

The NEM translates all of these physical operation dynamics into a market clearing mechanism with pricing for every 5-minute dispatch interval and, currently, settlement by averaging six dispatch intervals into a 30-minute trading interval on which all energy generated is paid for and all energy consumed is charged. The core business model for a storage asset in the NEM is, therefore, to maximise the arbitrage between buying energy when the price is low and selling it when the price is high. Section 7.4 discusses the rule change proposal to move to 5-minute settlement, although it is not expected that this would materially change the underlying business model of a pumped hydro asset.

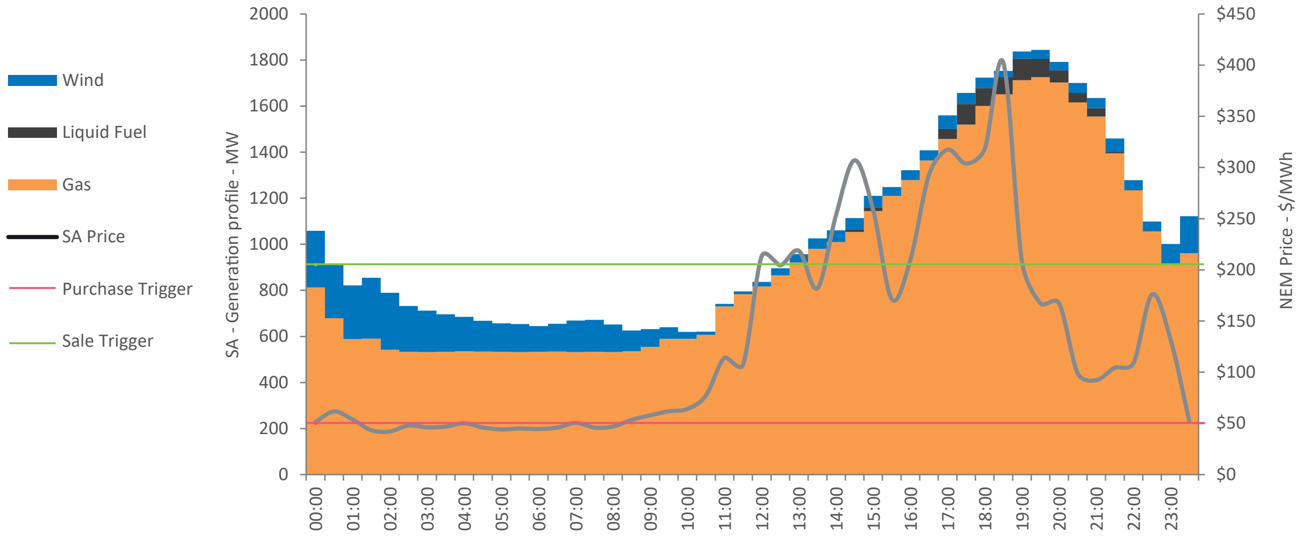
Figure 5.1 illustrates how PHES can generate revenue from spot price arbitrage on a given day – 9 June 2016. Let us assume a buy-price of $40/MWh and a sell-price $70/MWh. When the price is below $40/MWh, the plant pumps water uphill using energy purchased from the grid. When the price exceeds $70/MWh, the plant generates and sells electricity into the spot market. Energy market and financial modelling undertaken by EnergyAustralia and Melbourne Energy Institute has determined that, in this example, the arbitrage revenue (sales less purchases) would be $380 per MW of capacity per day.

Figure 5.1: SA generation and price data for June 9, 2016



To illustrate the variability in PHES revenue, another day, 29 January 2017, is shown in Figure 5.2 – it was a 35°C hot day in Adelaide with minimal wind generation. The buy-price in this case is $50/MWh and the sell-price is $200/MWh. A higher price is needed to be set on the sale side to ensure that the available reservoir volume is used in the highest price periods to maximise earnings. The revenue on this day would be $1,237 per MW of capacity.

