An Overview of the Snowy 2.0 Pumped Hydro Energy Storage Scheme

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1 SUMMARY

1.1 Overview

The underlying concept behind the Snowy 2.0 Pumped Hydro Energy Storage (PHES) Scheme is to generate electricity by releasing water from the upper Tantangara reservoir to drive the turbines and to capture the released water in the lower Talbingo reservoir. During periods of excess electrical energy in the National Electricity Market (NEM), the water is pumped from Talbingo back to Tantangara, thus completing a cycle.

The Tantangara reservoir has an active storage of 240 GL which, theoretically when full, is sufficient to generate 350 GWh of electrical energy (2000 MW for 175 hours) as promoted by Snowy Hydro.

Snowy 2.0 is also promoted as a closed loop system. This is not the case as both reservoirs are part of natural water courses. However, Snowy 2.0 can be operated as a closed loop system. In this case, the active storage of the Talbingo reservoir of 156 GL provides a constraint on the generation of 350 GWh in 175 hours.

In addition, the availability of water is problematic. Tantangara Reservoir has never been more than 70% full in the 23 years to December 2020. This means there has never been water available to generate 350 GWh of electrical energy over 175 hours in that time period.

In addition, the long-term average weekly volume of the Tantangara reservoir, in the same 23 years, is 18.15% which allows only 32 GL to be used for generation.

The long-term average storage available in Talbingo is found to be approximately 33 GL, essentially defining the operating parameters of Snowy 2.0 as a closed loop system. This volume is clearly insufficient to support 175 hours of generation, unless the water is allowed to spill which may violate the conditions of the 'Snowy Water Licence".

The restraints of available water and storage volumes force Snowy 2.0 to operate only as a peaking plant. This means the predicted sources of revenue though Firming Products and Retail Diversification are discounted as improbable. Capacity Revenue was not analysed as the future of a Capacity Market is still unknown. Annual energy yield and energy consumption have been calculated within these restraints and form the basis of a Discounted Cash Flow (DCF) analysis on a project basis.

The DCF analysis was conducted to determine the required fixed or average selling price, commonly known as the Levelised Cost of Energy (LCOE) of the annual energy yield. The analysis included an initial price increase by 2% per annum and also addressed the impact of an operating life using 50 years to match Snowy Hydro criteria and 75 years to match expectations based on PHES systems currently in operation. Table 1 summarises the analysis outcome.

Snowy 2.0	Selling Prices per MWh			
Revenue Inflation	0%		2%	
Construction Cost $bn	50 Years	75 Years	50 Years	75 Years
2.0	$218.20	$123.91	$166.58	$152.43
4.0	$269.55	$151.75	$205.79	$186.68
6.0	$320.91	$179.59	$244.99	$220.94
8.0	$372.27	$207.44	$284.20	$255.19
10.0	$423.63	$235.28	$323.40	$289.44

Table 1 Summary of DCF Analysis

Based on the publicly available information used in this paper, the Snowy 2.0 PHES Scheme is not viable without a significant increase in the price of energy sold.

1.2 Acronyms

Acronym	Meaning
AHD	Australian Height Datum
CF	Capacity Factor
DCF	Discounted Cash Flow
FSL	Full Supply Level
LCOE	Levelised Cost of Energy
LTAS	Long-Term Average Storage
MOL	Minimum Operating Level
NEM	National Electricity Market
NPA	National Parks Association
NPV	Net Present Value
PHES	Pumped Hydro Energy Storage
RTE	Round Trip Efficiency
TypDay	Typical Variable Renewable Energy Day

2 INTRODUCTION

The purpose of this paper is to provide politicians and the general public with information on issues with the Snowy 2.0 Pumped Hydro Energy Storage Scheme (Snowy 2.0) that prevent the scheme from performing as has been described by its operator and owner, Snowy Hydro Ltd, which is owned by the Federal Government.

It also outlines the financial burden this scheme will place on taxpayers.

Snowy 2.0 is an addition to the original Snowy Scheme which was built to capture and move water from east to west. Full details of the original scheme can be found on the Snowy Hydro website.[1]

The environmental review of the proposed scheme resulted in Snowy Hydro publishing its responses to the many issues raised. In particular the Response to Submissions (RTS) by Snowy Hydro claims:

"Snowy 2.0 will utilise otherwise unused low-cost generation (surplus coal and VRE) and provide dispatchable and firm capacity that can operate for days if required" (page 76).

This statement will be tested in this paper.

Further, the 2017 Feasibility Study for the scheme estimated the project cost to be in the order of $3.8 – $4.5 billion with a benefit of $4.5 billion[2]. Costs are more likely to be about $8 billion for the scheme work[3] and an additional $2 billion for the necessary transmission works.[4]

Snowy Hydro believes that the costs of additional transmission lines necessary for the connection of Snowy 2.0 to the NEM grid should not be a project cost[5].

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[1] https://www.snowyhydro.com.au/snowy-20/about/
[2] https://www.snowyhydro.com.au/snowy-20/about/
[3] "Snowy 2.0 Claims Don't Stack Up" National Parks Association 26 February 2020
[4] ibid
[5] "Snowy Hydro response to incorrect claims" November 2019 https:/www.snowyhydro.com.au/our-scheme/snowy2.0/faqs20-2/

3 SNOWY 2.0

3.1 The Snowy 2.0 PHES Scheme

The Snowy 2.0 Pumped Hydro Energy Storage scheme utilises the existing Tantangara and the Talbingo Reservoirs as the upper and lower storage areas for the scheme. Intake and outlet works will be constructed in each reservoir and these will be connected with 27 km of 10.0 m diameter tunnels. The power station and associated works will also be constructed underground.[6]

Table 2 lists data extracted from the "Snowy 2.0 Project and Business Case Overview" and which form the basis of many of the calculations that follow.

Snowy 2.0 Data	
Feature	**Value**
From "Snowy 2.0 Project and Business Case Overview"	
Tantangara Full Supply Level	1230 m AHD[7]
Tantangara Active Storage	240 GL
Tantangara Gross Storage	254.1 GL
Tantangara Dead Storage	14.1 GL (5.55%)
Talbingo Full Supply Level	550 m AHD
Talbingo Active Storage Volume	156 GL
Maximum Energy Output	350000 MWh
Maximum Power Output	2000 MW (2GW)
Duration of supply at Maximum Power Output	175 Hrs
Number of Pump/Turbines	6
Type of Pump/Turbine	Francis
Max Flow Rate	380 m3/sec (1.368 GL/hr)
Round Trip Efficiency (2000 MW)	67%
Round Trip Efficiency (1000 MW)	76%
Life of Snowy 2.0 for DCF analysis	50 years
Discount Rate	8.00%
Terminal value	$0
From Pumped Hydro Cost Modelling – Entura 10686B	
Variable O & M rate	A$7.19/MWh
Fixed O & M rate	A$58250.00/MW/Yr

[6] https://www.snowyhydro.com.au/snowy-20/about/

[7] Australian Height Datum - The datum that sets mean sea level as zero elevation. Mean sea level was determined from observations recorded by 30 tide gauges around the coast of the Australian continent for the period 1966–1968.

Values Calculated from Snowy Hydro Information	
Pumping Energy consumed to fill Tantangara Reservoir Active Storage at Max power input	522388 MWh (=350000 MWh/0.67)
Minimum Pumping Time	261.19 hrs (=522388 MWh/2000 MW)
Maximum Pumping Rate	0.919 GL/hr (=240 GL/261.19 hr)
Time for operational Mode Change	2.00hrs (=0.50 hr+ 1.50hr)
Tantangara Dead Storage	5.55 % (= 14.1 GL/254.1 GL)

Table 2 Snowy 2.0 Data

3.2 A Closed System

The "Snowy 2.0 Project and Business Case Overview" states that Snowy 2.0 will operate as a closed system.

