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1 Summary

This chapter explores the sources of revenue attributable to the Project, in addition to the holistically forecast impacts on Snowy Hydro's large and diversified portfolio of assets.

1.1 Introduction

The Project has a number of effects on the Snowy Hydro asset portfolio including utilisation, risks and operations. These effects are evaluated in the context of Marsden Jacob Associates (**MJA**) modelling results relevant to the business case of Snowy Hydro. For analysis of the context of broader benefits of the Project, including the Project's impact on the National Electricity Market (**NEM**), see *Supporting Chapter Five - Market modelling*.

1.2 Background

The Project will add 2,000 megawatts (***MW***) of dispatchable capacity to Snowy Hydro's asset portfolio, on top of the existing 5,262 MW (including gas and diesel).

The additional energy produced and capacity available from the Project will enable greater internal hedging of Snowy Hydro energy needs for mass market, Commercial and Industrial (***C&I***) and wholesale customer loads. It will also provide ancillary services and firming capacity for potential renewable projects sold direct to wholesale counterparties and indirectly through spot markets.

Snowy Hydro engaged independent market experts MJA as a third-party specialist economic modelling firm with comprehensive experience in the NEM. Multiple stages of work have been undertaken for both the Feasibility Study and for Final Investment Decision (***FID***). This chapter specifically explores the effects of MJA's *economic* evaluation of the Project in future market states, but converted into *financial* cash flow terms.

1.3 Scope and exclusions

Inclusions:

1. **Portfolio modelling** - Snowy Hydro portfolio modelling to understand under various scenarios the value of the Project over time and uncertainty in Net Present Value (***NPV***) terms; and
2. **Valuation** - translate economic fundamental analysis of the NEM supply-demand trajectory over time into net financial cash flows to derive Project present value;

1.4 Activities undertaken

Snowy Hydro undertook a comprehensive internal valuation of the addition of 2,000 MW of dispatchable capacity to Snowy Hydro's portfolio.

1.5 Snowy Hydro portfolio effects and internal valuation

The Project will add 2,000 MW of dispatchable capacity to Snowy Hydro's existing 5,262 MW portfolio.

The additional energy produced and capacity available from the Project will enable greater internal hedging of Snowy Hydro energy needs. It will also provide ancillary services and provide firming capacity for the market.

The Snowy Hydro internal valuation approach provides a NPV utilising the Board-approved, industry standard discounted cash flow (***DCF***) methodology and economic assumptions.

MJA's modelling considers the economic value created by the Project, as a standalone asset. MJA's economic assessment findings are thoroughly explored in *Supporting Chapter Five*. This chapter explores findings and recommendations that are specific to revenue sources that impact the Snowy Hydro asset portfolio.

The internal valuation explores the five key areas of financial value that are obtained from the Facilities:

1. **Storage value** - the ability to purchase energy at low prices for pumping, pump and store the energy as potential energy of water, then sell the energy when profitable;
2. **Capacity value** - the ability to sell and defend capacity 'hedge' (bespoke, very large, long-term and non-commoditised) products, providing network reliability and security by supporting or firming the capacity of non-dispatchable or intermittent generation;
3. **Security value** - current participation in the regulation and five-minute Frequency Control Ancillary Services (***FCAS***) markets with respect to frequency control services, and future participation in other FCAS markets (pending a Supervisory Control And Data Acquisition (***SCADA***) upgrade);
4. **Drought protection** - the Project's ability to circulate very large quantities of energy around a closed loop which does not not require new water from inflows increases the amount of energy and capacity that can be provided by the Scheme when inflows are at extreme lows; and
5. **Firming products** - the emerging market for storage-related products for balancing, firming, and shifting intermittent renewable output as Variable Renewable Energy (***VRE***) penetration increases.

Not developing the Project poses risk to Snowy Hydro:

1. **Transmission access** - Transmission will continue to be developed regardless of S2.0. Its development is required to leverage the temporal (time of day/seasonal and weather-related) diversity of geographically dispersed VRE resources, but without the Project, the transmission paths will ultimately bypass and crowd-out the existing scheme reducing future market access for Snowy Hydro. See *Chapter Sixteen - Transmission* for details; and
2. **Supply-demand competition** - increasing demand for firming product may be offset by market over-supply of firming technology, causing

downward pressure on prices and potential changes in the NEM's competitive landscape.