Figure 5.2: SA generation and price data for January 29, 2017



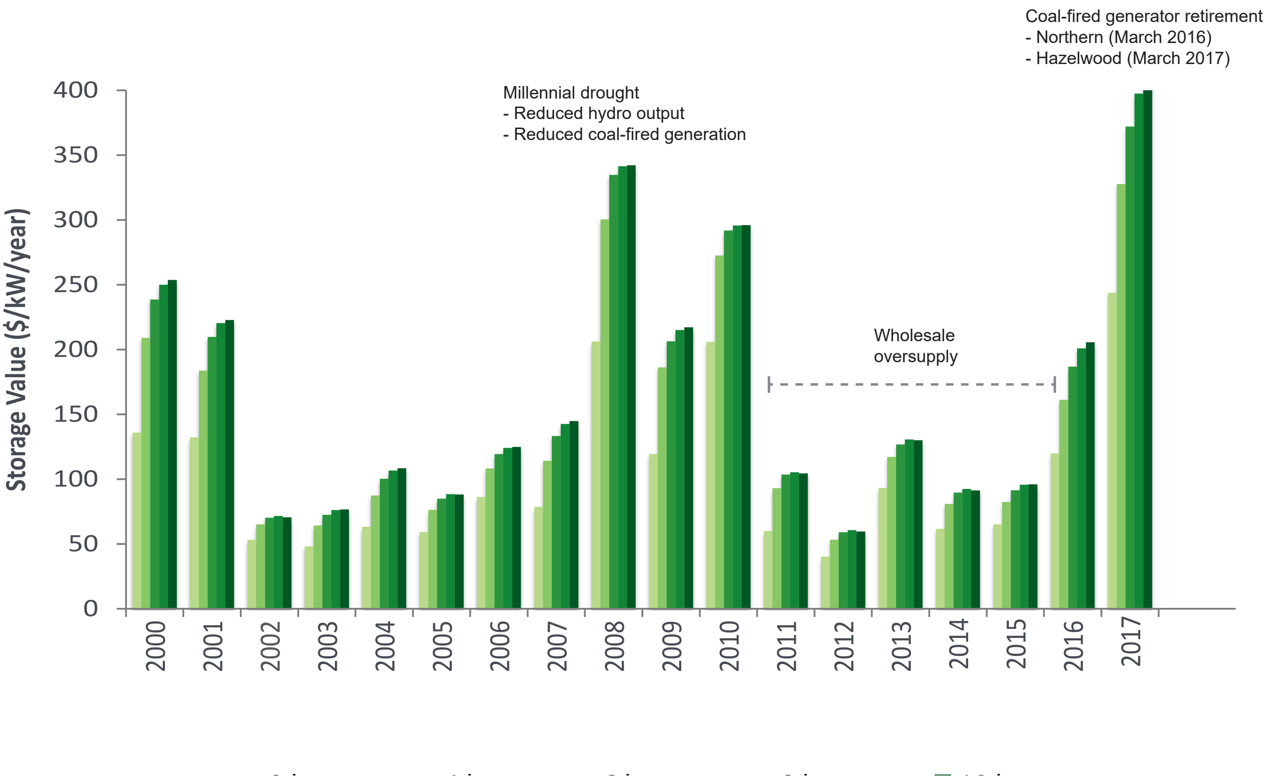
Of course, there will also be days where the market is not volatile and the difference between energy sales and purchases will be minimal. The following section of the report examines the potential value of spot price arbitrage to Cultana SPHES by applying the above arbitrage concept to historical data in the SA electricity market since 2000.

5.2 Historical spot price arbitrage

To show the potential range of revenues that a pumped hydro storage asset would have earned in the market based on historical prices, the half-hourly price data from AEMO is used to calculate the revenue that would have been earned, assuming that the dispatchers had perfect market foresight. The model is run for each 24-hour period and the results summed for each financial year, at a range of storage sizes between 2 and 10 hours. Importantly, this model assumes that the addition of the storage device has no impact on the market (i.e. a small machine assumption). For a 225MW storage, this would not be a valid assumption, and more detailed modelling is presented in the next section with revenue projections considering the impact of large capacity storage on price outcomes in the SA region of the NEM.

This analysis enables the number of hours of storage for PHES to be optimised. Figure 5.3 shows that the value of a storage system, in terms of $/kW/year of generating capacity, increases as the number of hours of storage increases. For example, the storage value accessible to an asset with 2 hours of storage is roughly 2/3 of the value accessible to an asset with 6 hours of storage. As the number of hours of storage increases beyond 6 hours, the incremental increase in value declines, since it is unusual for high-price events to be sustained over many hours. The results also show significant volatility in revenue from year to year, driven by supply and demand balances in the market. This analysis assumes the “small machine hypothesis”, that the calculation of arbitrage for the asset ignores the impact of the asset’s activity in the market on market prices.