A closed system is characterised by neither the upper nor the lower reservoirs having a natural source of water inflow. This is certainly not the case with Snowy 2.0, and this fact may limit the performance of the scheme.

If the quantity of water available in Tantangara is greater than the storage in Talbingo, either generation will be curtailed or water lost downstream. This may violate the conditions of the "Snowy Water Licence". This would not occur in a properly designed "Closed Loop" scheme. The scheme can, however, operate as a closed loop system. This means generating/pumping cycles will be controlled by the water and storage available and water will not be spilled.

3.3 350 GWh for 175 hours

In theory 350 GWh of generation is possible. This can be shown by the calculation of the potential energy held in the Tantangara Reservoir which can be determined by using the following formula:

E = m*g*h

= V. ρ.(9.81).(Hu – Hl)

Where:

V = Maximum active storage

= 216 GL[8]

= 2.16 x108 m3,

[8] Based on as constructed volume less allowances for siltation operational requirements and spoil disposal

ρ = Density of water

= 1,000 kg/m3,

h = Difference in elevation of maximum storage level for upper and lower reservoirs.

Hu = Tantangara FSL 1,230 m and

Hl = Talbingo FSL 550 m

Thus

E = 2.16 x 108 x 1000 x 9.81 x 680

= 144.1 x 1013 Joules

= 400,250 MWh

With the Tantangara reservoir full, the generation of 350,000 MWh appears reasonable when allowing for high energy losses associated with the design of the scheme.

However, there needs to be sufficient storage in the Talbingo Reservoir to store the water from Tantangara used for generation which complicates the operation of Snowy 2.0.

3.4 Generation Scenarios

The “Snowy 2.0 Project and Business Case Overview” includes 3 generation scenarios to demonstrate how the scheme will be operated. The 3 scenarios are:

1. Very High Variable Renewable Energy Day.
2. Very Low Variable Renewable Energy Day.
3. Typical Variable Renewable Energy Day.

These scenarios have been examined to determine generation/pumping cycles times, water flow rates, volumes of water transferred, energy generated and energy consumed. Results are included in Appendices 1,2 and 3. The data extracted from these scenarios, when matched with water and storage availability, effectively confines the analysis of the scheme to be based on Snowy 2.0 acting purely as a peaking plant. For this the key features of scenario 3, the time and energy consumed by pumping during daytime, formed the basis of developing the peaking plant operational modes.

4 ENERGY GENERATION

The theoretical amount of energy that can be produced by Snowy 2.0 in a year is dependent on the following factors:

- the amount of renewable energy available to meet the requirements of pumping
- the water available for generation in Tantangara Reservoir
- the amount of storage available in the Talbingo Reservoir which will determine the maximum time for generation before pumping is required
- the number of turbines available for generation
- the number of turbines available for pumping to recharge the upper Tantangara Reservoir
- the time to change operational mode from generating to pumping and from pumping to generating.

4.1 Renewable Energy Available

Snowy 2.0 as a PHES scheme consumes more energy pumping water into storage than it will generate. This is highlighted by the Round Trip Efficiency (= energy out/energy in) value of 67%. In addition, pumping creates a further demand on the electricity grid which will need to be serviced by renewable energy generators. The Snowy Hydro scenario 3[9], which demonstrates how Snowy 2.0 will normally operate, shows energy consumption to be 13687.5 MWh for the 8.5 hours of pumping each day. With a NEM wind fleet average capacity factor of 29%, 5553 MW of wind generation will be needed at a cost of approximately $12 billion[10]. This additional wind capacity will be unavailable to meet normal grid demand during pumping cycles.

Solar energy could also be used to meet the pumping demand but with a capacity factor of around 25% construction of an additional 6441 MW of solar capacity will need to be constructed at a cost in the order of $10.5 billion[11].

These solutions to supply the energy for daily pumping do not allow for days when there are wind and solar "droughts".

[9] See Appendix 3
[10] Bowden and Brooking 18 April 2021 "An overview of the costs of firming Wind Farms with Pumped Hydro
[11] Bowden and Brooking 18 May 2021 "An overview of the costs of firming Solar Farms with Gas Turbines

4.2 Tantangara Reservoir

The continual transfer of water from Tantangara Reservoir to Lake Eucumbene results in the water level in the Tantangara reservoir always being quite low.

The water levels for the period 1 Jan 1998 to 31 December 2020 have been reviewed and provide further evidence of the relatively small quantity of water available for generation. Table 3 and Table 4 summarise the data.

Capacity Data		
	Vol %	**GL**
Weekly Average	18.15	46.12
Max Weekly Reading	70.95	180.28
Min Weekly Reading	5.50	13.96
Median Weekly Reading	14.36	36.48
Max Annual Average	36.68	92.39
Min Annual Average	7.53	19.13
Med Annual Average	14.41	36.62

Table 3 Capacity Details

Gross Supply Availability	No of Weeks	% of time
Weeks ≥ 5.55%	100.00	99.92
Weeks > 10%	708	59.20
Weeks > 13.85%	603	50.42
Weeks > 18.54	518	43.31
Weeks > 25%	338	28.26
Weeks > 36%	115	9.62
Weeks > 50%	30	2.51
Weeks > 66.94%	4	0.33
Weeks >70.95%	0	0.00

Table 4 Capacity Occurrence Details

Table 4 shows that over 23 years the “Dead Storage” has always been full. Whilst an intake structure for the Tantangara-Talbingo transfer tunnel could be constructed to take water from the Dead Storage area it is considered that this will increase construction costs without a matching increase in revenue.

The data above indicate that Snowy 2.0 will never perform as stated by Snowy Hydro or the Federal Government.

Details of Weekly Water levels for the 23 year period are included in Appendix 4[12].

4.3 Talbingo Reservoir

If the scheme was in fact a closed loop system, Tantangara and Talbingo reservoirs would have the same active storage capacities which effectively set the maximum cycle time. The active storage of Talbingo Reservoir when "empty "only provides space for 156 GL[13]. This represents 66.94% of the gross volume of the Tantangara Reservoir[14]. There have only been four weeks in 23 years where there was more than 156 GL in the Tantangara Reservoir.

Talbingo Reservoir has a rated Minimum Operating Level (MOL) of 534.35 m AHD, a Full Supply Level (FSL) of 543.19 m AHD[15] providing an operating range of 8.84 m. The historic, long term average water level for Talbingo Reservoir is 541.47 m AHD which is 1.72 m below the FSL. For a reservoir surface area of 1,935.5 Hectares[16] the water storage available for generation with the water level at 541.47m is only in the order of 33 GL[17].

It is understood that the water level in the Talbingo Reservoir is controlled by the need to supply water to the Tumut 3 Pumped Hydro System, as well as the conditions of the Snowy Water Licence.

It is highly likely that the available generation capability for Snowy 2.0 will be reduced if the Tumut 3 system is not to be adversely impacted.

It is theoretically possible for the pumping intake/discharge outlet to be positioned below the current MOL. This will provide a greater generation capability but may not be possible due to Snowy Water Licence requirements.

The long term average storage capacity of 33 GL represents 18.54 % of Tantangara storage[18]. It should be noted that the weekly average capacity in Tantangara for years 1998 to 2020 is 18.15%. There are only 518 weeks (43.31% of the 23 years) where water available in Tantangara Reservoir exceeds the long term Average Storage

The long term average water storage space of 33 GL available in the Talbingo reservoir for generation is the major constraint on generation. The 175 hrs of continual generation as published by Snowy Hydro and the Federal Government is not possible.

