Snowy Hydro Group Project

Business Analytics Project

BUSA8031

Batteries Analysis

Macquarie University

Group Members
Group 1

Hasan Mustafa Tarique - 46242880
Fariha Mubasshira - 46279253

Sidharth Sindhu - 46343229
Raj Katare - 46843302

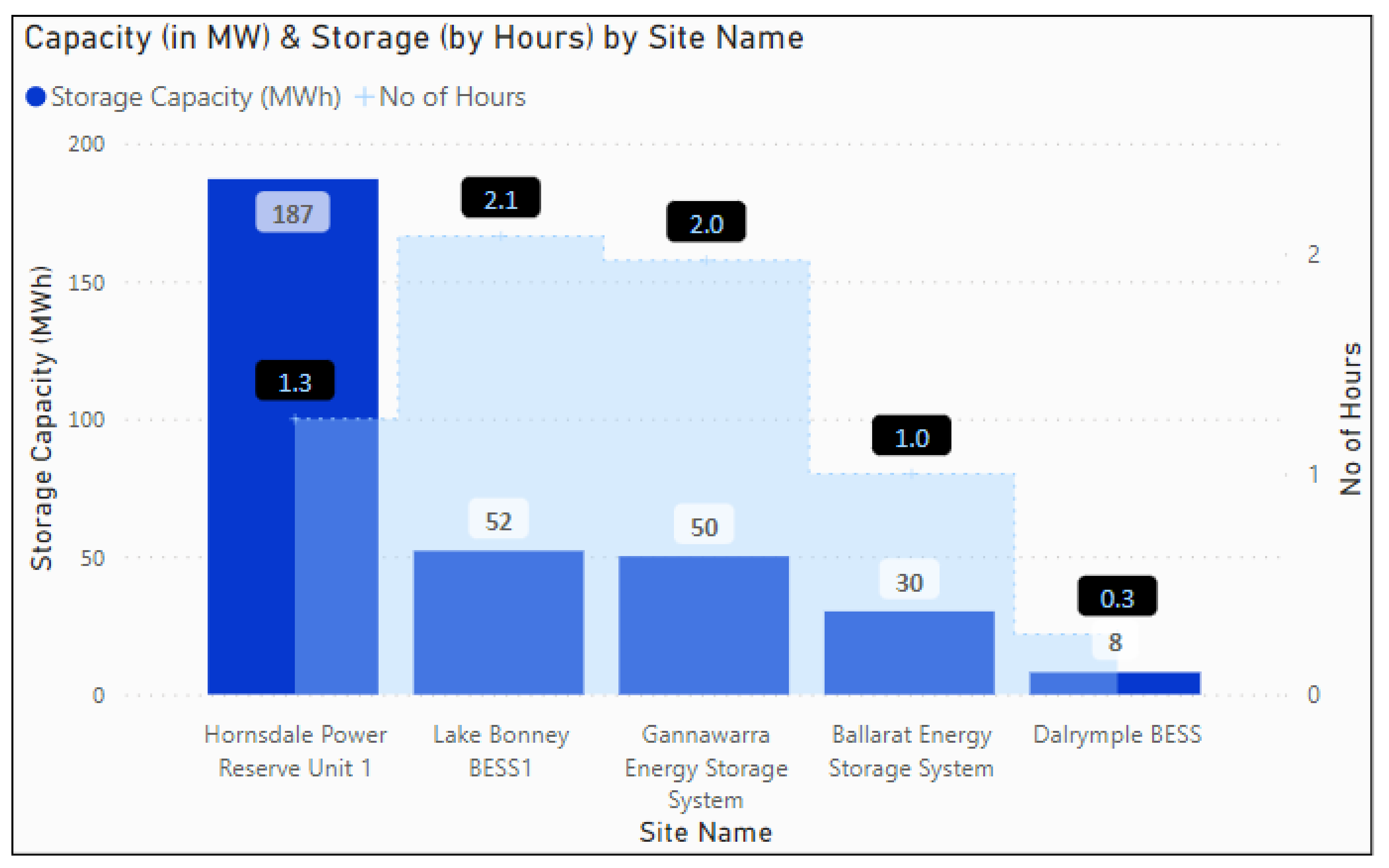
Mahsa Ebrahimian - 47259663
Saakshi Khatri - 46806725

Battery Storage Scenario

•Over 85 more huge batteries with a combined capacity of 18,660 MW are now under construction

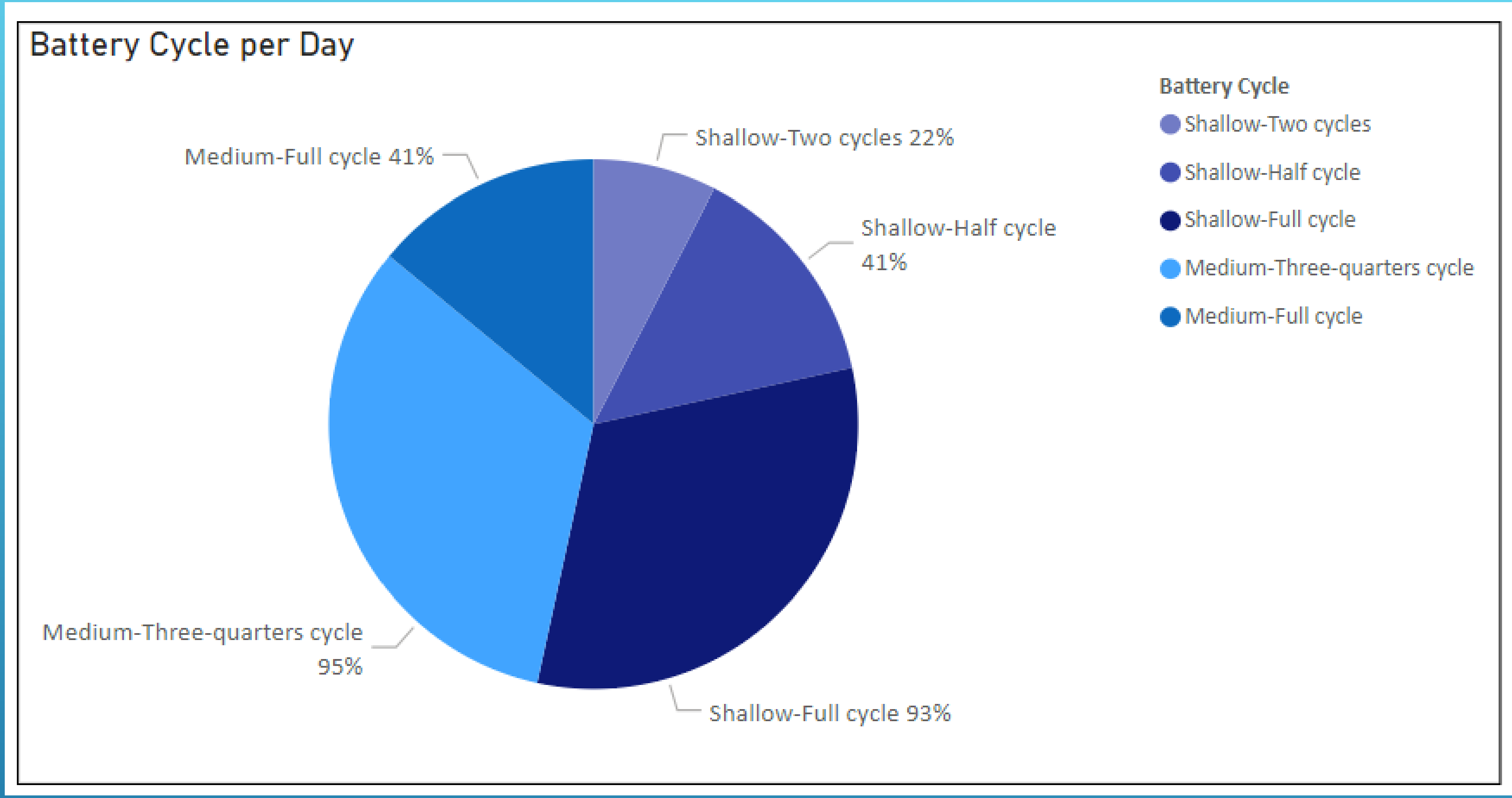
•Predicted power capacity of up to 1,200 MW