Figure 5.3: Generic arbitrage revenue model at various hours of storage



REFERENCE SCENARIO

- Demand - Medium scenario from AEMO, with medium PV uptake (850MW in 2020, increasing to 1600MW in 2030) and medium domestic battery uptake (0 GWh in 2017, increasing to 1.8GWh in 2030, or equivalent of 180,000 10 kWh units)
- Gas price - Medium AEMO scenario
- New renewable generation: Bungala solar (220MW), Riverland solar (300MW) and Tailem Bend solar (100MW)
- 100MW/129MWh battery commissioned by the SA government is included
- No new interconnectors are built

ALERNATE SCENARIOS

Low gas price	Using AEMO low gas price projection
Additional 200 MW Batteries	Assuming the proposed Lyon project is built
Additional Renewables	Assuming addition of 290 MW of new renewable projects
NSW Interconnector	Assuming a 650MW interconnector to NSW is built
Low demand	Using low AEMO demand case

5.3 Forecast spot price arbitrage

To model the forecast revenue from spot price arbitrage, a more sophisticated approach was followed, which included simulating the impact of the inclusion of the 225MW Cultana SPHES on the SA market, as well as other assumptions around the future generation mix and other input parameters.

The South Australian power system is modelled using the DENKI model - a security-constrained unit commitment and economic dispatch optimisation model developed at the Melbourne Energy Institute at the University of Melbourne. Unit commitment describes the problem of deciding which units to turn on and off in order to meet electricity demand, while economic dispatch determines the power output level the committed units should run at. The DENKI model includes a complex optimisation program to address these factors. An example of 48 hours of modelled dispatch is shown in Figure 5.4. The pumping and generation behaviour of the PHES plant is shown in Figure 5.5.

Figure 5.4: Dispatch of available generation for a typical 48-hour period in the reference case for 2020, including storage

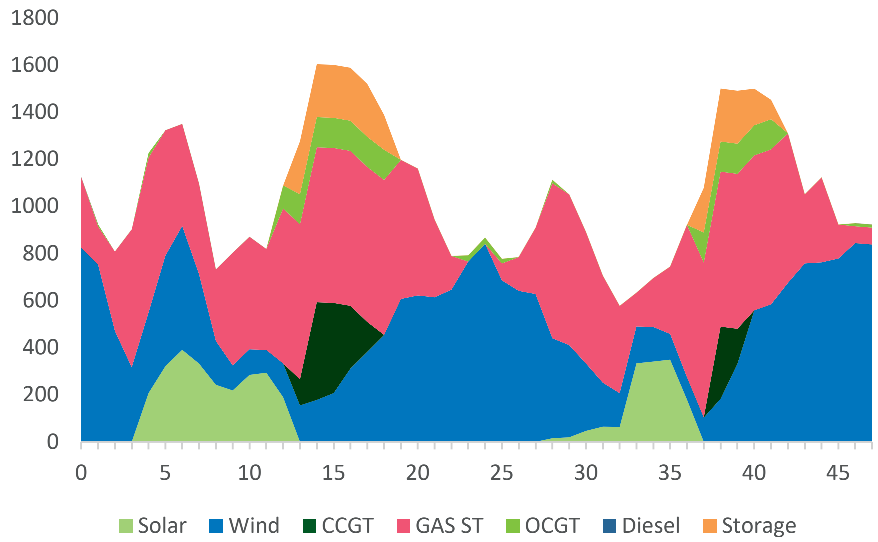
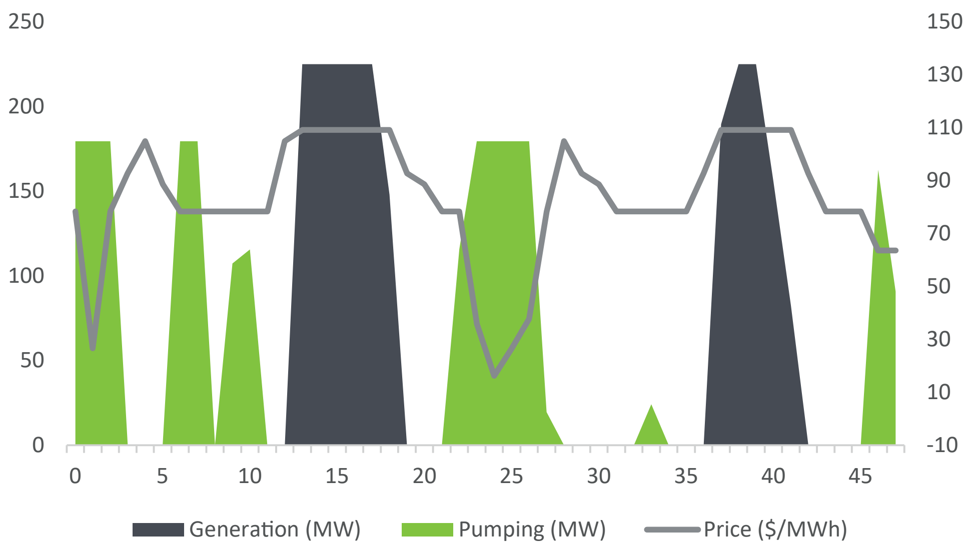