[12] Extracted from Snowy website
[13] Table 2
[14] Table 3
[15] Snowy Hydro RTS (Appendix O, page 63)
[16] Wikipedia
[17] =1935.5 Ha *1.72m
[18] = (33GL+14.1GL)/254.1 GL

A further constraint on the amount of generation possible is the availability of the required water. The number of weeks in the 23 years from 1998 to 2020 where the active storage water in Tantangara reservoir was less than 33GL is 657 (55%).

4.4 Operational Cycle Times

The time for a Generating/Pumping cycle depends on:

- available water from Tantangara Reservoir
- available storage in Talbingo Reservoir
- availability of renewable energy for pumping
- the number of turbines used for pumping
- the number of turbines used for generation
- time to change from generating mode to pumping mode.

4.5 Potential Annual Generation

In reviewing the operational modes depicted in the three scenarios in the Snowy business case, we have formed the opinion that these scenarios will not be used as detailed. Generating all day is essentially a base load operation which is not economical for pumped hydro schemes and can only take place if the Talbingo storage has the capacity available. Pumping will be required 1.5 days (37.5 hrs) which will reduce the time available for generation at peak periods.

It would appear from the Snowy Business case that the Typical Variable Renewable Energy Day (TypDay) will form a major part of the annual generation. Details of this scenario are shown in Appendix 3. However, if the energy production and pumping is undertaken as detailed in the TypDay, the long-term average storage (LTAS) in Talbingo Reservoir will be filled after seven days of generating as the pumping time does not permit return of all the water used for the daily generation.

Pumping at the same rate as detailed in TypDay will require five days to return available storage in Talbingo to the LTAS. This means there are periods when generation is not possible or is limited by storage in Talbingo.

To be able to generate consistently at morning and evening peak generation times is limited by the time taken to empty the Talbingo storage.

Details of two possible modes of operation that return the water used each day for generation at morning and evening peaks are shown in Table 5.

Item	Value	Explanation
Daily Generation Mode 1		
Water available	33 GL	See Table 1
Storage available	33 GL	See Table 1
Mode change time	2.0 hr	=1.5hr + 0.5hr
Pumping Flow Rate	0.740 GL/h-1	See Appendix 3
Pumping Time (hr)	8.5 hr	See Appendix 3
Water Returned	6.29 GL	= 8.5 hr * 0.740 GL/h-1
Pumping Power	1610.3 MW	See Appendix 3
Pumping Energy	13687.6 MWh	= 8.5 hr * 1610.3 MW
Generating Power	2000 MW	See Table 1
Generating Flow Rate	1.368 GL/h-1	See Table 1
Generating Time	4.6 hr	= 6.29 GL/1.368 GL/h-1
Energy generated	9200.0 MWh	= 4.6 hr* 2000 MW
Fixed Cycle time	24 hr	
Cycles per Annum	346	= 95 % operational availability
Energy generated pa	3183.2GWh	= 346 * 9200.0 MWh
Energy Consumed pa	4735.9 GWh	= 346 * 13687.6 MWh
Daily Generation Mode 2		
Generating Time	13.5 hr	
Generating Flow Rate	0.466 GL/h-1	= 6.29 GL/13.5 hr
Generating Power	681.3 MW	= 0.466 GL/h-1/1.368 GL/h-1 *2000 MW
Energy generated	9197.3 MWH	= 681.3 MW * 13.5 hr
Cycle time	24 hr	= 13.5 hr + 1.5 hr+ 0.5 hr + 8.5 hr
Cycles per annum	346	= 95 % operational availability
Energy generated pa	3181.2 GWh	= 346 * 9197.3 GWh
Energy Consumed pa	4735.9 GWh	= 346 * 13687.6 MWh

Table 5 Daily Generation Mode Data

Table 5 indicates that the maximum power to be used in generation can vary between 2000 MW and 681 MW. Generating time will vary accordingly.

The energy generated each year gives Snowy 2.0 a generation Capacity Factor (CF) of 3183.2/365*24*2000/1000 = 18% and a pumping CF =4735.9/365*24*2000/1000 = 27%. These values compare favourably with the energy CF of 17% (2978.4 GWh) and the pumping CF of 24% 4204.8 GWh which are stated in the "Snowy 2.0 Project and Business Case overview". Further the Round Trip Efficiency (RTE) of the above operational modes is 67% (= 3183.2 GWh/4735.9 GWh) which also compares favourably with the RTE stated in the Business case overview.

5 FINANCIAL ANALYSIS

The DCF analysis calculates the present value of the project cash flow to determine the required fixed selling price of the annual energy yield to produce a Net Present Value (NPV) = 0 for the discounted cash flow. An NPV = 0 means the project is viable at the chosen discount rate.

Selling prices for energy generated are calculated for a range of project costs including a cost of $2 billion for the necessary additions and modification required for the transmission of Snowy 2.0 output to the NEM grid[19] . The formulae used comply with Discounted Cash Flow project analysis principles.

The formulae are derived as follows:

NPV = Cash Flow/(1+r)^n - Initial Investment

Where Discount Rate = r

Annual Energy sold year n = En

Selling Price for Year n = Pn

Annual Costs year n = Cn

Life of Plant n years = 1 to N years

Annual Cash Flow year n An = Pn.En -Cn

Initial investment at start of Project= Io

NPV = ∑ (Pn.En -Cn)/(1+r)^n – Io

For NPV = 0

0 = ∑ (Pn.En)/(1+r)^n – (∑ Cn/(1+r)^n + I0)

The project meets financial requirements if the NPV = 0. Thus

∑Pn.En/(1+r)^n = ∑ Cn/(1+r)^n + Io

For a fixed selling price P and a fixed annual energy yield E we have

P =(∑ Cn/(1+r)^n + I0)/(E/(1+r)^n)

[19] National Parks Association of NSW: "Snowy 2.0 Claims don't stack up": 26 February 2020

Table 6 summarises the DCF data.

DCF Factors	Value
Discount Rate	8 %
Annual Cost Inflation	2.5 %
Annual Revenue Increases	0 % & 2.00%
Start Date	2025
Life of Plant	50 & 75 years
Cost of Wind RE	$50.00/MWh
Output GWh	3183.2 GWh
Input GWh	4735.9 GWh

Table 6 DCF Data

Table 7 summarises the DCF results.

Snowy 2.0 Life	Selling Prices			
Revenue Inflation	0%		2.00%	
Construction Cost $bn	50 Years	75 Years	50 Years	75 Years
2.0	$218.20	$123.91	$166.58	$152.43
4.0	$269.55	$151.75	$205.79	$186.68
6.0	$320.91	$179.59	$244.99	$220.94
8.0	$372.27	$207.44	$284.20	$255.19
10.0	$423.63	$235.28	$323.40	$289.44

Table 7 DCF Results

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

Revenue from Snowy 2.0 will result from operating as a peaking generator and the project will not be viable without a significant increase in the price of energy sold. This will result in an increase in the cost of electricity to consumers unless large subsidies are provided by the Federal Government to Snowy Hydro Ltd, a company it owns after investing $1.38 billion acquiring it from the New South Wales and Victorian Governments.

6.2 Recommendations

An independent panel of appropriately qualified and experienced professionals undertakes a review of the project in accordance with established business practice in the private sector to determine the likely completed cost of the project, which must include transmission costs and rehabilitation of those areas where the environment has been impacted by the construction of the scheme.