•8 times bigger than the battery at Hornsdale



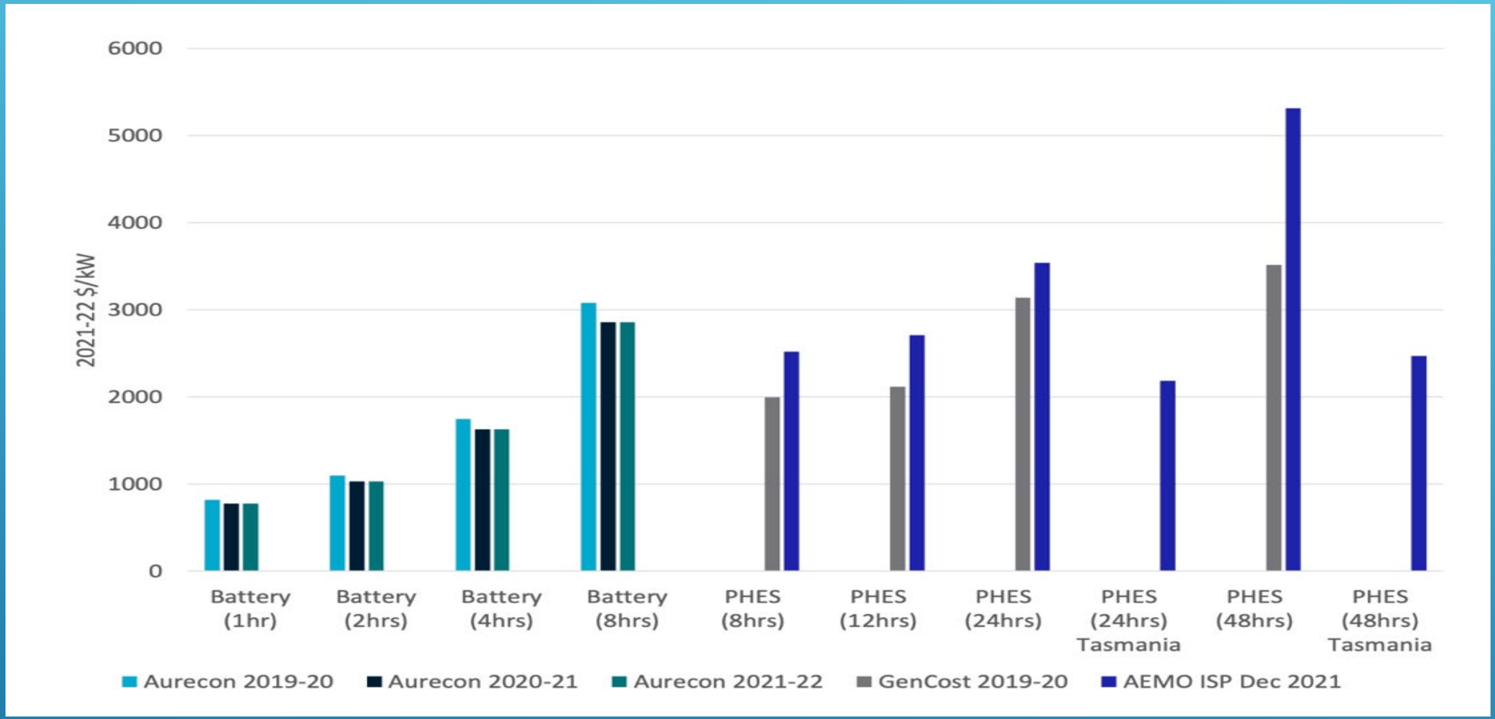
AEMO has defined these dispatchable storage depth classes as:

- Shallow storage – includes virtual power plant (VPP) battery and 2-hour large-scale batteries. The value of this category of storage is more for capacity, fast ramping, and FCAS (not included in aemo's modelling) than it is for its energy value.
- Medium storage – includes 4-hour batteries, 6-hour pumped hydro, 12-hour pumped hydro, and the existing pumped hydro stations, shoalhaven and wivenhoe. The value of this category of storage is in its intra-day shifting capability, driven by demand and solar cycles.

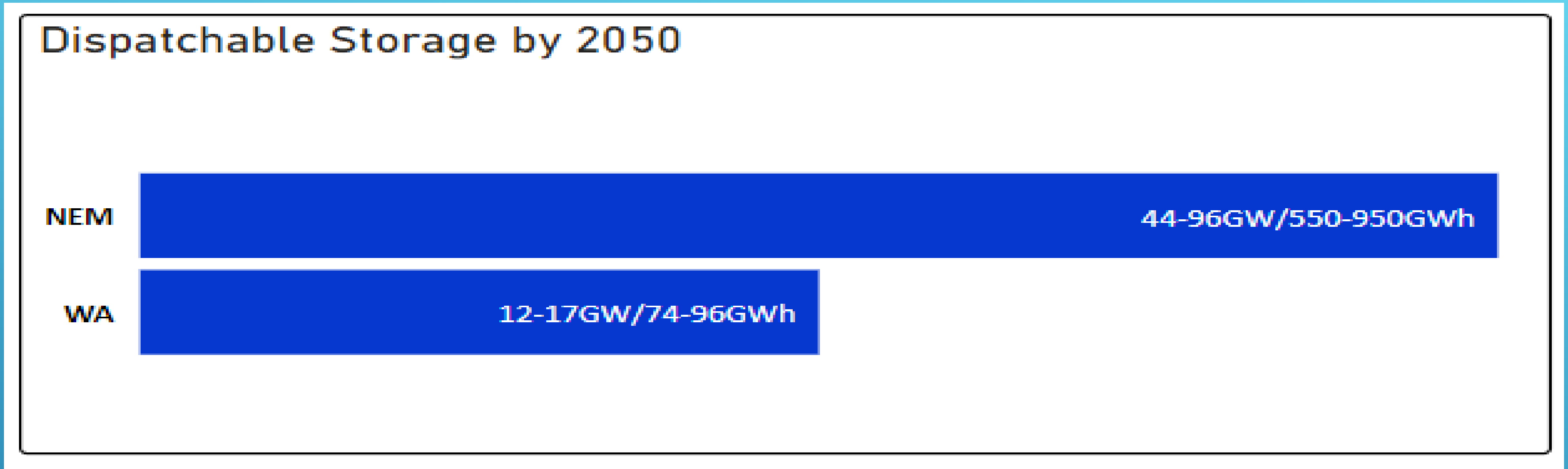


Shallow storages make at least one full cycle on 93% of days, with an extra half-cycle on 41% of days and two cycles on 22% of days. The means the average number of cycles per day for shallow storage is 1.4. For medium storages, three-quarters of a cycle is typical, though a full cycle is achieved on 41% of days (the upper end of this size category includes 12-hour storages, for which one cycle is the maximum possible in 24 hours).

Battery Storage across different durations



CATEGORY	CHALLENGES	RECOMMENDATIONS
Short-duration electricity storage (1–4 hours)	Short duration storage is expected to play a major role in decarbonisation across Australia's grids and its industries, particularly in the near term (to 2030). Although commercially mature options exist to meet Australia's short-duration storage needs, there are supply chain risks that could create deployment bottlenecks and drive up prices.	• Continue to deploy commercial utility scale (100+ MWh) short-duration electrical storage technologies alongside the demonstration of technologies currently in development to create optionality. • Consider and develop strategies to de-risk battery supply chains through a number of strategic diversification pathways, including, but not limited to: strategic supply chain and manufacturing partnerships; developing domestic value chains; developing resource circularity; and investing in research, development and demonstration (RD&D) for alternative battery chemistries.
Medium (4–12 hours) and long intraday (12–24 hours) electricity storage	Australia's medium to long intraday storage demand will become more significant in the near term with deeper levels of renewables penetration, and for industry sites with limited grid connectivity. Although some commercial technologies exist, they are not always applicable depending on the end use or region in question. There are also several other technology options currently in development, but these are not yet competitive and require further demonstration and deployment.	• Rapidly demonstrate and commercially deploy medium to long intraday duration technologies capable of providing hundreds of megawatt hours to multiple gigawatt hours of storage to create a diverse set of options for major grids and industry applications. • Conduct further regional studies to better understand geological storage opportunities, such as with adiabatic compressed air energy storage (A-CAES) and PHES subsystems, and opportunities to take advantage of existing capital and sites, including evaluating opportunities created through mine closure efforts.
Long multiday (24–48 hours) and seasonal (100+ hours) electricity storage	Multiday and seasonal storage will play a key energy 'insurance' and resilience role in major and isolated grids, with deployments expected to increase beyond 2030 as higher levels of renewables are adopted. However, at these durations, storage technology options are limited and often have long lead times, with many stakeholders still considering investment options, including those that minimise storage investments, and evaluating trade-offs as they transition to net zero.	• Conduct further analysis to better understand Australia's requirements for multiday and seasonal storage, the trade-offs that exist and the technology pathways available. • Develop the pipeline of projects to meet Australia's potential long-term seasonal and multi-day needs, including identifying and implementing opportunities to accelerate PHES deployments, and progressing emerging multi-day and seasonal technologies.



On the other note, The CISRO did an assessment, and used the Australian Energy Market Operator's (AEMO) 2022 Integrated System Plan for its analysis of what might be required with the step change and hydrogen superpower scenarios, suggesting the NEM could need between 44 and 96GW/550-950GWh of dispatchable storage by 2050, while Western Australia might need 12-17GW/74-96GWh.