Figure 5.5: Details of the behaviour of the storage for the same 48-hour period. Note that while the generation occurs on single blocks, the pumping is split over several periods

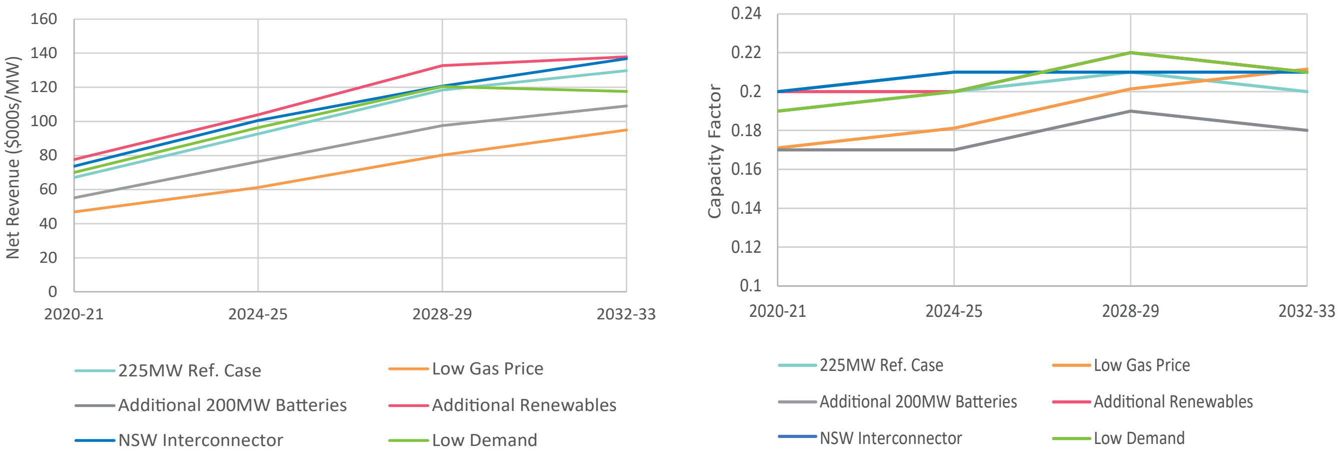


5.4 Scenario analysis

To estimate the range of likely revenue from arbitrage over the period 2020 to 2032, a Reference Case was developed and a selection of plausible scenarios were run, each as a modification to the Reference Case. The modelled revenue results for the Reference Case and scenarios are shown in Figure 5.6.

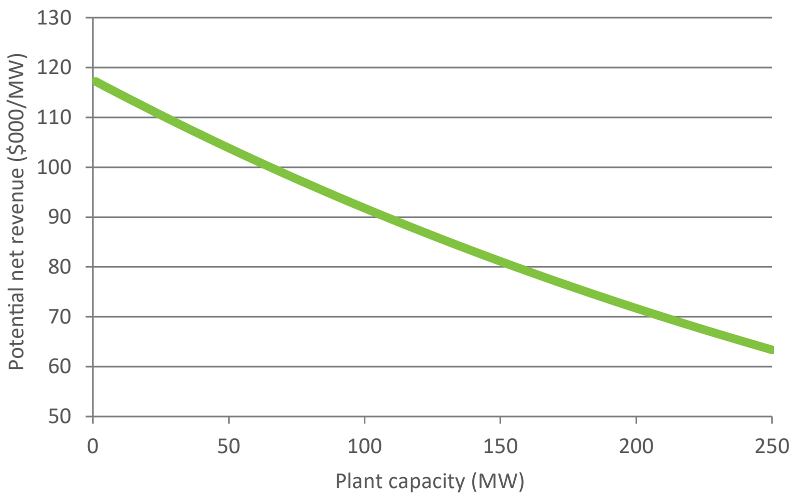
The low gas price scenario shows the most impact, with a considerably lower revenue as peak prices set by the gas generators are lower than in the Reference Case. The additional battery scenario also has a negative impact on revenue, resulting from erosion of peak pricing events and a lower capacity factor. The low-demand scenario and the NSW interconnector scenario both have limited impact, due to a modest difference for the interconnector case, and compensating effects on the generating and pumping costs for the low-demand scenario. The scenario with increased renewables drives an uplift in revenue, resulting from lower pumping costs.