A number of other factors were considered in internal valuation:

1. **Risk limits** - A review for a potential increase in risk limits will be required for Futures Cash Flow at Risk and Stress Test internal policy. Credit risk limits for individual counterparties may need to be increased as Snowy Hydro increases its contracting levels with them, and/or a wider spectrum of counterparties may arise.
2. **Large-Scale Generation Certificates (*LGC*)** - LGC benefit and liability was considered. Any potential benefit was excluded from modelling, and the likely additional liability arising from Snowy 2.0 was considered immaterial;
3. **Liquidity threshold** - future liquidity requirements will be quantified when TransGrid's long-term transmission plans are clear. Management however believe that transmission redundancy will likely increase in the future and and dispatch capability failure risk will reduce; and
4. **Hydraulic operations** - the Project can be operated as desired within the confines of the Snowy Water Licence and Snowy Hydro's operational risk tolerances. The Project can provide additional control over the consequences and to a lesser extent the frequency or duration of impact of extreme inflows through careful planning of operations.

2 Activities undertaken

Snowy Hydro undertook a comprehensive internal valuation of the addition of 2,000 MW of dispatchable capacity to Snowy Hydro's portfolio.

3 Snowy Hydro portfolio effects and internal valuation

3.1 Overview

The Project will add 2,000 MW of dispatchable capacity to Snowy Hydro's portfolio, on top of the existing 5,262 MW.

The additional energy produced and capacity available from the Project will enable greater internal hedging of Snowy Hydro energy needs for Mass Market, Commercial & Industrial (***C&I***) and wholesale customer loads. It will also provide ancillary services and provide firming capacity for potential renewable projects sold direct to wholesale counterparties and indirectly through spot markets.

3.2 Additional assets to portfolio

Compared to other currently available storage options, Snowy 2.0 is a project that benefits from being at the higher end of the economies of scale for both capacity and energy.

3.2.1 Capacity Value

The construction of the Project will add an additional 2,000 MW of dispatchable or firm capacity to Snowy Hydro's portfolio, on top of the existing 5,262 MW.

3.2.2 Energy Value

Assuming a reasonable amount of foresight with respect to inflows and market risk, Snowy 2.0 has a relatively long energy duration:

350 GWh @ 2000 MW - 175 hours (~7 1/3 days) at full capacity.

On average, Snowy Hydro currently generates approximately four terawatt hours (***TWh***) on an annual basis, although this may vary significantly from year to year. This is in line with existing long-term storage capabilities and the water license requirements. Given its closed-loop nature (ie water used will be returned to the upper reservoir through pumping), the Project will not result in any extra releases of water from the Scheme, but the Project will have the ability to recycle water over the short and medium-term. The Base Case predicts at full asset utilisation an annual expected generation of approximately 2.8 TWh of time-shifted generation with a commensurate pumping expectation of approximately 3.7 TWh.

3.3 Internal valuation

The Snowy Hydro internal valuation approach provides a NPV utilising the Board-approved, industry standard DCF methodology and economic assumptions. Importantly, Snowy Hydro's internal valuation modelling utilises the key outputs of the MJA Report as the basis of the future market state, and is consistent with MJA's economic evaluation.

Customers may purchase standard wholesale products that deliver unbundled storage, capacity, and security from Snowy 2.0. Alternatively, they may purchase new firming products that bundle this storage, energy and capacity with energy from renewable generation. Sales of firming products can also incorporate synergies between Snowy 2.0, the existing Scheme and Snowy Hydro's current retail business.

The internal valuation approach considers this range of potential channels to market, and incorporates value contribution from five key sources:

1. Storage Value;
2. Capacity Value;
3. Security Value;
4. Drought protection Value; and
5. Firming products.

3.3.1 Storage Value

The key principle of storage value is to purchase energy at low prices for pumping, store the energy as potential energy of water at higher elevations, then

sell the energy when the demand/supply balance signals profitable release of the stored water. The Project's storage value is analogous to a battery and will be vital in contributing on an unprecedented scale to displacing the energy produced by renewables to when it is needed the most, at peak times.