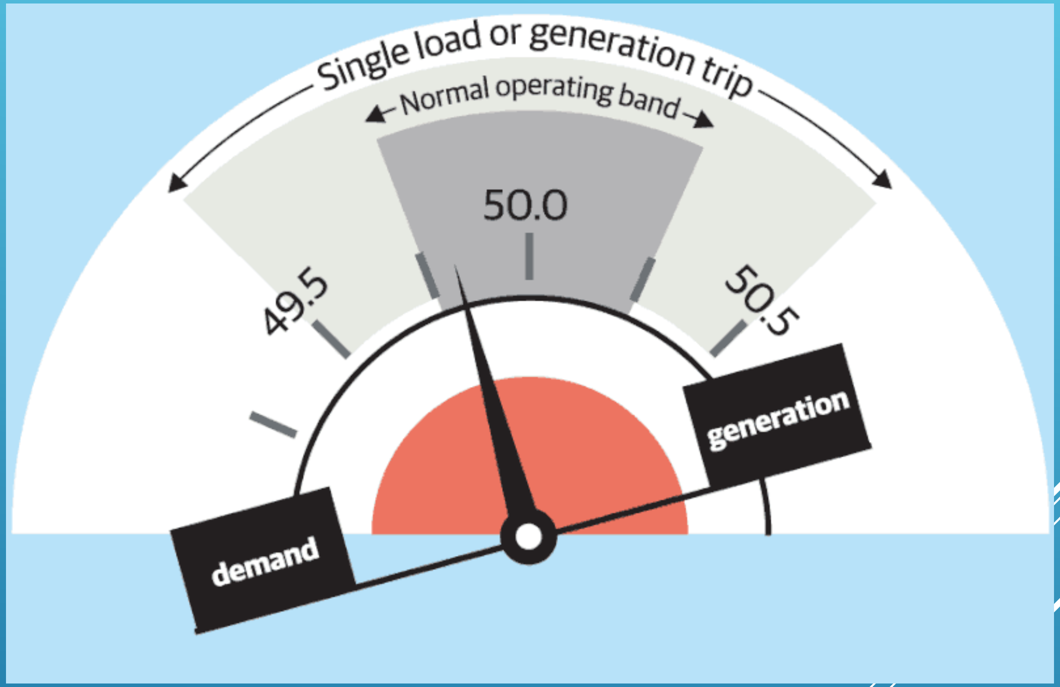
The CSIRO expects investment in short and medium-duration storage to play an important part, while it also suggests investment in thermal energy storage systems would be required to deliver process heat in industrial settings. While there are a number of storage technology options the report flags that there are only a handful that are commercially mature. Others remain under development.

Frequency Control Ancillary Services

The Australian Energy Market Operator (AEMO) uses FCAS as one of its management tools for power system security.

FCAS is an essential component of the safety net measures that ensure AEMO can reach and sustain its goals, hence it is crucial that it is given when needed to maintain safety of the electricity system.

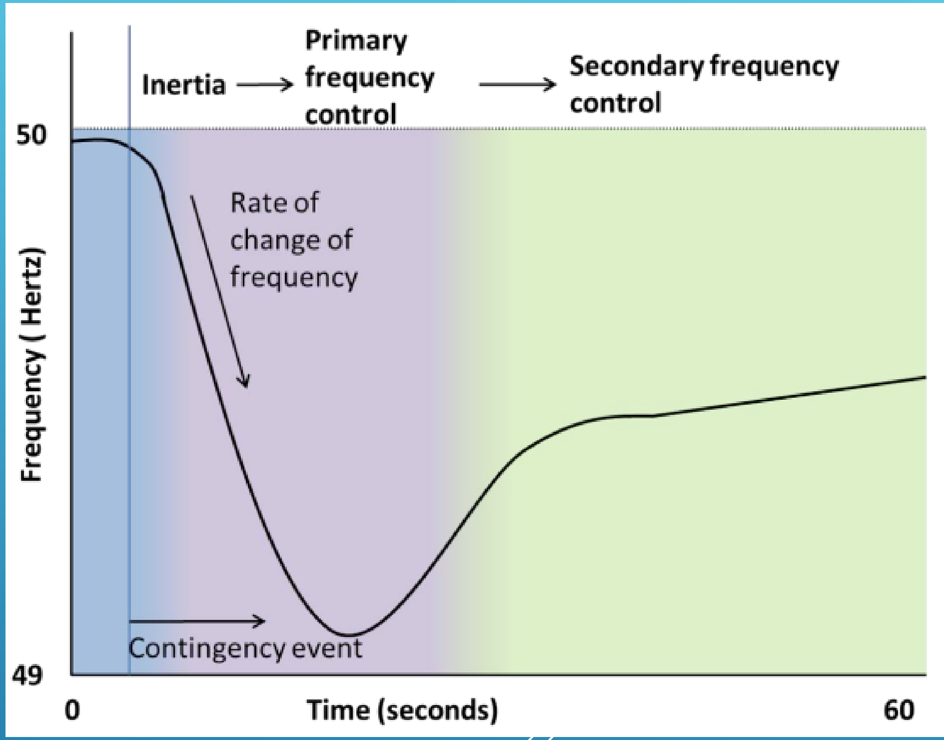
There are currently two types of FCAS – contingency and regulation



CONTINGENCY FCAS

Contingency FCAS is procured to manage frequency recovery and return the frequency back within the normal operating frequency band (50 +/- 0.15 Hz), following a contingency event affecting the power system (such as the loss of a generator, load or network element).

These services are delivered automatically by enabled providers that have bid into the National Electricity Market (NEM) to deliver contingency FCAS in response to any frequency deviation outside the normal operating frequency band that may occur.



REGULATION FCAS

Regulation FCAS is procured to manage small perturbations around 50 Hz when frequency is within the normal operating frequency band.

Regulation FCAS is controlled by AEMO's Automatic Governor Control (AGC) system, which sends pulses to regulation-enabled generators to increase or decrease output every four seconds.

Further,

There are eight different frequency markets across the NEM.

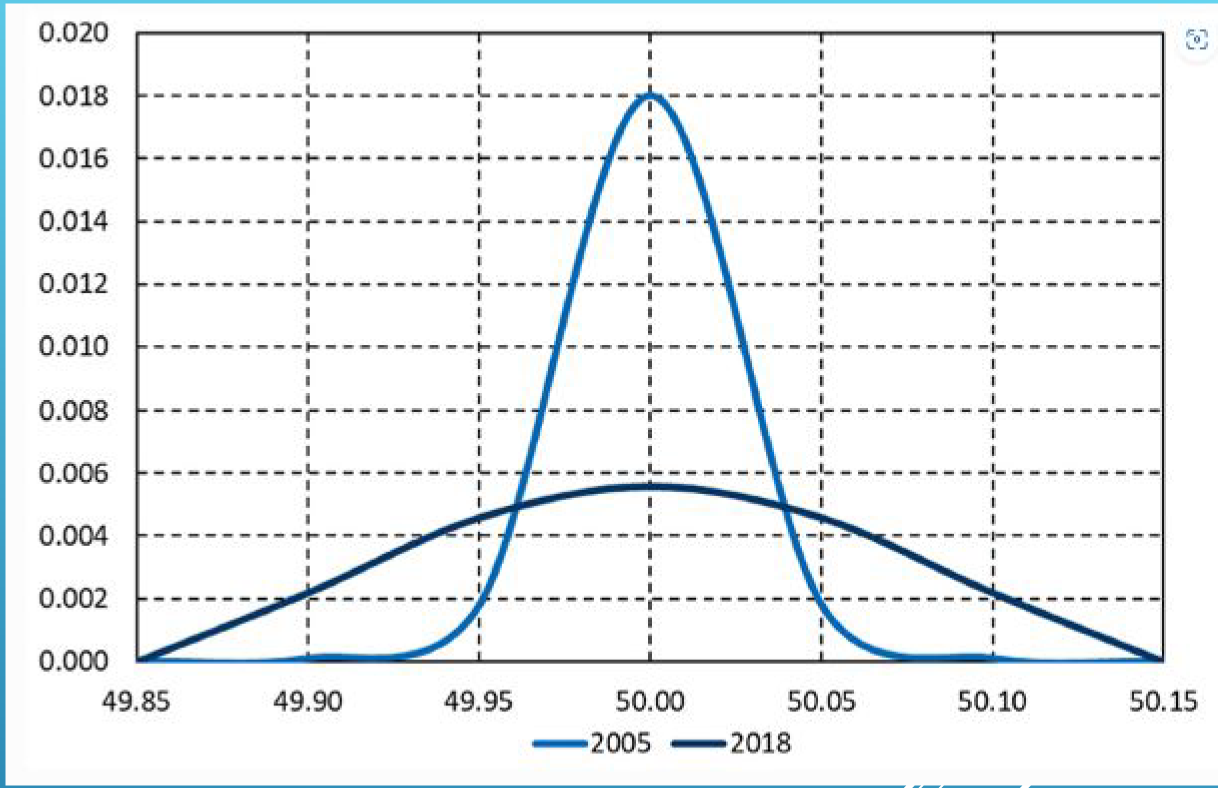
Two regulation markets	Six contingency markets
These are used to correct a minor drop or rise in frequency and typically provided by thermal generators, including: •Regulation market to raise •Regulation market to lower	These are used to arrest a major drop or rise in frequency, stabilize, or recover frequency following a major fall or rise in frequency, including: 6-second contingency market to raise 6-second contingency market to lower 60-second contingency market to raise 60-second contingency market to lower 5-minute contingency market to raise 5-minute contingency market to lower

FCAS is becoming critical to the market as more variability exists within the system.