Depending on the outcome of the review, the actions taken and work completed by Snowy Hydro staff should be assessed against established engineering and economic business best practices.

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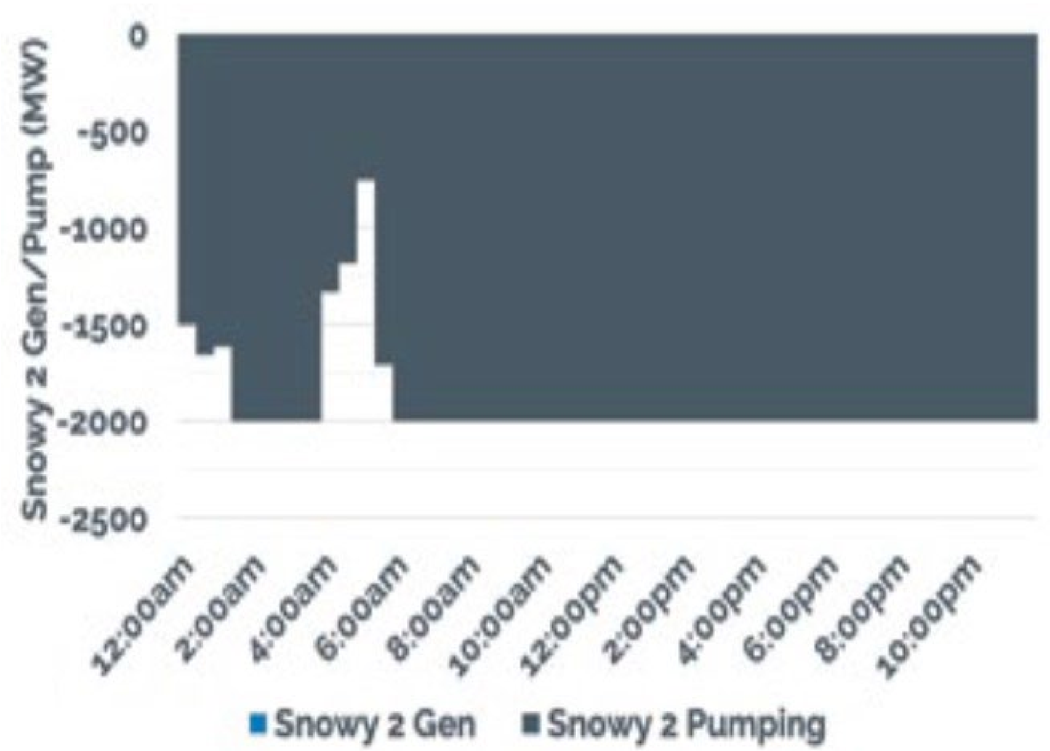
7 APPENDICES

7.1 Appendix 1 - Very High Variable Renewable Energy Day

It is assumed that, on a Very High Renewable Energy Day, Snowy 2.0 will not be required to generate power. Rather, it will take advantage of the abundance of renewable energy to pump water from the Talbingo reservoir to Tantangara, thus recharging for the next generating cycle.



From	To	Time(h)	MW(G)	MWh	MW(P)	MWh
12.00 am	12.30 am	0.5	0	0	2000	1000
12.30 am	1.00 am	0.5	0	0	2000	1000
1.00 am	1.30 am	0.5	0	0	1500	750
1.30 am	2.00 am	0.5	0	0	1650	825
2.00 am	2.30 am	0.5	0	0	1625	812.5
2.30 am	3.00 am	0.5	0	0	2000	1000
3.00 am	3.30 am	0.5	0	0	2000	1000
3.30 am	4.00 am	0.5	0	0	2000	1000
4.00 am	4.30 am	0.5	0	0	2000	1000
4.30 am	5.00 am	0.5	0	0	1350	675

From	To	Time(h)	MW(G)	MWh	MW(P)	MWh
5.00 am	5.30 am	0.5	0	0	1200	600
5.30 am	6.00 am	0.5	0	0	750	375
6.00 am	6.30 am	0.5	0	0	1700	850
6.30 am	7.00 am	0.5	0	0	2000	1000
7.00am	7.30 am	0.5	0	0	2000	1000
7.30 am	8.00 am	0.5	0	0	2000	1000
8.00 am	8.30 am	0.5	0	0	2000	1000
8.30 am	9.00 am	0.5	0	0	2000	1000
9.00 am	9.30 am	0.5	0	0	2000	1000
9.30 am	10.00 am	0.5	0	0	2000	1000
10.00 am	10.30 am	0.5	0	0	2000	1000
10.30 am	11.00 am	0.5	0	0	2000	1000
11.00 am	11.30 am	0.5	0	0	2000	1000
11.30 am	12.00pm	0.5	0	0	2000	1000
12.00pm	12.30 pm	0.5	0	0	2000	1000
12.30 pm	1.00 pm	0.5	0	0	2000	1000
1.00 pm	1.30 pm	0.5	0	0	2000	1000
1.30 pm	2.00 pm	0.5	0	0	2000	1000
2.00 pm	2.30 pm	0.5	0	0	2000	1000
2.30 pm	3.00 pm	0.5	0	0	2000	1000
3.00 pm	3.30 pm	0.5	0	0	2000	1000
3.30 pm	4.00 pm	0.5	0	0	2000	1000
4.00 pm	4.30 pm	0.5	0	0	2000	1000
4.30 pm	5.00 pm	0.5	0	0	2000	1000
5.00 pm	5.30 pm	0.5	0	0	2000	1000
5.30 pm	6.00 pm	0.5	0	0	2000	1000
6.00 pm	6.30 pm	0.5	0	0	2000	1000
6.30 pm	7.00 pm	0.5	0	0	2000	1000
7.00 pm	7.30 pm	0.5	0	0	2000	1000
7.30 pm	8.00 pm	0.5	0	0	2000	1000
8.00 pm	8.30 pm	0.5	0	0	2000	1000
8.30 pm	9.00 pm	0.5	0	0	2000	1000
9.00 pm	9.30 pm	0.5	0	0	2000	1000
9.30 pm	10.00 pm	0.5	0	0	2000	1000
10.00 pm	10.30 pm	0.5	0	0	2000	1000
10.30 pm	11.00 pm	0.5	0	0	2000	1000

From	To	Time(h)	MW(G)	MWh	MW(P)	MWh
11.00 pm	11.30 pm	0.5	0	0	2000	1000
11.30 pm	12.00 am	0.5	0	0	2000	1000
Total Energy						45887.5
Average Power					1911.98	

From the above graph and Snowy Data Table 1, we can determine for 1 day:

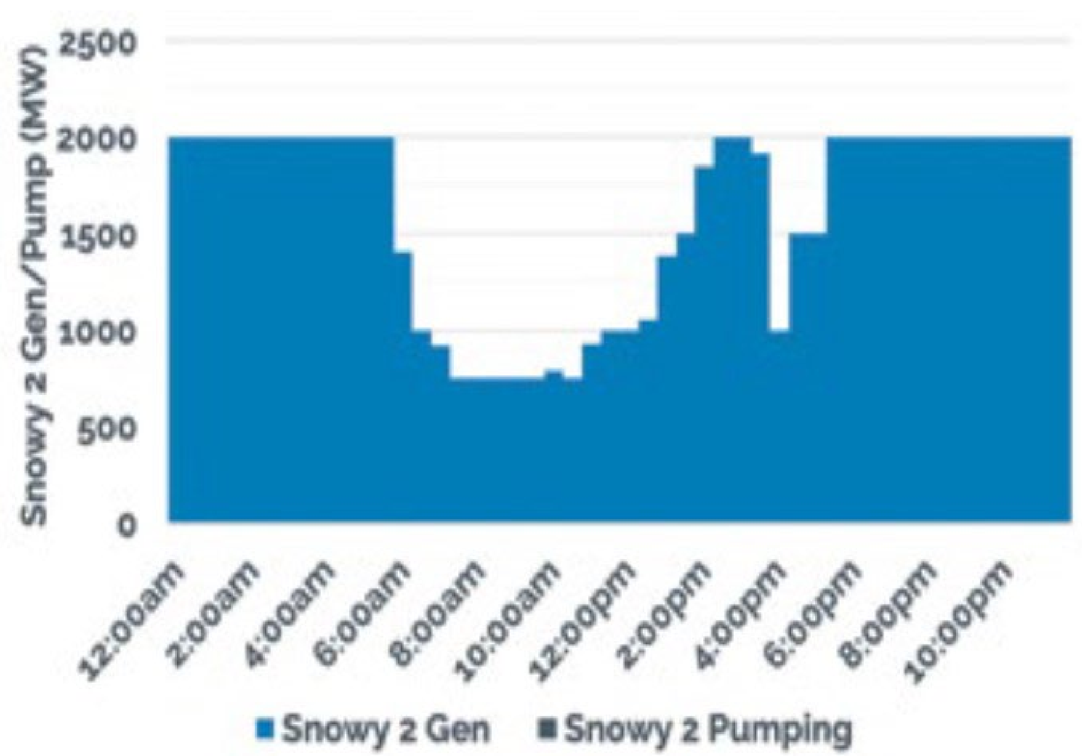
Feature	Value	Explanation
Average Pumping Power (MW)	1911.98	Ranged from 750 MW to 2000 MW.
Pumping Time (h)	24	From Graph
Pumping input (MWh)	45887.52	1911.98 MW*24 h
Pumping Flow Rate (GLh-1)	0.879	(1911.98 MW/2000 MW)*0.919 GLh-1
Water Returned to Tantangara reservoir (GL)	21.09	0.879 GLh-1*24 h
Talbingo Long Term Average Active Storage (GL)	33	See Para 2.6
Time to empty Talbingo storage (h)	37.5	33 GL/0.879 GLh-1
Tantangara storage required (%)	12.99	(33 GL/254.1 GL)*100
Tantangara storage availability (% of Time)	100	See Table 4

Table 8 Pumping Data

The scenario does not reflect the variability of RE over a day with large amounts of energy from roof top and utility solar complementing wind generation during daylight hours and wind generation reducing during the night. Firming with batteries defeats the purpose of Snowy 2.0 and coal generation cannot be relied on in the future unless there are major policy changes by Government.

7.2 Appendix 2 - Very Low Variable Renewable Energy Day

It is assumed that, on a Very Low Renewable Energy Day, Snowy 2.0 will be required to maximize power generation. However, the water level in the Talbingo reservoir may well be a constraining factor. Snowy 2.0 is, in effect, acting in a base load role currently the role of coal fired generators. This raises the issue of which form of generation will act as baseload if there are two or more consecutive Very Low Renewable Energy Days.



From	To	Time(h)	MW(G)	MWh	MW(P)	MWh
12.00 am	12.30 am	0.5	2000	1000	0	0
12.30 am	1.00 am	0.5	2000	1000	0	0
1.00 am	1.30 am	0.5	2000	1000	0	0
1.30 am	2.00 am	0.5	2000	1000	0	0
2.00 am	2.30 am	0.5	2000	1000	0	0
2.30 am	3.00 am	0.5	2000	1000	0	0
3.00 am	3.30 am	0.5	2000	1000	0	0
3.30 am	4.00 am	0.5	2000	1000	0	0
4.00 am	4.30 am	0.5	2000	1000	0	0
4.30 am	5.00 am	0.5	2000	1000	0	0
5.00 am	5.30 am	0.5	2000	1000	0	0
5.30 am	6.00 am	0.5	2000	1000	0	0
6.00 am	6.30 am	0.5	2000	1000	0	0
6.30 am	7.00 am	0.5	1400	700	0	0
7.00am	7.30 am	0.5	950	475	0	0
7.30 am	8.00 am	0.5	875	437.5	0	0
8.00 am	8.30 am	0.5	675	337.5	0	0
8.30 am	9.00 am	0.5	675	337.5	0	0
9.00 am	9.30 am	0.5	675	337.5	0	0

From	To	Time(h)	MW(G)	MWh	MW(P)	MWh
9.30 am	10.00 am	0.5	675	337.5	0	0
10.00 am	10.30 am	0.5	875	437.5	0	0
10.30 am	11.00 am	0.5	675	337.5	0	0
11.00 am	11.30 am	0.5	1000	500	0	0
11.30 am	12.00pm	0.5	1150	575	0	0
12.00pm	12.30 pm	0.5	1150	575	0	0
12.30 pm	1.00 pm	0.5	1250	625	0	0
1.00 pm	1.30 pm	0.5	1500	750	0	0
1.30 pm	2.00 pm	0.5	1750	875	0	0
2.00 pm	2.30 pm	0.5	850	425	0	0
2.30 pm	3.00 pm	0.5	1500	750	0	0
3.00 pm	3.30 pm	0.5	1500	750	0	0
3.30 pm	4.00 pm	0.5	2000	1000	0	0
4.00 pm	4.30 pm	0.5	2000	1000	0	0
4.30 pm	5.00 pm	0.5	2000	1000	0	0
5.00 pm	5.30 pm	0.5	2000	1000	0	0
5.30 pm	6.00 pm	0.5	2000	1000	0	0
6.00 pm	6.30 pm	0.5	2000	1000	0	0
6.30 pm	7.00 pm	0.5	2000	1000	0	0
7.00 pm	7.30 pm	0.5	2000	1000	0	0
7.30 pm	8.00 pm	0.5	2000	1000	0	0
8.00 pm	8.30 pm	0.5	2000	1000	0	0
8.30 pm	9.00 pm	0.5	2000	1000	0	0
9.00 pm	9.30 pm	0.5	2000	1000	0	0
9.30 pm	10.00 pm	0.5	2000	1000	0	0
10.00 pm	10.30 pm	0.5	2000	1000	0	0
10.30 pm	11.00 pm	0.5	2000	1000	0	0
11.00 pm	11.30 pm	0.5	2000	1000	0	0
11.30 pm	12.00 am	0.5	2000	1000	0	0
Total Energy				39562.5		
Average Power			1648.44			

From the above graph and Table and Snowy Data Table 1, we can determine for 1 day:

Feature	Value	Explanation
Average Generating Power (MW)	1648.44	Ranged from 675 MW to 2000 MW.
Generating Time (hours)	24	
Generating output (MWh)	39562.56	1648.44 MW*24 h
Generating Flow Rate (GL/h)	1.128	1648.44 MW/2000 MW*1.368 GLh-1
Water Used (GL)	27.02	1.128 GLh-1*24 h
Talbingo Long Term Aver. Active (LTAA) Storage Available (GL)	33	See Para 2.6
LTAA Storage Used (%)	81.88	27.02GL/33GL*100
Time for Maximum Generation (hours)	25.23	33 GL/1.308 GLh-1
Time required at max Power to fill LTAA storage (hours)	24.13	33 GL/1.368 GLh-1
Time to Empty LTAA Storage after 24 hours Generation (hours)	30.74	27.02GL/0.879 GLh-1
Water required in Tantangara reservoir (%)	18.54	((33+14.1)/254.1)*100
Time water available in Tantangara	43.14[20]	516 weeks in 23 years[21]
Time to fill Talbingo after 1 Very Low RE day @ max. power (hours)	4.37	(33-27.02) GL/1.368 GLh-1