Snowy Hydro is a vertically-integrated business with long-term average hydro generation of 4 TWh per annum. Currently, mass market customer loads in NSW and VIC of 3.5 to 4.0 TWh approximately match the long-term generation levels from the Scheme. In periods when hydro generation is below mass market load, this will be balanced by utilising gas generation capability, buying from spot, buying from the wholesale market or through long-term hedge contracts which enable flexibility to buy gas and allow cover from pumping.

With additional energy from the Project when it is required, this will allow greater internal hedging of energy needs to cover existing mass market load and future growth. Excess energy above mass market requirements could be used to underpin C&I customers, provide a firming capability to back renewable projects, sold through wholesale market, or on the spot market.

With recycling of water from the Project, and the increase in storage, this operational diversification and flexibility will improve management of inflows and weathering of drought conditions.

Snowy Hydro is already a major provider of storage to the NEM, and with the Project, will then possess the largest storage capability and give Snowy Hydro significant competitive advantage.

With greater storage facilities, this will allow Snowy Hydro to better manage generation across time periods, and take advantage of intertemporal price differentials.

3.3.2 Capacity Value

General

The basis for Project capacity value is equivalent to Snowy 1.0 capacity value (on a $/MW/hour basis). Value is derived from the ability to sell capacity products where the value is a function of supply/demand capacity balance, expected price volatility and new entrant pricing, as well as the capability to defend with fast start physical generation assets. Capacity is crucial for reliability and security by supporting or firming the capacity of non-dispatchable or intermittent generation.

Snowy Hydro is currently the largest provider of capacity products to the market. A large proportion of Snowy Hydro's capacity is committed to the Hedge Book, which has been sold to the major retailers in the market in large volume, long-term contracts. Another major component of capacity usage is tied by the mass market load, which is forecast to grow through the corporate plan period. The balance of capacity is sold on the wholesale market, through C&I customers or the spot market.

Value of capacity

There are three main reference price benchmarks for Capacity value:

1. **Open Market Deals** that are recent, actual and comparable;
2. **Bilateral, Over The Counter (*OTC*) Deals** transacted by Snowy Hydro that are recent, actual, and comparable; and
3. **Fundamental New Entrant Price (*NEP*) Modelling** of ground-up Open Cycle Gas Turbine (***OCGT***) plant cost amortised over its useful life of operations.

As the Project will provide capacity 'hedge' product (bespoke, very large, long-term and non-commoditised product) small, short-term capacity products are not deemed an appropriate benchmark.

Considering the lack of market deals to value capacity, Snowy Hydro intend to value capacity using their extensive historical and currently written bilateral deal experience. Snowy Hydro's valuation is derived from both actual trades with counterparties over the last decade, undertaken to hedge current Snowy Hydro capacity, and also fundamental NEP modelling of the least-cost New Entry of OCGT. This ground-up fundamental analysis models the NEP for the fair value of new-build OCGT, reflecting material changes in the following key drivers:

1. Identify which site is the most likely new entrant;
2. Macroeconomic factors and base case assumptions; and
3. Capital expenditure estimates for new entrant plant and supporting infrastructure.

3.3.3 Security Value

The regulation frequency control services are provided by generators and controlled by the Australian Energy Market Operator (***AEMO***) that continually monitors the system frequency and sends control signals out to generators providing regulation in such a manner that the frequency is maintained within the normal operating band of 49.85 Hz to 50.15 Hz.

In assessing the value attributed to system security, the Project valuation considers the current and future capability of the existing Snowy Hydro fleet with respect to security services. Currently, the SCADA system restricts Snowy Hydro participation to the regulation and five-minute FCAS markets with respect to frequency control services. However, a scheduled SCADA upgrade will enable Snowy 1.0 to participate across all eight FCAS markets, as will the Project. For this reason, the extent of FCAS value attributed to the Project has been subject to only value in excess of full utilisation of Snowy 1.0.