These variabilities can include the following:

- Sudden demand changes due to extreme temperatures
- Sudden rise or drop in renewable generation due to cloud cover
- The unexpected exit of generators like coal generators that typically provide FCAS services
- Increasingly unexpected transmission outages with extreme weather-driven events.

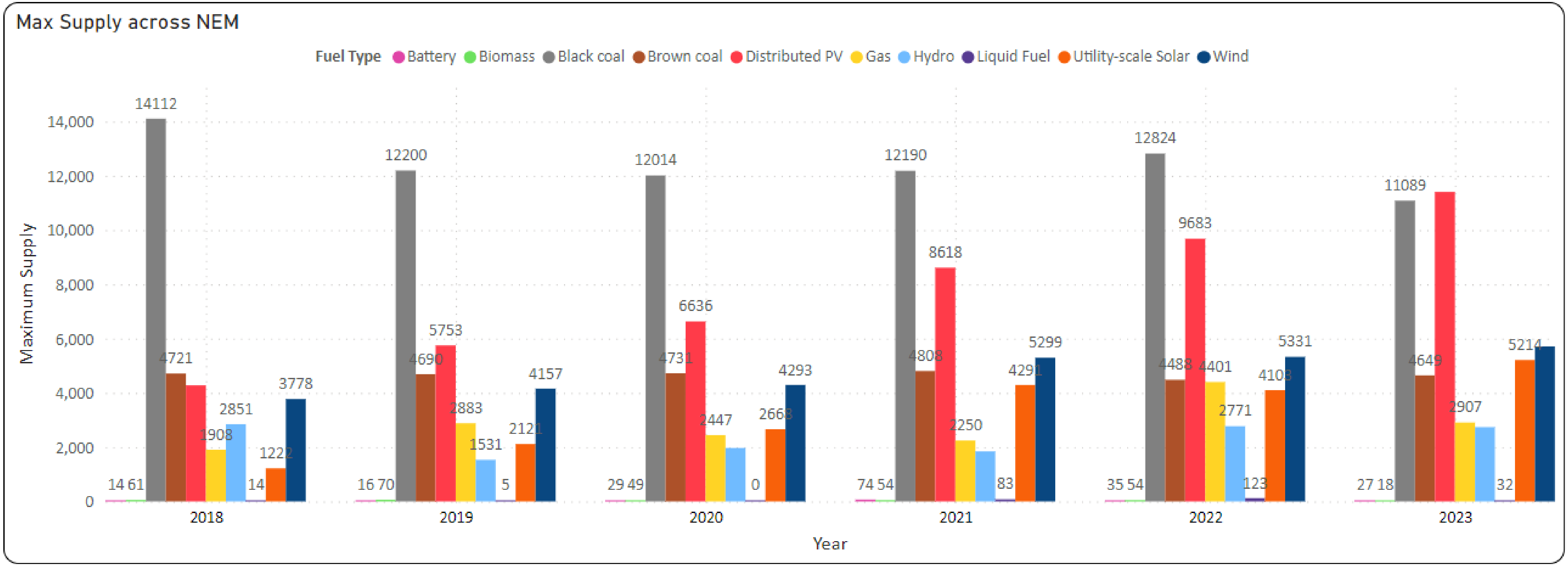
Put simply, there is a lot more volatility within the system that throws off the supply and demand balance, making frequency control more important than ever.



Frequency distribution within the normal frequency operating band in the NEM (2005 Snapshot vs. 2018 Snapshot)

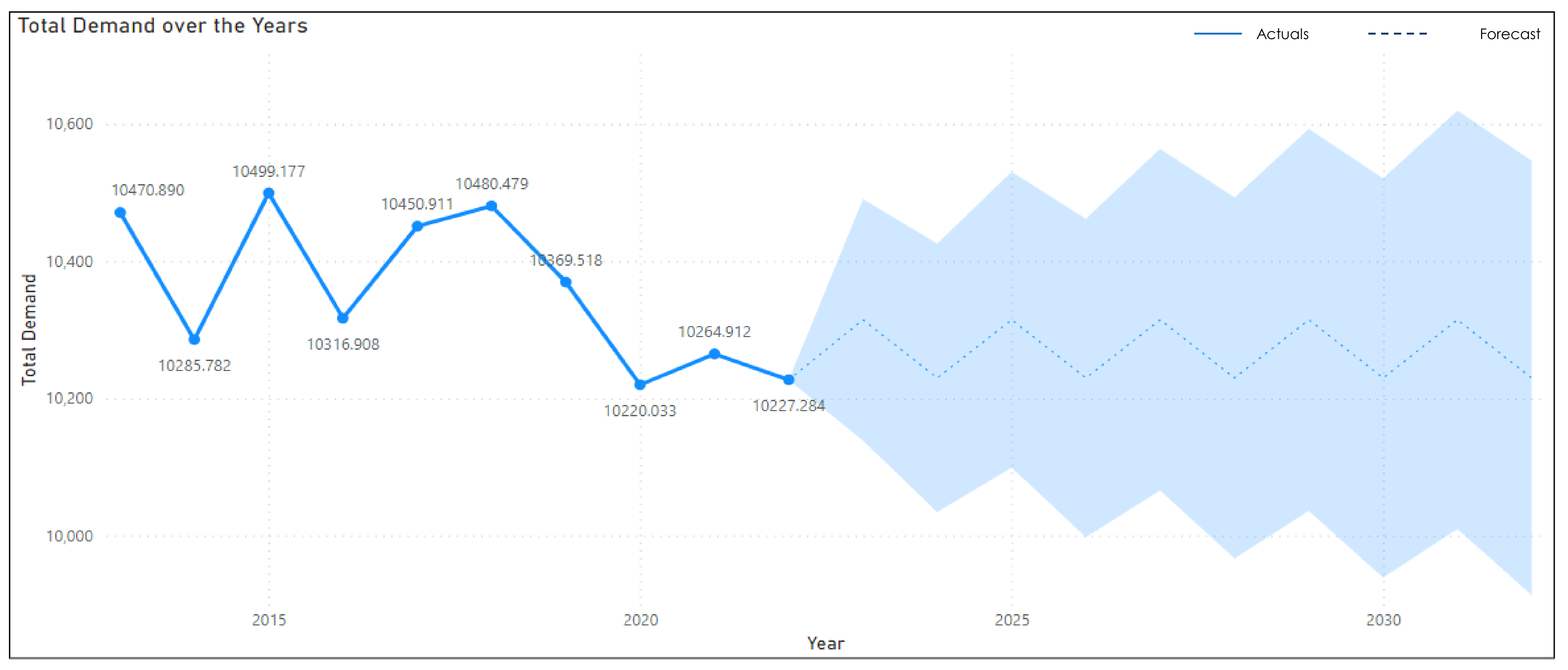
Figure shows the distribution of frequency for NEM for the years 2005 and 2018. Frequency distributions for the NEM are increasingly further away from the 50 Hz mark. The widening range indicates that the control of frequency deteriorated between 2005 and 2018. In 2005, renewable energy penetration was approximately 9%. By 2018, this had doubled to 18% of the total energy generated.

NEM PENETRATION Across all sectors over past 5 years



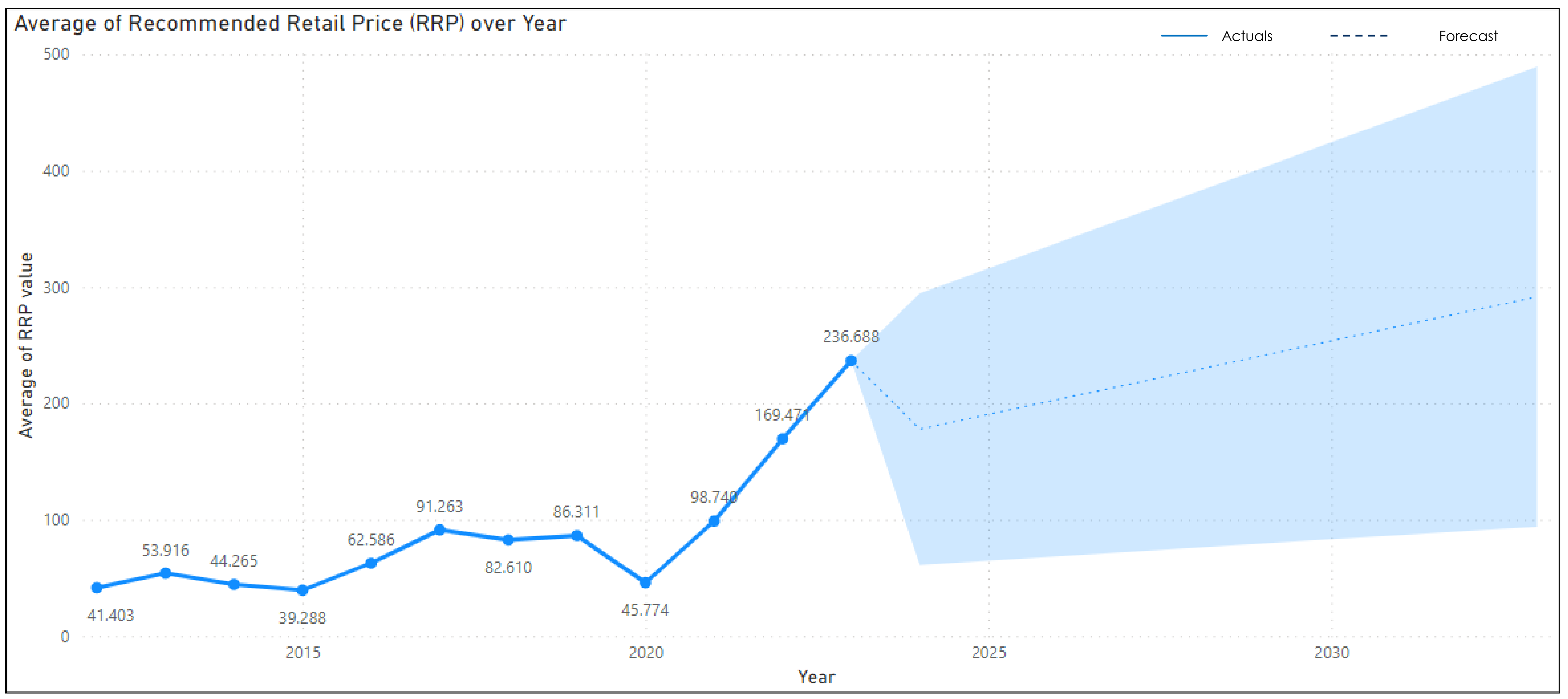
- Between 2018 and 2023, Distributed PV had the largest increase in Maximum Supply (166.68%) while Black coal had the largest decrease (21.42%).
- Across Fuel Type, Hydro had the most interesting recent trend and started trending up on 2021, rising by 48.16% (890.57) in 2 years.