Figure 5.6: Net revenue ($'000/MW) and capacity factor for the Reference Case and each of the scenarios



In addition to the 225MW SPHES capacity case, simulations with various plant sizes were also run, to demonstrate the revenue impact of adding additional storage capacity into the market. The analysis demonstrates that the spot market arbitrage revenue per MW of capacity declines with increase in project capacity.

Figure 5.7 Relationship between size of PHES system and modelled market revenue (Reference Case, 2020/21)



5.5 Contracting strategy

Typically, in the renewable energy industry there are two principal methods of commercialising the revenue streams available to a project:

– Merchant: The project earns spot market revenue directly from the market (as settled by AEMO) and revenue from any environmental products such as LGCs by selling into the market directly. This exposes the project to upside as well as downside, and so is characterised by a more volatile earnings stream; and

– Contracted: Project revenues are contracted to an off-taker who purchases all the energy and Large-scale Generation Certificates, (LGC's) at a set price, typically with escalation. This can allow the project to be bankable with project finance (and associated lower financing costs) as it provides for stable cash flows. However, it can reduce the rate of return given that the off-taker is taking all the market pricing risk on electricity and LGCs, and ensures an off-take price to compensate for taking that risk.

It is also possible to have hybrid models whereby a project could be part merchant and part contracted, or be contracted for a medium term (e.g. 5 years) and then become merchant.

Given the volatility in spot price arbitrage revenue, the business case for Cultana SPHES project will be assisted by some contracted revenues, even if the project isn't fully contracted. There are two principal contracting opportunities – cap contracts and firming contracts. SPHES project can also earn revenue from selling ancillary services. These potential revenue sources are explored further below.

5.5.1 Cap contracts

Cap contracts (or caps) are automatically-exercised call options, typically with a strike price of $300/MWh, settled every half hour. Caps are used to protect electricity buyers from extreme prices, from $300/MWh up to the Value of Lost Load (VoLL). Caps are typically purchased by retailers and large industrial energy users directly participating in the market who require them to protect against volatile prices, and typically sold by fast-start generators, such as gas peakers and hydro plants.

The purchaser of a cap pays the seller a premium upfront in exchange for protection against price excursions above the strike price, i.e. the cap seller pays out the market price less the strike price.

In South Australia, caps are currently priced at $15/MWh in CAL19, and the market is indicating a shortage of hedging products to protect against extreme price volatility. The seller of a $15/MWh cap would earn $15 x 8760 = $131,400/MW/year in upfront premium, but would need to pay out (from the proceeds of spot market revenue at high price) whenever the price exceeded $300/MWh.

Cultana SPHES could be a new supplier of caps in the SA market, given its fast-start characteristics and ability to capture a very high proportion of market volatility, due to the high correlation of price spike events and the running of the pumped hydro storage. Given the current market direction, with coal-fired generation fully retired in SA, increasing share of renewables and high gas prices, the trend is expected to be towards higher cap contract values.

Financial modelling of spot price arbitrage undertaken does not take into account price events over $300/MWh, so the revenue from the sale of cap contracts is in addition to spot price arbitrage revenue.

5.5.2 Firming contracts

A firming contract is an alternative approach of deriving revenue from storage to spot price arbitrage and sale of caps. A firming contract enables a PHES operator to lock in the market revenue under a medium to long term arrangement.

A firming contract can involve the hydro storage plant purchasing the variable output of the renewable energy provider and selling back a standard tradeable product such as baseload or peak firm energy, firm to VoLL. Alternatively, a renewable energy generator or an energy retailer with a large portfolio of intermittent renewables could purchase the dispatch rights to PHES in order to firm up supply from renewable energy sources. Firming contracts could also be of interest to large industrial energy users, who see the appeal of purchasing low cost non-firm renewable energy and then firming it up to match their load.

One of the recommendations of the Finkel Review is to impose Generator Reliability Obligations (GRO) on new renewable energy projects, i.e. obligations to firm up a share of their forecast generation output by developing or entering into contracts with dispatchable generation sources. Gas-fired generators, pumped hydro storage, and battery storage can potentially provide the required firming. PHES has a major advantage over batteries in firming renewable generation, as batteries can only offer very limited hours of storage at competitive prices. Pumped hydro storage can provide significantly longer hours of storage.

EnergyAustralia has conducted a market sounding during the feasibility study to ascertain potential market interest in firming products. A number of potential counterparties, including renewable energy developers and large industrial users, have shown interest in a firming product that could be provided by the Cultana SPHES project. Targeted discussions with prospective counterparties are planned for September – October 2017.

5.6 Ancillary services

PHES can also provide a range of ancillary services which are outlined below.