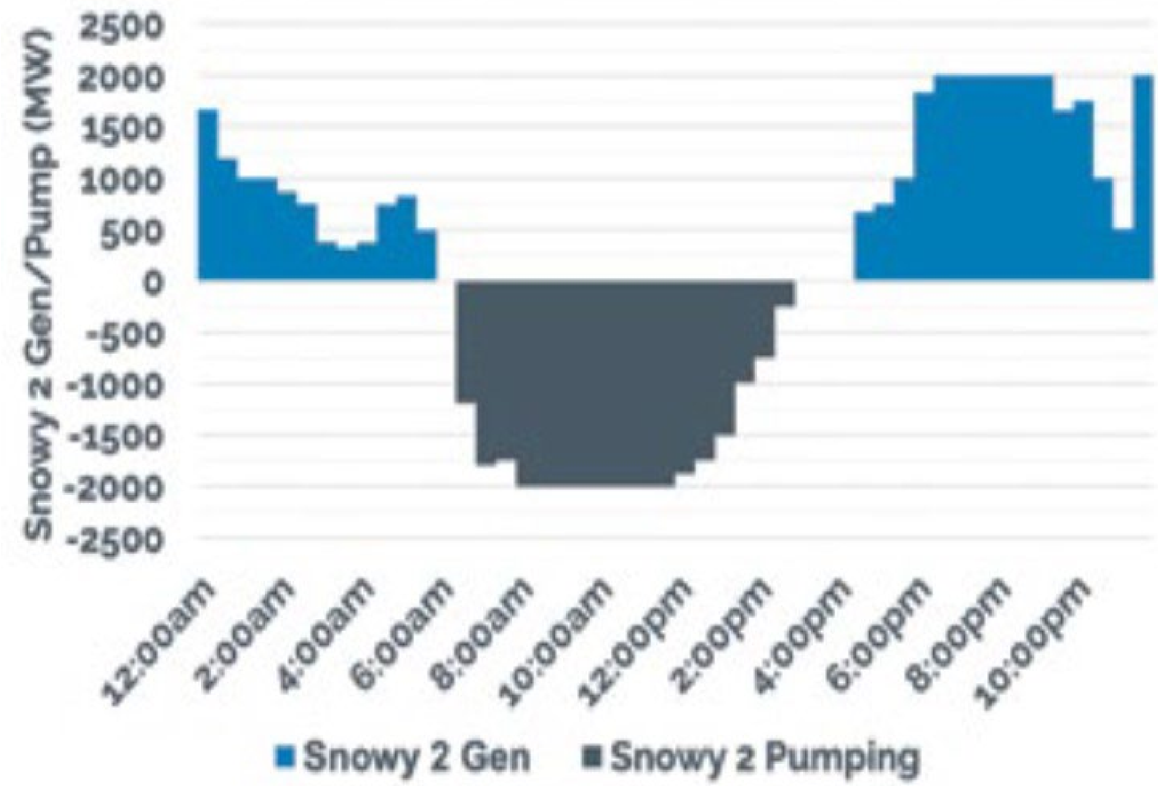
Table 9 Generation Data

From the above it can be seen that after one Very Low RE day, there is only enough storage to allow 4.37 hours of generation at maximum output. Pumping will then be required to empty the LTAA storage in Talbingo reservoir. This will take at least 37.5 hours[22]. If pumping resumes after 24 hours generation, then LTAA storage at Talbingo will be emptied in 30.74 hours. Return to full generation capability will take longer if the pumping period is interrupted by generation using the water already pumped into the Tantangara Reservoir. The time to change operational modes will also have a detrimental effect on recharge time.

[20] See Table 3
[21] See Table 4
[22] See Table 9

7.3 Appendix 3 - Typical Variable Renewable Energy Day

This is thought to be the prevalent mode of operation i.e. acting as a peak load generating plant. Water availability will also have an impact on the operating mode.



From	To	Time(h)	MW(G)	MWh	MW(P)	MWh
12.00 am	12.30 am	0.5	1750	875	0	0
12.30 am	1.00 am	0.5	1250		625	0
1.00 am	1.30 am	0.5	1000	500	0	0
1.30 am	2.00 am	0.5	1000	500	0	0
2.00 am	2.30 am	0.5	875	437.5	0	0
2.30 am	3.00 am	0.5	750	375	0	0
3.00 am	3.30 am	0.5	375	187.5	0	0
3.30 am	4.00 am	0.5	250	125	0	0
4.00 am	4.30 am	0.5	375	187.5	0	0
4.30 am	5.00 am	0.5	750	375	0	0
5.00 am	5.30 am	0.5	875	437.5	0	0
5.30 am	6.00 am	0.5	50	25	0	0
6.00 am	6.30 am	0.5	0	0	0	0
6.30 am	7.00 am	0.5	0	0	1125	562.5

From	To	Time(h)	MW(G)	MWh	MW(P)	MWh
7.00am	7.30 am	0.5	0	0	1750	875
7.30 am	8.00 am	0.5	0	0	1375	687.5
8.00 am	8.30 am	0.5	0	0	2000	1000
8.30 am	9.00 am	0.5	0	0	2000	1000
9.00 am	9.30 am	0.5	0	0	2000	1000
9.30 am	10.00 am	0.5	0	0	2000	1000
10.00 am	10.30 am	0.5	0	0	2000	1000
10.30 am	11.00 am	0.5	0	0	2000	1000
11.00 am	11.30 am	0.5	0	0	2000	1000
11.30 am	12.00pm	0.5	0	0	2000	1000
12.00pm	12.30 pm	0.5	0	0	1875	937.5
12.30 pm	1.00 pm	0.5	0	0	1750	875
1.00 pm	1.30 pm	0.5	0	0	1500	750
1.30 pm	2.00 pm	0.5	0	0	1000	500
2.00 pm	2.30 pm	0.5	0	0	750	375
2.30 pm	3.00 pm	0.5	0	0	250	125
3.00 pm	3.30 pm	0.5	0	0	0	0
3.30 pm	4.00 pm	0.5	0	0	0	0
4.00 pm	4.30 pm	0.5	0	0	0	0
4.30 pm	5.00 pm	0.5	625	312.5	0	0
5.00 pm	5.30 pm	0.5	750	375	0	0
5.30 pm	6.00 pm	0.5	1000	500	0	0
6.00 pm	6.30 pm	0.5	1875	937.5	0	0
6.30 pm	7.00 pm	0.5	2000	1000	0	0
7.00 pm	7.30 pm	0.5	2000	1000	0	0
7.30 pm	8.00 pm	0.5	2000	1000	0	0
8.00 pm	8.30 pm	0.5	2000	1000	0	0
8.30 pm	9.00 pm	0.5	2000	1000	0	0
9.00 pm	9.30 pm	0.5	2000	1000	0	0
9.30 pm	10.00 pm	0.5	1675	837.5	0	0
10.00 pm	10.30 pm	0.5	1750	875	0	0
10.30 pm	11.00 pm	0.5	1000	500	0	0
11.00 pm	11.30 pm	0.5	500	250	0	0
11.30 pm	12.00 am	0.5	2000	1000	0	0
Total Energy				32475		27375