Total Demand Across Years with Actual from 2018-2023 and forecast from 2024 – 2032



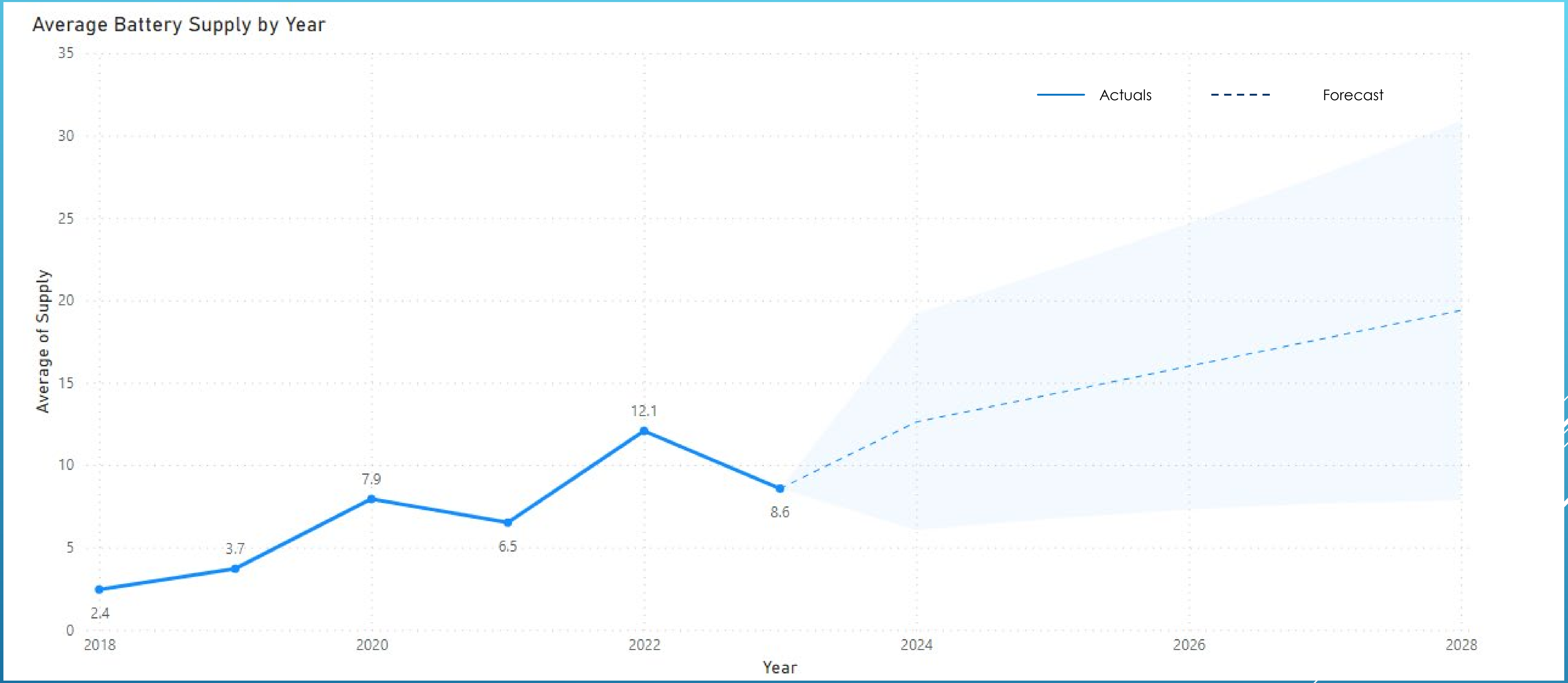
Total Demand trended down, resulting in a 2.33% decrease between 2013 and 2022.
Total Demand started trending down on 2016, falling by 0.87% (89.62) in 6 years.
Total Demand dropped from 10,316.91 to 10,227.28 during its steepest decline between 2016 and 2022.
For forecast the range of maximum total demand is between 10229.99 to 10314.65

Average Recommended Retail Price Across Years with Actual from 2018-2023 and forecast from



Average of RRP value jumped from 82.61 to 236.69 during its steepest incline between 2018 and 2023.
Average of RRP value trended up, resulting in a 471.67% increase between 2012 and 2023.
Average of RRP value started trending up on 2018, rising by 186.51% (154.08) in 5 years.
Average of RRP value for next 3 years would rise to 203.11 , for 5 years would be 228.42 and for 10 years would be 291.

Average Battery Supply Across Years with Actual from 2018-2023 and forecast from 2024 – 2028



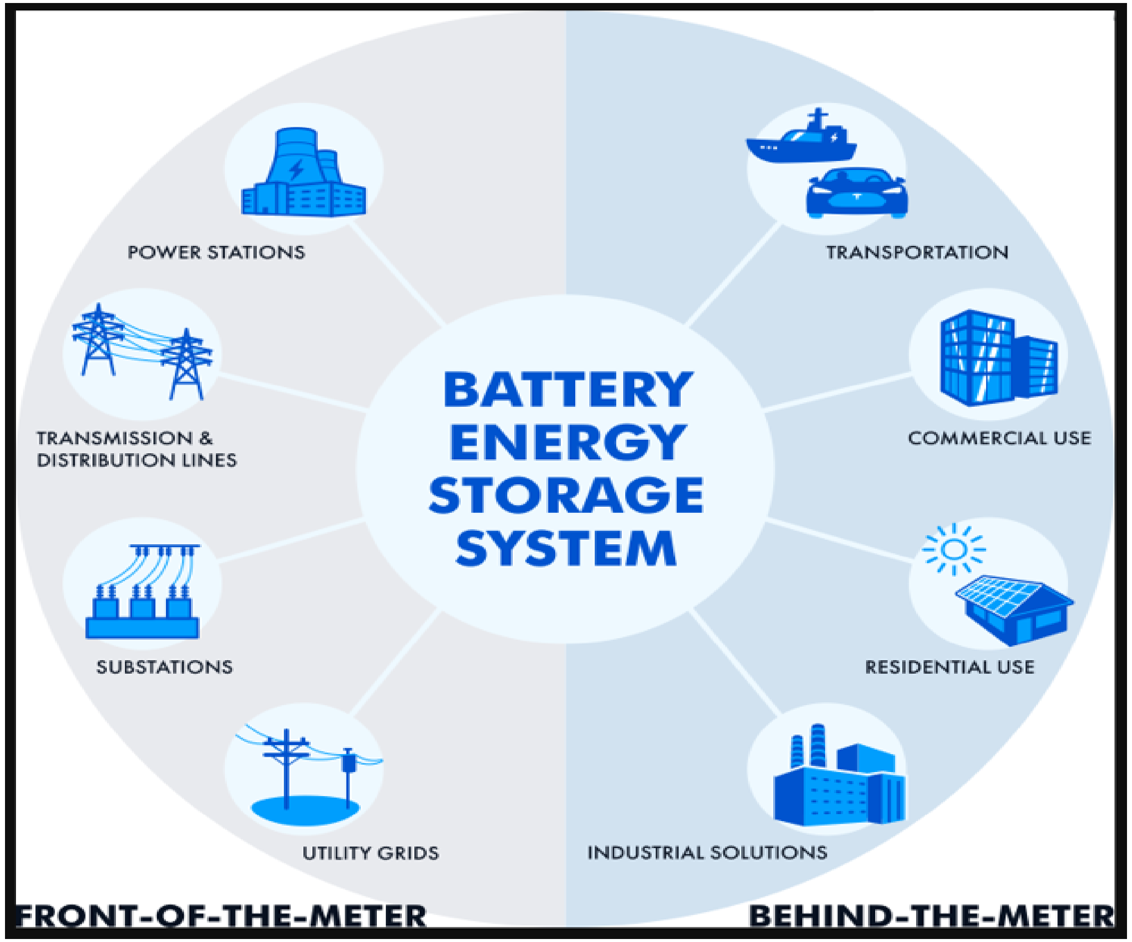
Average of Supply trended up, resulting in a 251.64% increase between 2018 and 2023.
Average of Supply started trending up on 2018, rising by 251.64% (6.13) in 5 years.
Average of Supply jumped from 2.44 to 8.57 during its steepest incline between 2018 and 2023.
3 years : 14.30 , 5 years: 17.69, 10 years : 19.38

Meter Analysis

The electric grid is linked to a battery storage system in front of the metre before the metre. In other words, power from the grid is stored in the battery, which may subsequently be used to power the company during periods of high demand or power outages.