Frequency Control Ancillary Service (FCAS): The Australian Energy Market Operator (AEMO) contracts generators to provide frequency control services – to inject power (raise frequency) or withdraw power (lower frequency) under various circumstances in order to keep frequency in the network within the desired range.

In the South Australian market, the value of FCAS is generally very low, except on the rare occasions when it is required (islanding events), when the value typically goes to the market cap. Only a few generators typically provide this service and the addition of a competing generator is likely to reduce the value of the FCAS market in SA.

System Restart Ancillary Service (SRAS): In order to restart the system following a black out, AEMO contracts services of two generators in South Australia to provide System Restart Ancillary Services. The role of these generators is to re-energise the network so that other generators can synchronise and re-enter the market. In order to offer SRAS, the generator must be able to start without a live grid. Cultana PHES would intend to enter the market to offer SRAS to AEMO in the next contracting round following its construction.

South Australian Energy Transformation RIT-T: Following a series of blackouts in the SA market, ElectraNet proposed in 2016 a new interconnect between SA and either VIC or NSW or QLD (South Australian Energy Transformation project). Under the National Electricity Rules, a significant new network element cannot be added to the asset base unless it goes through a Regulatory Investment Test – Transmission (RIT-T). The RIT-T requires a rigorous determination of the costs and benefits of the proposal and consideration of any viable non-network alternative solutions. Cultana SPHES could provide a non-network alternative to an interconnect, on the basis that it can provide inertia, voltage support and frequency control at a critical point in the grid.

Inertia: Currently, there is no market for inertia in the NEM. While inertia is a vital component of a large AC grid, in the case of the NEM, it has always been provided for free by coal, gas and hydro generators. Declining share of coal and gas-fired generation in the market has placed a focus on the need for inertia. The Finkel Review has recommended the minimum levels of inertia to be established in each NEM region. This is particularly pertinent for South Australia, which has the capacity to provide more wind and solar PV than its total demand, at least during low demand periods. Pumped hydro can provide inertia, so growing demand for inertia in the South Australian NEM region provides potential revenue upside to Cultana SPHES.

> “Cultana SPHES could provide a non-network alternative to an interconnect”

6 Financing approach

Historically, renewable energy developments in Australia have been mostly project financed off balance sheet, i.e. with non-recourse debt. Many Australian and international lenders are active in the Australian renewable energy project finance market, including the Clean Energy Finance Corporation (CEFC).

Non-recourse debt financing typically requires long term offtake agreements for electricity and LGCs with investment grade counterparties, fully wrapped Engineering Procurement Construction contracts, and Operations & Maintenance contracts, all with financier step-in rights. Recently, some larger developers have undertaken renewable energy projects on their balance sheet, with partial merchant exposure or with shorter-term (e.g. up to 5 years) offtake agreements. Ultimately, the financing approach is dependent on the forecast project cash flows and the risk appetite of debt and equity providers, as reflected in the interest rate and required return on equity, respectively.

However, there are several features of this SPHES project which suggest that off-balance sheet financing might not be the most appropriate structure, including:

- higher technology risk, as compared to solar and wind technologies which are more mature;
- the uncertainty of securing long term offtake arrangements; and
- regulatory uncertainty, including the impact of the Finkel Review recommendations on how the SA Government's Energy Plan may evolve.

As the principal project proponent, EnergyAustralia has the financial capacity to fully fund the project on its balance sheet. Its parent entity China Light and Power is also actively investing in energy assets across the Asia Pacific region. China Light and Power may consider the potential for joint venture partners in certain projects and has done so successfully in this region. Equity investors in renewable energy projects include both Australian and international institutional investors and strategic players in the energy sector. International equity investors have been particularly active in the Australian market in recent years.

7 Regulatory, market and system development issues

7.1 LGC and STC liability

Under the Renewable Energy Target (RET), electricity retailers and large energy users directly participating in the market are required to surrender Large-scale Generation Certificates created by grid-scale renewable energy generators to meet their proportion of the annual target (33,000GWh nationally by 2020) and Small-scale Technology Certificates created by rooftop solar PV systems, solar hot water systems and other residential/small commercial installations.

For the PHES project, this could be applied in one of two ways:

– if the pump load is considered individually and is liable for LGCs and the generation is considered renewable and eligible for LGCs, this could result in a potential net benefit of up to $5 million per annum.

– Another interpretation of the RET legislation is that the net power consumption (due to round-trip losses of 28%) will be liable for LGCs and STCs. This results in an annual cost of over $1 million based on assumed LGC and STC prices (the approach used in this study).

As demonstrated by the above analysis, the application of RET to pumped hydro storage has a material impact on the economics of Cultana SPHES. As at the time of writing the Clean Energy Regulator (CER) is in the process of determining the treatment of new entrant energy storage (batteries and pumped hydro) under the RET legislation and regulations.