From	To	Time(h)	MW(G)	MWh	MW(P)	MWh
Average Power				1202.78		1610.29

From the above graph and Snowy Data Table 1, we can determine for 1 day:

Feature	Value	Explanation
Average Generating power	1202.5 MW	Ranged from 250 MW to 2000 MW.
Generating Time	13.5 hours	from 4.30 pm until 6.00 am
Energy generated	16233.8 MWh	1202.5 MW*13.5 h
Water Discharged	11.10 GL	(1202.5 MW/2000 MW) *1.368 GLh-1 *13.5h
Pumping Time	8.5 hours	from 6.30 am until 3.00 pm
Average Pumping Power	1610.3 MW	Ranged from 250 MW to 2000 MW.
Pumping Energy Required	13687.5 MWh	1610.3 MW*8.5 h
Pumping Flow Rate	0.740 GLh-1	(1610.3 MW/2000 MW)*0.919 GLh-1
Water Returned	6.29 GL	(0.740 GLh-1*8.5 h)
Time to return all water	15.0 Hr	(11.10GL/0.740 GLh-1)
Water retained in Talbingo	4.81 GL	(11.10 GL-6.29 GL)

Table 10 Snowy Typical VRE Day Data

If generation hours are kept constant over time, pumping time will be a maximum of 8.5 hours day and 4.81 GL of water will remain in Talbingo Reservoir each day. If active storage available in the Talbingo Reservoir is 100% it would be filled in approximately 32.5 days (156 GL/4.81GLday-1). However, assuming that long term average active storage is only available, it would be filled in approximately seven days (33 GL/4.81GLday-1). Water would then be discharged downstream which may not meet water licence conditions.