3.3.4 Drought Protection Value

The Project would provide additional strategic benefits relating to drought protection. Drought protection arises from the Project's ability to circulate very large quantities of energy around a closed loop, which does not not require new water from inflows to operate. Today, Snowy Hydro is more diversified in terms of fuel resource risk with a larger proportion of gas generation compared to the time of the ten year dry inflow sequence and the one-in-five hundred-year-low

inflow of 2007. Despite this, the Project would provide value by virtue of a significant increase in the amount of energy and capacity that can be provided by the Scheme when inflows are at these extremes. The Project would provide for 'normal Snowy Hydro' generation to be reduced and replaced by the Project that utilises low-cost 'excess' generation. While this is not related to the move to renewable generation, it is protection from the possibility of increasing very hot summers and dry conditions.

3.3.5 Firming Products

General

Given the increased renewable penetration, a market would emerge for the storage-related products for balancing, firming, shifting intermittent renewable output to demand shape. These products will leverage both capacity and storage value and possibly security as bundled storage products. The existing Scheme has storage-related products in place such as cap-swap, shared-benefit caps in which Snowy Hydro sells mostly capacity and provides some embedded optionality to leverage its flexibility and large storage. Snowy Hydro needs to explore new products to meet the new storage and capacity needs of the market and hence capture the economic, market, and other synergy values of the Project.

Firming products will take some capacity, energy, risk and head office resourcing to sell customers bespoke load-following products that for some customers, can be accredited to a renewable energy project if that is their preference. Firming will require either support from flexible gas generation or from storage, to provide generation that follows the customer's load, less the intermittent renewable generation.

This revenue product presents the most likely area for commercial gain due to the high margins and market demand/volume. From an overall market perspective, if there are not adequate and affordable 'firming' solutions, retailers will be required to either develop their own solutions or increase such costs to customers. This would likely have more significant impacts to smaller retailers, thus potentially reducing retail competition.

Channels and range of these new storage products include:

1. **Corporate Power Purchase Agreement for renewables** - Directly with large government and C&I customers or through energy brokers. This market channel would be useful for Snowy Hydro to mitigate the market power of big gentailers and help Snowy Hydro secure long-term storage products;
2. **Merchant renewable developers** - They might want some firming products to standard product or certain customer load shape to make it easier to sell to market or its customers;
3. **Gentailers** - (AGL Energy, Origin Energy, Energy Australia, etc.) Those who have renewable portfolio needs firming storage products. These products would also help improve the economic operations of their large base load generators; and

4. **Retailers** without sufficient physical hedge, for example Alinta in NSW and Meridian/Powershop.

Renewable Energy Procurement Program (REP-P)

Snowy Hydro announced in November 2018, the signing of eight wind and solar contracts, enough to provide cheaper energy to 500,000 households.

The eight projects, totalling 888 megawatts (MW), are located across New South Wales and Victoria and are expected to generate about 2.9 terawatt hours of energy annually.

The new renewable energy generation, 'firmed' by existing Snowy Hydro assets, is a game-changer and will push down future energy prices. This will bring on significant new energy supply and therefore much-needed competition to the market, and will enable Snowy Hydro to pass on lower wholesale prices to our customers.

The renewable energy Snowy Hydro have contracted will enable Snowy Hydro to offer very competitive, firm wholesale prices (ie. the cost of the raw renewable energy plus the cost of 'firming') - for below $70/MWh for a flat load, for up to 15 years.

3.3.6 Effect of Swaps (eg Power Purchase Agreements) on Snowy 2.0 pumping cost

MJA modelling of pumping cost

MJA minimises the cost of pumping by targeting spot prices periods that combine relatively low prices with low price elasticity of demand (ie low sensitivity feedback effect of the extra demand created by pumping on the resultant settled spot price in the bid stack).

Snowy Hydro agrees that this is the correct fundamental approach for minimising pumping costs in long run economic modelling. However, there are second-order effects of having a swap contract position that creates leverage on the price elasticity that can increase pumping cost if the net swap position is positive (ie sold) and vice versa if a negative position. However, these are deemed complex, highly uncertain and hard to quantify effects to the fundamental drivers of minimising pumping cost. They are likely to create more, rather than less, modelling error if included in MJA's valuation due to the dynamic nature of portfolio construction optimisation. Thus, this operational optimisation value is not currently modelled in the business case, but represents unquantified upside value.