7.2 Transmission Use of System charges (TUoS)

Similarly, if the pumping load is considered separately from the generation and is defined as a large load, then the project could also be liable for TUoS charges on the net load of a 225MW pumping station. Based on large load pricing published by ElectraNet a customer using the Davenport 275kV connection point would be exposed to the locational capacity price ($/MW/day) and either a pre-selected capacity or energy based price for the non-locational and common service.

As a 250MW pump, this could equate to approximately $15 million per annum. A strong case can be made that the PHES is only temporarily storing the energy before it is transmitted to the final consumer, and therefore the TUoS charges should be applied only to the final consumer of the power, otherwise there would be ‘double charging’ for the same units of electricity. This matter requires clarification with AEMO, the Australia Energy Market Commission (AEMC) and the Australian Energy Regulator (AER).

7.3 Energy Security Target (EST)

The draft SA Energy Security Target states that a portion of electricity supplied into the SA grid must come from a source with real inertia, and the value of the certificates generated will be up to $50/MWh. Assuming that the PHES project will generate close to 400GWh per year and a mid-range price, it will produce EST certificates worth around $10 million per year. In reviewing the proposed regulations, it is expected that the pumping load would not be liable to surrender certificates and only retail loads will be liable.

7.4 5-minute settlement rule change

The Australian Energy Market Commission (AEMC) is currently proceeding with a rule change to change the current 30-minute settlement period to a 5-minute settlement period. In the context of this study, there are pros and cons with regards to the rule change, and the net impacts on the viability of the PHES project cannot be estimated at this time. However, the change is not expected to fundamentally impact the business model of the PHES project.

7.5 Finkel Review

In June 2017, the final report of the Finkel Review was released, with 50 recommendations for the enhancement of energy security in the NEM. Several of these recommendations have significant implications for the SPHES project, relating to the recommendations that energy security can be improved by requiring new projects to have more reliable dispatch by implementing a GRO, more security through inertia requirements, demand side management and encouraging low-carbon generation technologies. These recommendations present material upside for a pumped hydro project, and 49 of these critical recommendations have already been adopted by CoAG. Implementation of these recommendations will assist in underpinning the business case for Cultana SPHES, in particular, by requiring contracts for firming, as described in section 5.5.2, to be made.

7.6 State based renewable energy targets

South Australia has a 50% renewable energy target to be met by 2025. Some reports suggest this target is already close to being met. A considerable number of new solar and wind plants are planned and committed, so penetration of renewables will likely exceed 50% within the next five years. The Victorian Government has set a target of 25% by 2020, and 40% by 2025, requiring around 5,400MW of new renewable energy capacity to be installed. The impact of an increased share of renewables in Victoria would likely result in improved economics for PHES, due to greater need for firming of intermittent renewable generation.

7.7 Market-imposed constraints

Currently, AEMO at certain times imposes a constraint on state-wide wind output at 1200MW if there is insufficient synchronous generation online, such that no more than 1200MW wind can be generating. This is to maintain sufficient system strength (specifically fault levels) in the SA region to ensure a secure operating state. This constraint, plus the Heywood interconnector constraint to manage rate of change of frequency in SA on a non-credible contingency, forces more generation online in the SA region. Synchronous generation in the current market is essentially the gas-fired generation in Adelaide but with the current gas prices and with the high heat rate at Torrens Island there is limited “baseload” economic gas generation. There is significant lost value caused by this constraint, both in terms of constraining existing wind generation that would otherwise come to the market and also chilling the pipeline of new wind investment in the state. With Cultana SPHES operating at Davenport, it is highly unlikely that this constraint would be binding because it adds synchronous generation at lower marginal cost than the gas-fired generators in Adelaide.

8 STAKEHOLDER AND COMMUNITY

8.1 Land access

The main stakeholders who have a primary interest in granting access to the land required for the Cultana SPHES facility include:

– the Department of Defence and Commonwealth of Australia (for approvals related to CTA land);

– the State Government (for State Crown land approvals);

– the Local Council (for council land access and local planning approvals);

– private land holders; and

– local Aboriginal people, the Barngarla people.

In reviewing the requirements for approval, it is expected that securing a contracted Access Agreement to obtain access to DoD land could take considerable time, which is most likely to be on the critical path for the Cultana SPHES project. The Consortium has recently submitted an Access Application to the DoD and is awaiting feedback.