Examples of In-Front Meter

- Utility-scale generation
- Utility-scale energy storage
- Transmission and distribution lines



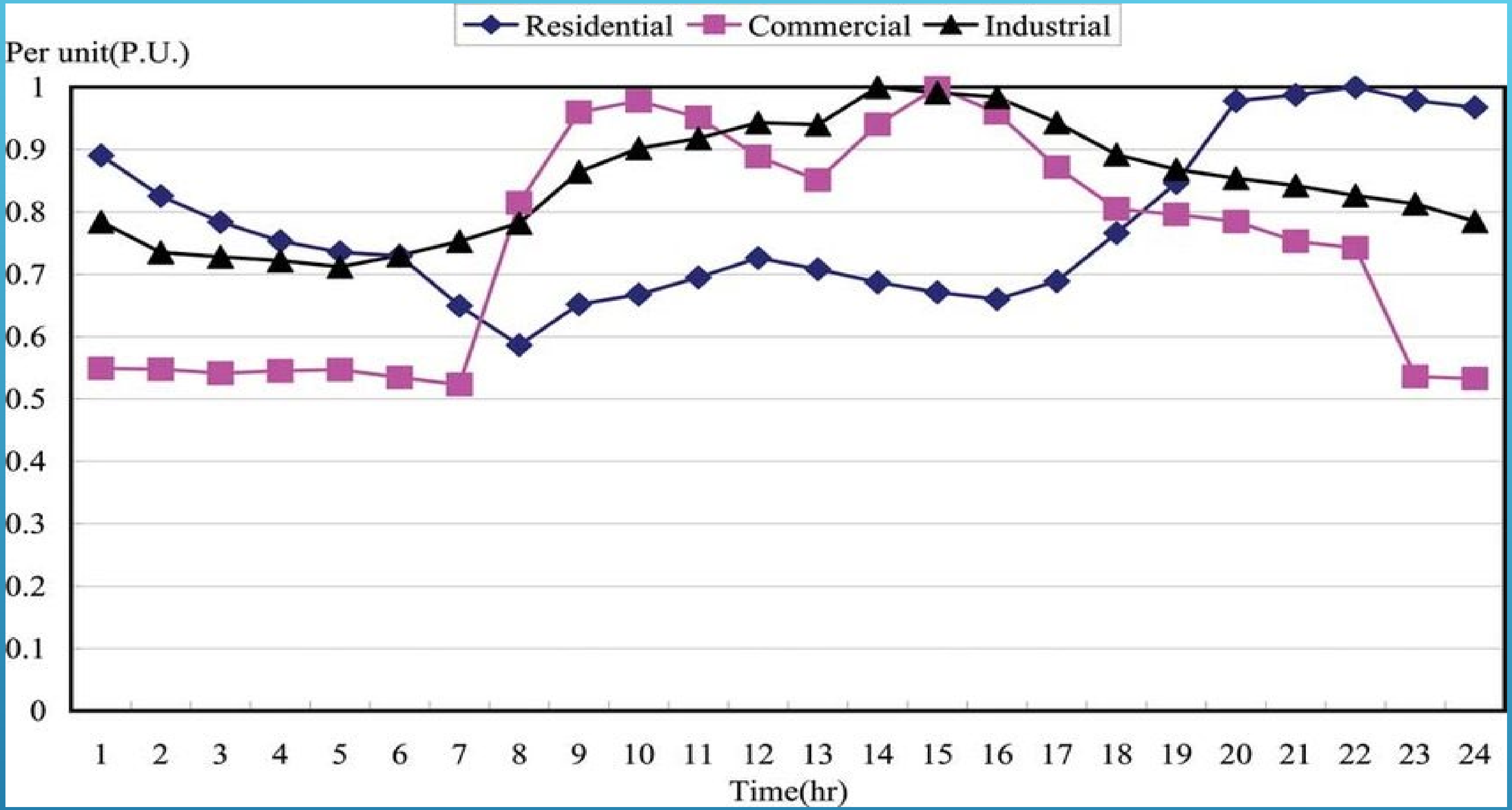
BTMS systems directly supply electricity to buildings and home, and help minimize the grid impact, integrate EV charging and more.

Examples of Behind The Meter

- On-site generation
- On-site energy storage
- Microgrids

The difference between behind-the-meter (BTM) and front-of-meter systems comes down to an **energy system's position in relation to your electric meter**. A BTM system provides power that can be used on-site without passing through a meter, while a front-of-meter system provides power to off-site locations. The power provided by a front-of-meter system must pass through an electric meter **before reaching an end-user**.

Typical load patterns of residential, commercial, and industrial customers



In relation to the standard deviation numbers for industrial activity, it is important to keep in mind that most industrial activities include small motors that run intermittently over the day. Their loads can be rather high when compared to the typical power of the industry, which might result in quite large standard deviation values. There was no attempt to create a straightforward model for industrial consumers like there was for commercial consumers.

Market Revenue Analysis

For both types of battery installations, there are a variety of potential streams available to commercial and industrial-sized businesses that we can talk about them here.

- In-front of the meter:

✓ Energy market

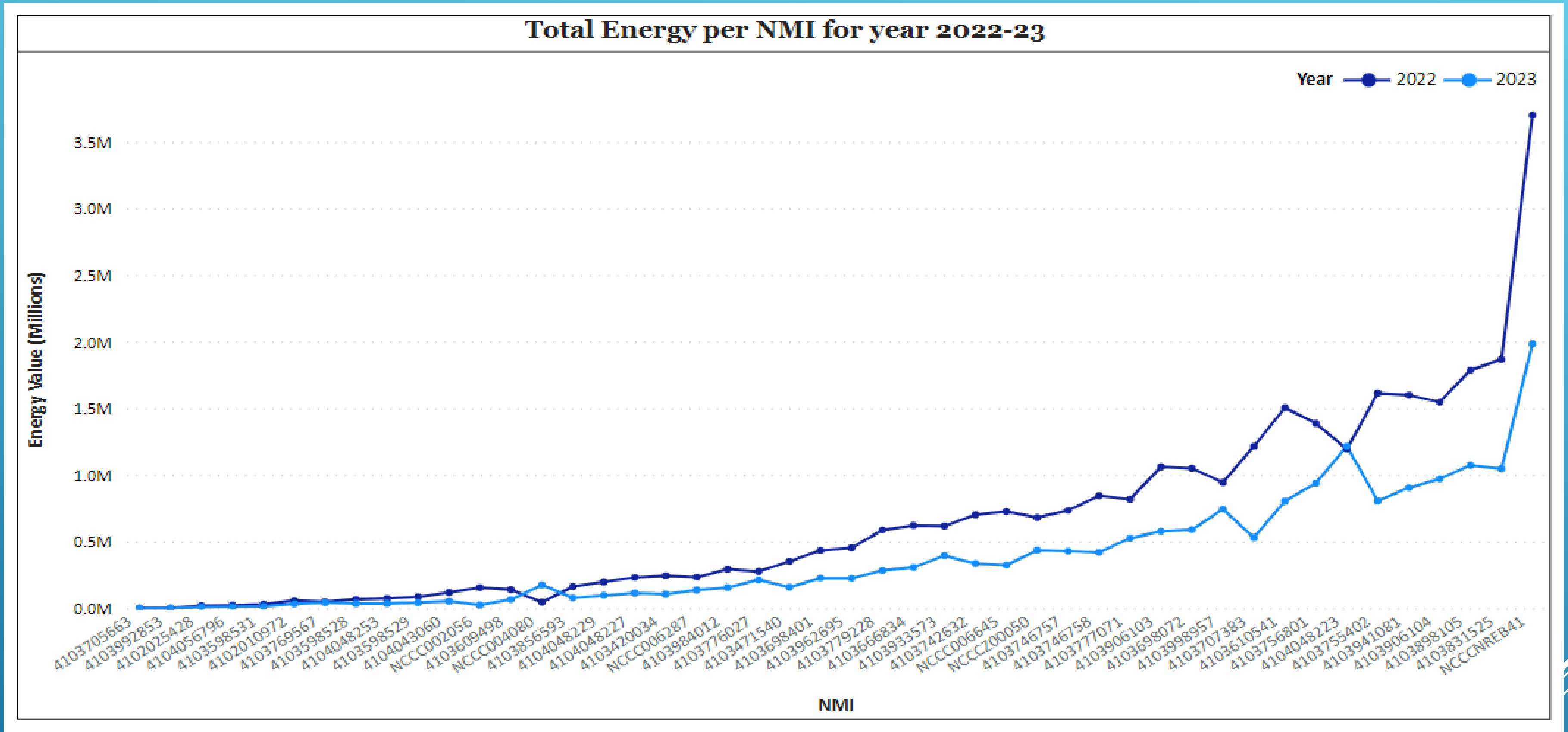
✓ The capacity market

- Behind the meter:

✓ Self-consumption

✓ Demand charge reduction

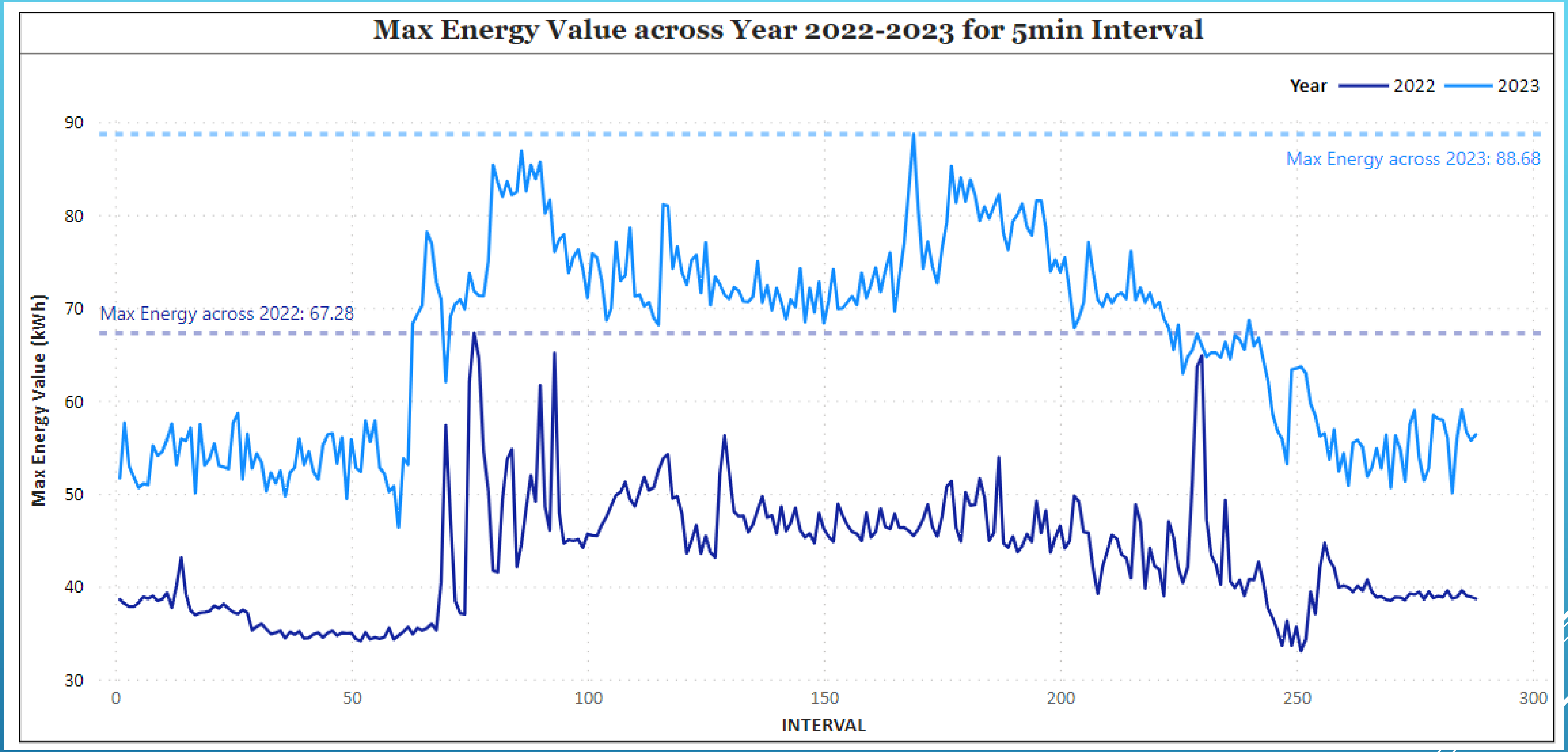
ANALYSIS ON NMI DATA



Total Energy was higher for 2022 (3,04,91,121.01) than 2023 (1,76,35,922.00).

NMI NCCCNREB41 in Year 2022 made up 7.69% of total Energy.

Energy value for 2022 and 2023 diverged the most when the NMI was NCCCNREB41, when 2022 were 17,16,247.96 higher than 2023.

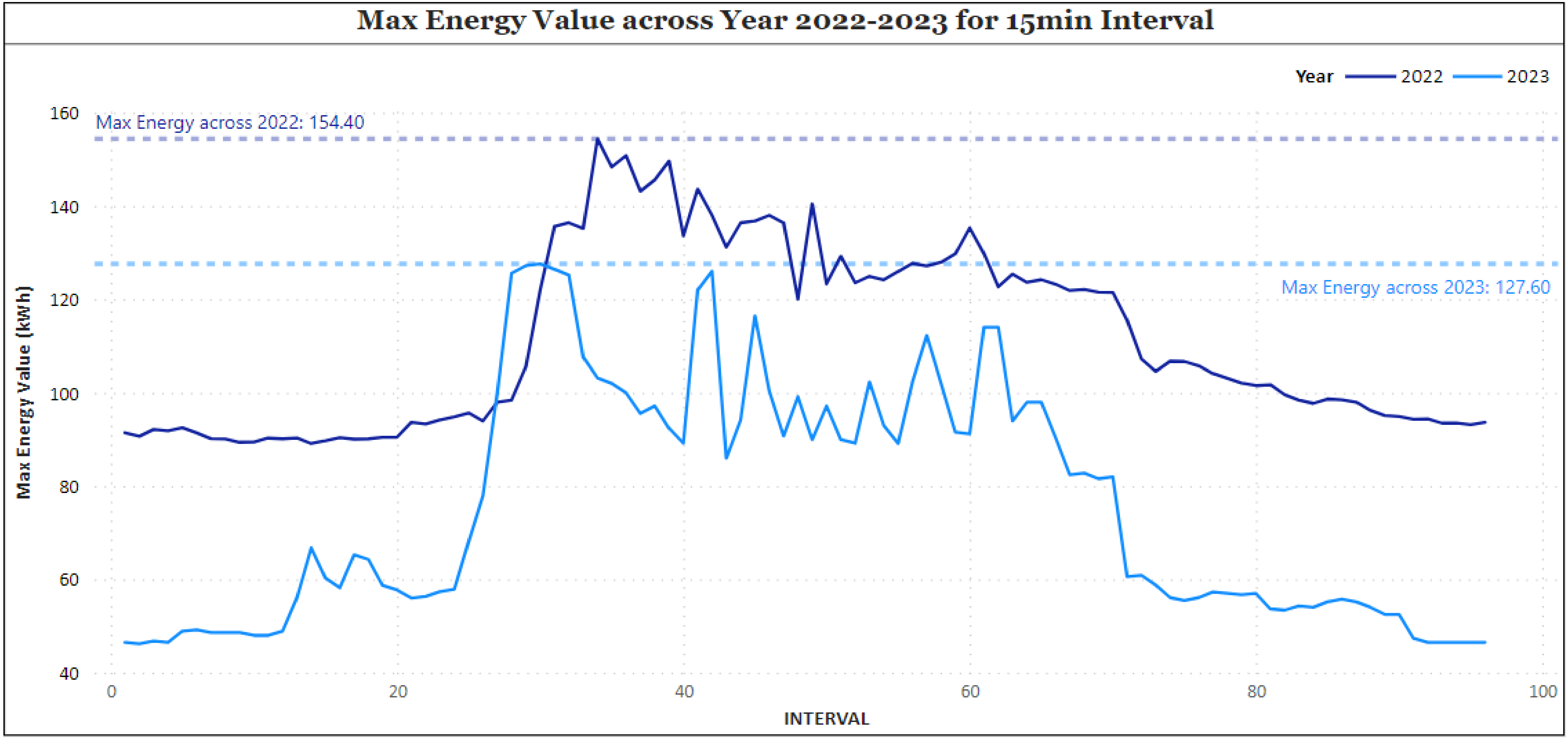


At interval for 169 it has the highest Max Energy Value per day of 88.68 and was 91.29% higher than that at interval 60, which had the lowest Max Energy Value per day at 46.36.