Tranche 1 of the REP-P provides value to Snowy 1.0 (not Snowy 2.0)

There are potential effects of swaps (eg the REP-P Power Purchase Agreements (***PPA***) on Snowy 2.0's pumping cost.

It is important to note that the current REP-P process synergises Snowy 1.0 and thus is not applicable to Snowy 2.0 value. Thus, for the purposes of modelling Snowy 2.0 incremental cash flows, the REP-P bought PPA position adds portfolio value to Snowy 1.0 and thus should not be applied to Snowy 2.0. This is because

it is deemed that for the most part the Tumut 3 pumps can fully utilise the value provided by the REP-P bought swap position.

However, if at a later date there is a second tranche of REP-P PPA asset acquisitions, then in this case the pumping cost of Snowy 2.0 would likely be affected as Snowy 1.0 would be unable to provide this added pumping capacity.

3.4 Risk Impact

3.4.1 Risk to Snowy 1.0 of not developing the project

Risk factors

With predicted NEM decarbonisation and likely New Entry of 4 TWh to 10 TWh of renewables energy, will required complementary New Entry of capacity and storage atrophy Snowy 1.0's current value proposition? The two major material risk factors are access to unconstrained transmission and changes in the supply-demand economic balance.

Transmission access

See *Supporting Chapter Sixteen - Transmission*.

Supply-demand competition

With regards to projected supply-demand balance in the NEM, Snowy Hydro believe that intermittent New Entry will likely expand the market for firming product beyond today's requirements, thus elevating demand, and resultant price, for both Snowy 1.0 and the Project's product. However, there is a risk that this non-firm, energy New Entry could create a market overreaction of firming technology (eg OCGT and Li+) New Entry. In this hypothetical scenario, current Snowy 1.0 value could be eroded due to downward pressure on prices and changes to the NEM's competitive landscape. This would be irrational behaviour by market participants to enter the market and create a negative economic profit market outcome, but this could reasonably be considered a potential downside risk.

3.5 Hydraulic operations

Snowy Hydro operates under the Snowy Water Licence, which confers a number of rights and obligations upon the business. Key to the operation of the Project will be continued compliance with the water release requirements detailed in the Snowy Water Licence.

Market modelling outlined in *Supporting Chapter Five* demonstrates that the Project can be operated as desired within the confines of the Snowy Water Licence and Snowy Hydro's operational risk tolerances.

In extreme inflow scenarios, risks arising in all hydropower developments will become present in the Project. During prolonged periods of extreme drought, there is a risk of generation exposure without an increase in pumping. Under persistent wet conditions, the forecast generation and pumping profiles have potential to be impacted by downstream channel capacity constraints. This risk

can be mitigated through a reduction in generation output. At somewhat wetter than 10% Probability of Exceedance (***PoE***) inflows (depending on start levels of relevant storages), the forecast release profile will be constrained (as would Tumut 3 generation) by the water licence pre-Snowy Mountains Authority release constraint when Blowering Dam floods.

This infrequent constraint can be minimised through careful planning and be kept within acceptable risk limits. These scenarios do, and will continue to, occur, but the Project can provide additional control over the consequences and to a lesser extent the frequency or the duration of impacts through careful planning of operations. These constraints are similar to the risks Snowy Hydro already manages in day-to-day operations of the rest of the Scheme.

The interconnected operation of the Project with Eucumbene storage and Tumut 1, 2, and 3 Power Stations is presented in Figure 1. This illustrates the current Scheme and future Project water resource and flows. Specifically, it illustrates the potential to pump water from Talbingo to Tantangara and through to Eucumbene, and help mitigate spills under extreme wet scenarios.

See *Supporting Chapter Eighteen - Hydrology* and *Supporting Chapter Five* for more information.