8.2 Planning and approvals

The key legislation related to planning and environmental approvals that could potentially be applicable to the Cultana SPHES facility, based on the Consortium's past experience with similar projects, include the following:

– Environment Protection and Biodiversity Conservation Act 1999

– Native Title Act 1993, Development Act 1993

– Environment Protection Act 1993

– Aboriginal Heritage Act 1988

– Coast Protection Act 1972

– Marine Parks Act 2007

– Harbours and Navigation Act 1993

– Fisheries Management Act 2007

– Native Vegetation Act 1991

8.3 Grid connection

ElectraNet, operator of the SA transmission grid, has provided a Connection Options Report and Indicative Pricing Offer that detail the cost of connection to the SA electricity grid. This includes the capital cost of the connection from its high voltage (275kV) Davenport-Cultana transmission line through to the project's switchyard and the costs of operation and maintenance of these assets over the operating life. ElectraNet has provided an Indicative Pricing Offer on which the project has been able to base its connection charges. These have been included as operating rather than as capital cost.

8.4 Environmental assessment

A preliminary desktop survey was completed investigating the current environmental conditions at the Cultana SPHES site, which was followed by a flora and fauna ground survey and a number of site visits to confirm the desktop research. The preliminary survey included a review of information on the site and approvals requirements from the relevant authorities, during which no issues that would prohibit continuance of the subsequent phases of the project were identified.

The exchange of water between the Gulf and the facility was an area of particular interest. In some ways, the project has a relatively benign impact because it is not changing the temperature of chemical composition of the seawater. However, the main issue has been to minimise the velocity of exchange which has been addressed through careful design of the marine interface.

8.5 Community Engagement

The consortium first engaged with the local community in late May 2017. This early engagement involved meetings with the Port Augusta Council (Mayor Sam Johnson and CEO John Banks) and the Shack Road Association president Robin Sharp. Following these meetings, and on the request of the Council, a Stakeholder Plan was developed and implemented. Council highlighted the approach of OZ Minerals as being best practice in this area and their approach included “town hall” meetings where community could be briefed.

On the evening of Thursday 10 August, the consortium held a Community Information Session in Port Augusta. This was well attended with 30-40 members of the community, including Defence personnel, contractors, families, local business owners and ex-Northern employees now at Sundrop, among others. The consortium presented an overview of the project, its rationale, the high-level concept design and the process to be undertaken. The presentation was followed by almost an hour of Q&A. In a sense, it formed part of the Knowledge Sharing activities, as it was possible to share some of the project design concepts and a ‘flyover’ movie to illustrate the project facilities; this was output from the project activities.

The issues of most important to the community were:

- understanding the potential impacts of the project on the Upper Spencer Gulf, including salinity, tidal, temperature, evaporation, boating and marine life issues;
- understanding the potential visual amenity and noise issues in and around Shack Road; and
- understanding the employment opportunities both in construction and in operation.

The consortium undertook to take on board this feedback and work it into the more detailed engineering design.

9 Conclusions

To assess the economic feasibility of the Cultana SPHES, a project Internal Rate of Return (IRR) has been calculated based on the cost and revenue assumptions discussed earlier in this report. The cash flow projection, including all market and ancillary revenues, results in a nominal, post-tax project IRR of 10%, which is broadly equivalent to a benchmark project hurdle rate commensurate with technology and market risks of private sector investment in a project of this nature.

A sensitivity analysis has shown a range of project IRRs from 8% to 12% depending on a variety of scenarios, including high and low revenues as modelled and capital cost sensitivities of ± 20%. Options for further analysis to validate and enhance estimated project returns include:

– investigating an alternative project concept that may involve lower capital cost;

– further engineering work to improve the of accuracy on the project cost estimates;

– reduce the uncertainty in relation to ancillary market opportunities, including the Finkel Review recommendations and the SA Government's Energy Plan; and

– the potential for funding support from ARENA, CEFC and/or the SA Government.

Seawater was chosen due to the sustainability concerns of sourcing freshwater for initial reservoir fill, as well as ongoing top up to account for evaporation. While this does add costs relative to freshwater, most notably in the coatings and special alloys that need to be used, it is the site's layout and requirement for slow velocity water exchange on the coast that causes the bulk of the capital costs beyond a typical pumped hydro project.

In summary, this feasibility study into the Cultana SPHES project has found that the project:

– is technically feasible;

– can address the market need for energy firming to facilitate the growth of renewable energy in South Australia; and

– can be economically viable, under a range of identified plausible scenarios.

The seawater pumped hydro storage technology could be deployed widely across Australia, especially where freshwater resources are limited, to support the growing share of renewable energy in the generation mix. A key consideration is the proximity to transmission infrastructure in an area of the grid that is not subject to constraints.