7.4 Appendix 4 - Tantangara Water levels 1998 - 2020

		Weekly % of Gross Storage																						
Week	Day	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	4-Jan	6.70	7.20	9.5	7.5	7.10	18.90	7.36	8.81	7.27	5.90	6.85	7.70	6.88	42.80	25.41	26.12	29.45	23.34	21.47	28.51	43.05	49.80	8.59
2	11-Jan	6.70	7.30	9.4	7.1	7.00	16.10	7.34	8.07	6.93	5.90	6.85	7.26	6.62	39.64	24.79	25.85	29.37	24.57	21.90	23.84	43.44	50.20	8.53
3	18-Jan	6.60	7.10	8.2	6.9	6.80	11.90	7.28	7.52	6.74	5.80	6.85	7.01	6.42	36.84	25.55	25.74	29.27	25.80	22.02	20.58	43.84	50.08	8.38
4	25-Jan	6.60	7.30	7.5	6.8	6.70	8.70	6.85	7.29	6.83	5.70	6.85	7.00	6.30	33.07	25.89	25.45	29.27	27.05	22.23	20.86	41.58	48.68	8.53
5	1-Feb	6.60	7.20	7.7	6.9	6.90	7.90	7.07	7.36	6.72	5.60	6.85	6.75	6.21	29.13	26.79	25.49	29.22	27.66	23.22	20.88	36.63	47.32	8.43
6	8-Feb	6.50	7.00	7.3	6.8	6.90	7.90	7.07	7.28	6.66	5.50	6.85	6.58	6.32	27.84	24.55	25.56	29.02	28.17	24.16	20.94	31.50	46.02	8.32
7	15-Feb	6.30	6.80	6.9	7.0	7.90	7.90	7.49	7.59	6.69	5.70	6.85	6.40	6.64	27.63	22.07	25.52	28.90	28.64	24.36	21.08	26.59	44.65	8.85
8	22-Feb	6.20	6.70	6.8	7.1	8.20	6.30	7.33	7.40	6.40	5.70	6.85	6.36	6.77	29.30	22.97	25.48	29.27	29.47	24.44	21.02	26.50	43.05	9.51
9	1-Mar	6.10	6.60	6.9	6.9	8.00	6.20	7.33	7.43	6.29	7.60	6.85	6.26	6.64	28.56	25.55	25.90	29.23	28.63	24.47	20.96	26.70	41.52	9.60
10	8-Mar	5.90	6.60	6.9	6.8	7.80	6.20	7.33	7.28	6.18	6.02	6.85	6.21	6.70	25.89	50.86	26.08	29.18	24.57	24.51	20.95	26.62	40.20	10.25
11	15-Mar	5.80	6.60	6.8	6.7	7.50	6.30	6.52	7.22	6.04	6.06	6.86	6.23	7.29	23.43	52.61	26.04	29.30	20.55	24.55	20.91	26.53	38.78	10.99
12	22-Mar	5.70	6.50	6.8	7.1	7.25	6.30	6.38	7.12	6.04	6.40	7.02	6.25	7.01	20.51	51.15	26.13	29.32	16.62	20.72	20.99	26.37	37.13	11.26
13	29-Mar	5.70	6.80	7.0	7.1	7.04	6.20	6.26	7.12	5.97	6.50	7.18	6.23	6.83	18.41	47.84	26.23	29.77	14.43	16.72	21.06	26.38	34.81	11.39
14	5-Apr	5.60	6.90	7.1	6.9	6.85	6.30	6.18	7.10	5.90	6.50	7.35	6.13	6.81	16.60	43.85	26.30	30.65	14.57	15.85	21.02	26.28	32.98	11.93
15	12-Apr	5.60	6.90	7.0	6.8	7.00	6.30	6.15	6.96	5.85	6.40	7.52	6.16	6.80	15.34	39.37	26.41	32.31	15.36	15.85	21.20	26.15	30.52	12.84
16	19-Apr	5.70	6.80	7.2	6.7	6.80	6.30	6.11	6.82	5.84	6.30	6.96	6.21	6.75	13.35	34.98	26.41	33.60	15.90	15.93	21.27	26.30	28.10	12.98
17	26-Apr	5.90	6.70	7.2	6.8	7.00	6.30	6.09	6.76	5.89	6.30	6.86	6.43	7.12	11.43	31.51	26.43	34.28	16.87	16.01	21.55	26.25	25.95	11.44
18	3-May	5.90	6.70	7.0	6.9	6.90	6.30	6.12	6.69	5.89	6.50	6.99	6.97	7.11	9.78	27.46	26.41	34.89	17.60	16.21	21.91	26.17	23.91	13.91
19	10-May	6.00	6.70	7.5	6.8	6.80	6.30	6.15	6.62	5.99	6.60	7.07	6.86	7.22	9.33	23.35	26.32	35.49	18.09	16.59	22.01	26.43	22.54	17.07
20	17-May	6.10	6.80	7.8	6.8	6.70	6.30	6.18	6.57	6.20	6.50	6.96	6.81	7.08	10.35	19.83	26.71	36.08	19.21	18.24	22.09	26.49	20.92	18.07
21	24-May	6.20	6.80	7.9	6.8	7.00	6.30	6.25	6.54	6.28	6.90	7.02	6.78	6.96	11.49	19.81	25.82	36.60	20.64	18.80	22.92	26.50	19.18	17.51
22	31-May	6.30	7.20	7.8	6.8	7.50	6.60	6.37	6.54	6.31	7.19	7.02	6.72	7.46	14.04	21.19	21.79	38.51	21.87	19.35	23.50	26.55	19.18	16.36
23	7-Jun	6.50	7.60	7.9	6.8	7.30	6.60	6.42	6.53	6.33	7.47	7.00	6.73	8.13	15.47	23.60	21.40	40.69	23.20	22.65	24.00	26.63	19.23	15.51
24	14-Jun	6.80	7.70	8.0	7.0	9.00	6.70	6.53	6.52	6.33	7.28	7.05	7.04	7.97	16.84	25.71	22.18	42.20	24.10	29.92	24.29	26.91	19.48	14.44
25	21-Jun	7.20	9.00	8.4	7.2	10.70	6.90	7.08	6.86	6.62	7.22	7.45	7.10	9.39	18.34	27.68	22.75	44.91	26.12	31.13	24.44	27.79	19.38	14.50
26	28-Jun	8.50	8.70	11.3	7.4	11.60	7.00	7.60	8.13	6.66	7.71	7.38	7.18	9.47	22.11	28.79	23.65	51.24	27.75	36.10	24.48	28.20	18.59	16.08
27	5-Jul	8.10	8.40	11.4	7.6	10.30	7.40	7.92	8.22	6.69	8.79	7.65	9.46	8.88	23.13	26.60	24.33	57.14	28.78	36.22	24.61	28.96	18.25	15.88
28	12-Jul	9.40	8.10	10.7	7.7	11.80	7.50	7.76	9.85	6.73	11.55	8.69	9.40	8.46	25.97	24.97	24.55	58.64	29.65	36.68	25.24	30.48	17.88	15.19
29	19-Jul	8.50	7.90	9.7	8.9	12.90	7.60	7.89	10.33	6.74	10.54	9.29	9.19	11.71	24.89	26.80	25.79	60.34	31.38	37.84	25.75	31.33	21.08	14.55
30	26-Jul	9.30	8.40	9.4	9.2	11.70	7.40	7.64	10.73	7.09	9.14	11.25	9.18	11.11	26.57	25.74	26.91	59.72	34.89	44.94	26.32	32.10	22.33	12.90
31	2-Aug	10.30	8.10	11.2	8.9	10.60	7.70	8.09	10.02	7.28	9.76	10.48	9.05	10.29	26.25	24.07	25.75	58.99	38.85	48.35	27.46	33.29	22.33	11.98
32	9-Aug	13.40	8.10	10.5	8.3	10.60	7.70	8.21	9.82	7.30	9.91	10.59	8.73	10.69	25.75	21.76	26.03	57.51	41.01	49.80	30.02	36.17	21.85	10.34
33	16-Aug	14.30	10.70	15.9	9.4	10.60	8.80	8.82	14.36	7.16	9.34	10.23	8.46	11.97	25.29	22.54	27.46	54.15	39.99	48.52	32.24	39.97	21.38	10.77
34	23-Aug	19.10	10.30	18.1	9.6	10.70	10.35	9.71	14.36	7.02	9.11	10.29	9.21	16.63	27.81	25.23	28.72	51.95	37.81	46.75	35.73	43.42	23.84	12.84
35	30-Aug	20.90	10.10	20.0	11.4	9.80	11.90	9.67	14.36	7.09	8.55	10.23	10.51	18.47	26.82	29.65	31.51	49.15	38.82	45.31	34.74	46.21	26.04	13.76
36	6-Sep	20.10	10.40	21.5	15.5	10.50	17.50	12.75	12.34	7.20	7.90	10.83	11.91	28.16	24.52	29.07	29.50	45.65	38.46	47.84	32.35	49.72	26.27	16.80
37	13-Sep	19.30	11.70	25.6	19.3	13.80	16.30	15.31	12.09	7.53	7.60	10.29	12.33	35.22	23.01	28.89	25.87	42.44	36.52	51.29	30.93	52.92	26.72	17.16
38	20-Sep	18.60	12.90	29.8	23.2	18.30	9.10	17.23	17.62	7.25	7.73	10.73	11.18	36.32	24.27	27.97	28.18	38.78	33.74	54.51	29.78	54.75	26.90	15.58
39	27-Sep	21.50	12.30	28.5	24.6	19.70	9.45	16.22	22.26	6.97	7.50	13.60	11.23	34.61	25.44	25.49	30.14	34.83	30.65	54.38	26.26	51.40	27.28	15.80
40	4-Oct	22.00	12.00	30.1	23.9	23.10	19.80	14.51	26.64	6.83	7.24	13.35	13.50	31.93	31.09	25.26	29.45	31.04	26.99	61.33	23.15	47.74	26.36	17.81
41	11-Oct	22.40	12.40	28.8	21.8	26.90	22.09	12.12	28.96	6.63	6.93	12.76	13.61	29.12	34.21	24.02	27.18	27.74	23.27	70.29	20.28	44.20	24.60	20.12
42	18-Oct	21.90	11.50	27.1	20.9	29.50	21.06	9.64	30.10	6.45	6.75	9.73	15.11	35.51	32.13	24.54	24.41	25.83	19.47	70.95	21.06	40.52	23.04	20.95
43	25-Oct	22.70	10.40	30.0	21.5	31.50	19.24	8.39	28.40	6.39	6.51	8.27	14.60	37.39	30.27	22.56	23.87	22.99	17.06	70.81	21.90	36.94	21.23	24.18
44	1-Nov	21.00	9.50	30.8	21.2	32.00	17.21	8.22	26.30	6.41	6.83	7.52	12.81	37.31	31.11	20.06	24.66	19.70	17.38	68.02	22.63	37.00	19.37	27.75
45	8-Nov	18.90	10.10	28.9	22.1	29.90	15.38	8.66	25.36	6.28	7.11	7.33	12.06	38.12	31.83	21.77	24.98	18.45	18.62	64.08	23.42	37.89	18.27	28.60
46	15-Nov	17.20	11.70	26.0	20.4	26.10	12.77	11.81	24.70	6.28	7.06	7.52	12.41	37.61	30.55	23.97	26.62	18.78	19.81	60.61	24.38	38.66	16.96	26.88
47	22-Nov	14.80	13.30	23.4	19.3	25.20	9.92	14.85	21.88	6.28	6.85	7.31	9.39	38.23	27.89	24.79	27.57	19.39	20.70	56.61	25.34	39.37	15.25	24.12
48	29-Nov	11.70	15.70	20.3	17.3	25.60	9.57	14.72	19.07	6.26	6.85	8.04	8.00	36.42	30.59	25.36	28.09	19.84	20.88	52.17	26.84	42.95	13.53	21.45
49	6-Dec	9.20	16.80	17.5	15.1	24.00	8.69	12.22	17.19	6.04	6.85	8.33	7.43	39.19	37.22	25.66	28.71	20.44	20.90	47.56	34.77	44.38	12.03	18.23
50	13-Dec	8.00	15.10	14.3	12.0	29.00	7.91	10.93	15.44	6.04	6.85	7.82	7.01	45.66	35.20	25.56	29.21	21.70	21.02	43.09	39.94	45.26	10.53	15.29
51	20-Dec	7.90	12.20	41.7	9.7	24.10	7.36	12.01	11.62	6.60	6.85	8.61	6.82	46.34	31.73	25.81	29.34	21.79	21.10	38.46	41.62	48.90	9.21	12.53
52	27-Dec	7.50	9.50	8.5	8.1	24.40	7.89	10.96	8.42	5.90	6.85	8.27	6.99	45.89	29.19	26.11	29.47	22.11	21.31	33.61	42.38	50.11	8.65	9.66
Annual Weekly Average		10.80	9.07	14.41	11.10	13.63	9.78	8.87	12.24	6.52	7.20	8.29	8.52	17.81	25.20	27.83	26.28	35.21	25.19	36.68	25.51	35.71	26.80	14.74
Max in Year		22.70	16.80	41.70	24.60	32.00	22.09	17.23	30.10	7.53	11.55	13.60	15.11	46.34	42.80	52.61	31.51	60.34	41.01	70.95	42.38	54.75	50.20	28.60