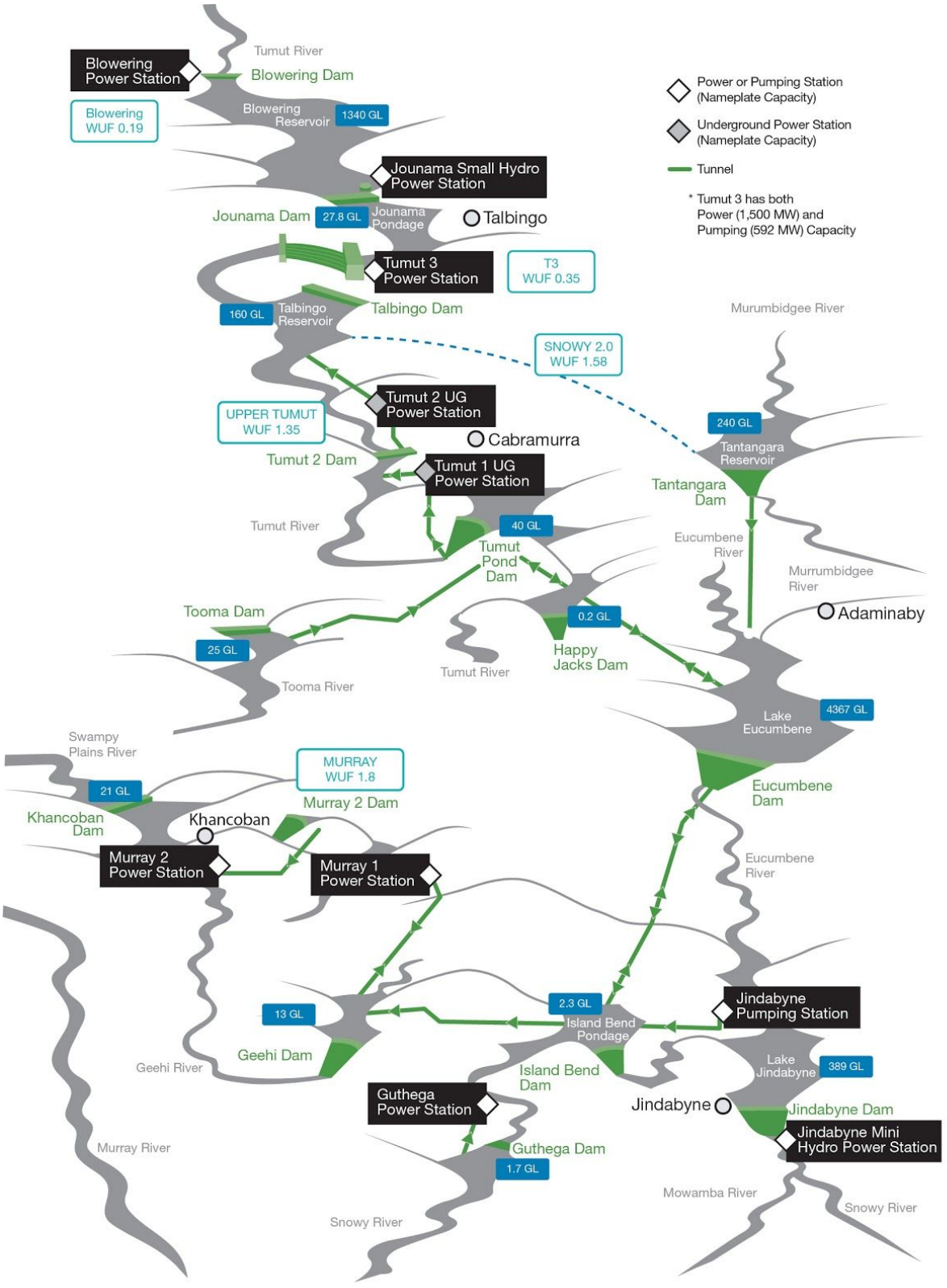

Figure 1: Current Scheme and future Project water resource and flows

4 Definitions and abbreviations

AEMO	Australian Energy Market Operator
C&I	Commercial and Industrial
DCF	Discounted cash flow
FCAS	Frequency Control Ancillary Services
FID	Final Investment Decision
MJA	Marsden Jacob Associates
NEM	National Electricity Market
NEP	New Entrant Price
NPV	Net Present Value
OCGT	Open Cycle Gas Turbine
OTC	Over The Counter
PoE	Probability of Exceedance
PPA	Power Purchase Agreements
SCADA	Supervisory Control And Data Acquisition
VRE	Variable Renewable Energy