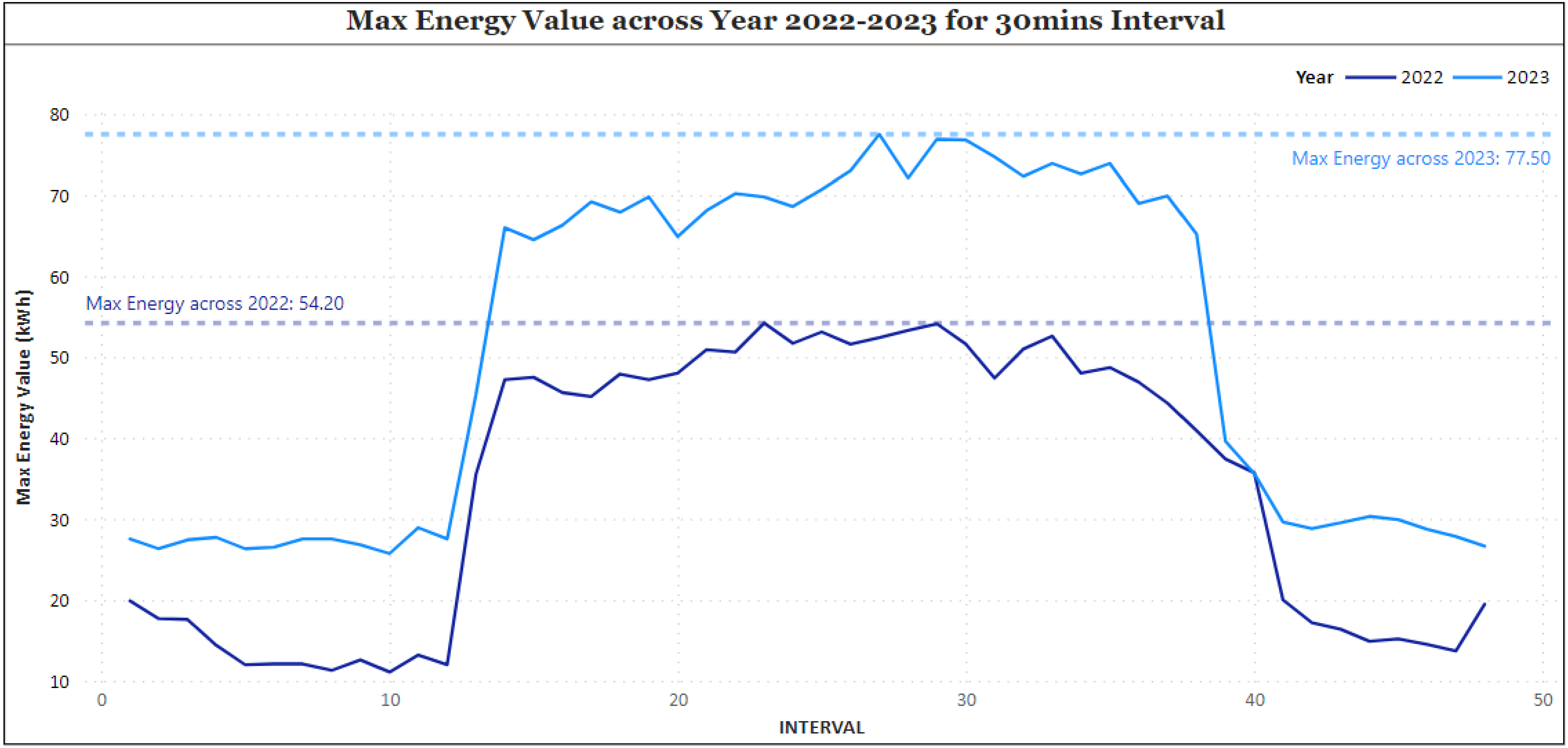
Across all 288 INTERVAL, Max Energy Value per day ranged from 46.36 to 88.68.

Interval 169 had the highest Max Energy Value per day at 88.68, followed by 86 and 90. 60 had the lowest Max Energy Value per day at 46.36.

On further analysis, we found out that these intervals are during afternoon and early mornings, that mean's energy consumed is more.



Interval 34 in year 2022 made up 0.86% of max energy value (kwh).
Average max energy value (kwh) was higher for 2022 (111.33) than 2023 (75.77).
Max energy value (kwh) for 2022 and 2023 diverged the most when the INTERVAL was 39, when 2022 were 57.20 higher than 2023.

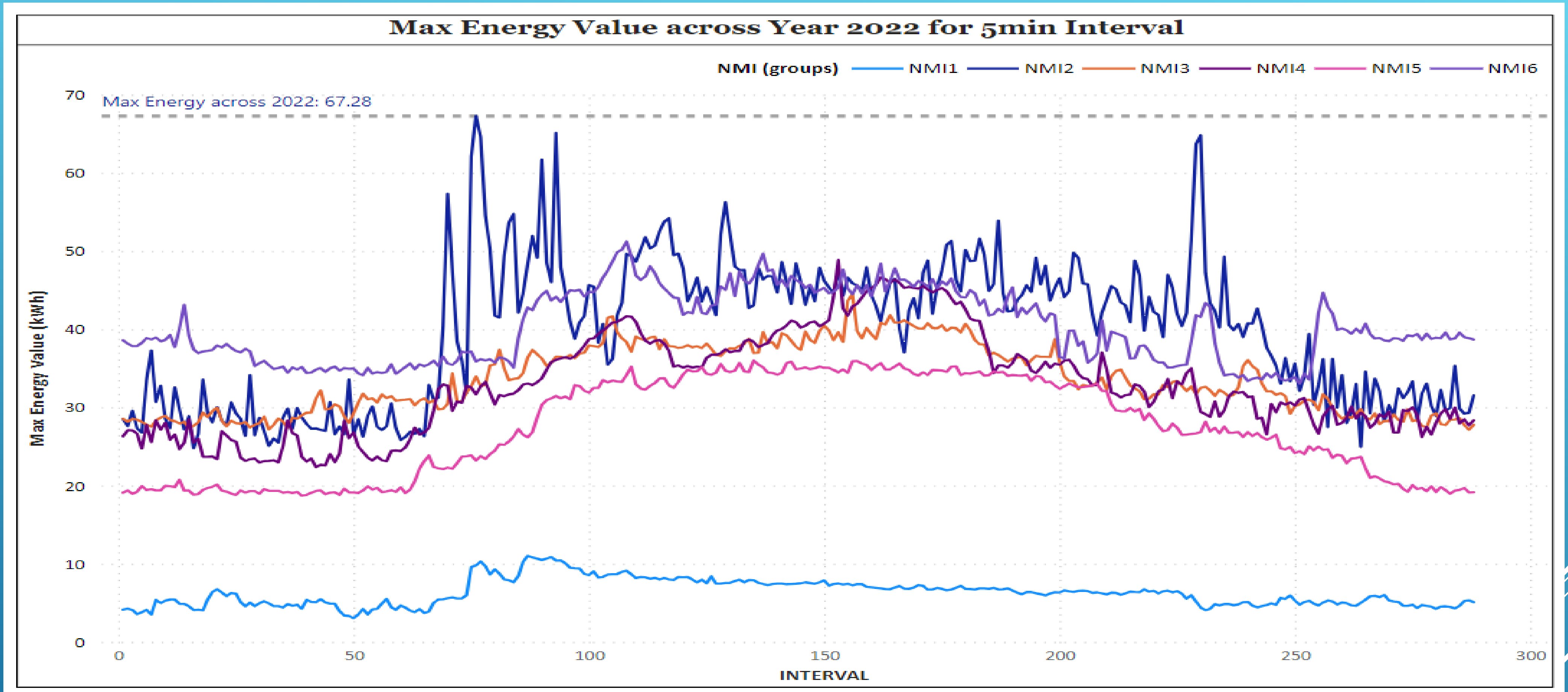


Average max energy value (kwh) was higher for 2023 (50.86) than 2022 (34.12).

Max energy value (kwh) for 2023 and 2022 diverged the most when the INTERVAL was interval 31, when 2023 were 27.30 higher than 2022.

4104056796 has data only for one month in year 2022, i.E. In may-2022

Grouping of NMIs into 6 groups



NMI GROUP 2 HAS THE HIGHEST ENERGY PEAKS ACROSS THE INTERVALS AT INTERVAL 76 AND 230

On Analysing the data, we can see that potential cutoff value should be around average data.

The average KW for cutoff should be around 35 kW, and accordingly battery's can be installed across the University.

Load factor (LF) = Energy draw/total possible for the factor of 1.2

Load Factor here would be

Total Energy Consumed over year 2022 is 22.32 MW

Max Usage in that year 67.28 KW

In a year, 365 days and 24 hrs.', hence the load factor would be given as follows

LF = 22320.00 K / (365*67.28*24) =~ approx. 0.03

Since LF is between 0.03 – 0.04, that means battery usage will depend on spill of energy, and there is high potential to save excess energy.

CONCLUSION

We can further say that the Behind the meter is more beneficial to be installed within the universities.

- Across the report, we have see that the demand has been somewhat same, however supply and Storage capacity is been increasing

- With exhaustion of renewable sources, it would be beneficial to increase the battery capacity storage across the utilization

THANK YOU !!