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# Framework and Demonstration of a Multi-Market Model for better visibility and Co-ordination between IESO, LDCs, and TSO (FDMM, the project)

Survalent Technology

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# 1. Executive Summary

The IESO Grid Interoperability Working Committee has recognized a critical challenge in advancing the autonomy and market participation of Distributed Energy Resources (DERs): the insufficient visibility, data sharing, and coordination among IESO and LDCs in managing distribution network assets. The committee's risk assessment, conducted between 2019 and early 2020, underscored a significant information gap that impedes accurate forecasting, coordination, and balancing of energy supplies amidst the increasing penetration of DERs.

Addressing these challenges, the focus of the project is to develop a proof-of-concept platform through the Framework and Demonstration of a Multi-Market Model (FDMM). This platform aims to aggregate Advanced Distribution Management System (ADMS) data from the LDCs, thereby enhancing the coordination and operational visibility required for effective management of these assets on the distribution network. The FDMM will establish a comprehensive framework and approach to ensure seamless data integration and real-time information sharing.

By implementing the FDMM, the Ontario province is poised to achieve several key benefits:

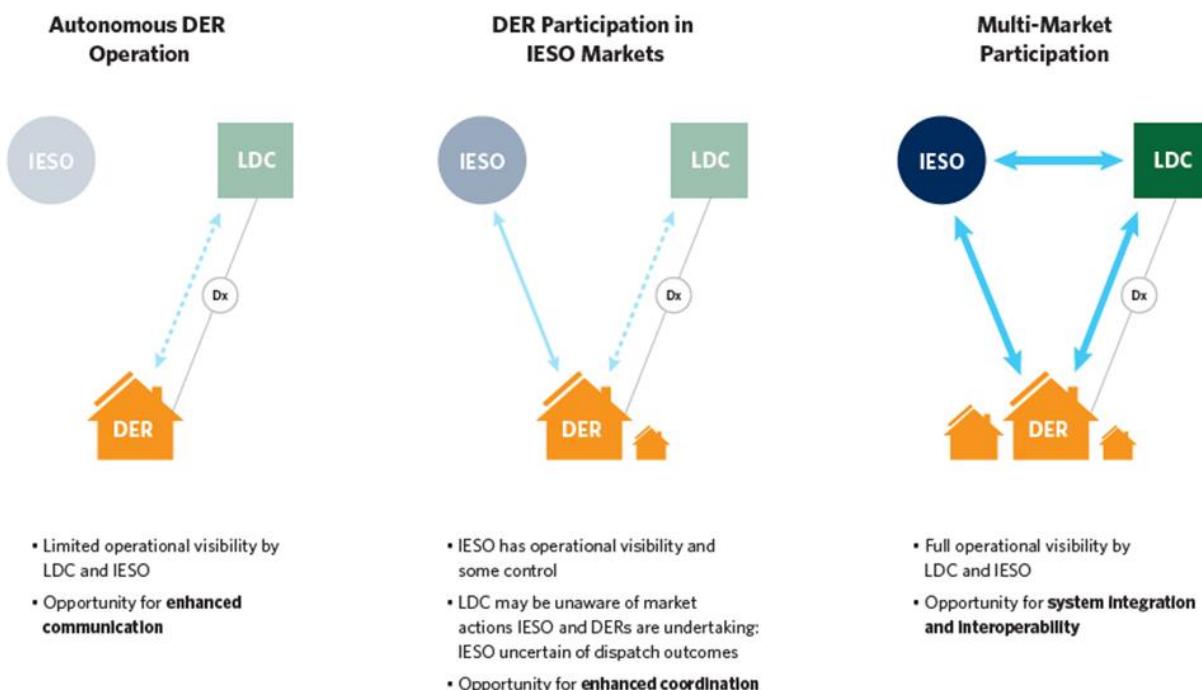
- **Enhanced Electrical System Reliability:** Improved real-time data access and coordination will bolster the reliability of the electrical system.
- **Increased Market Participation:** A robust information platform will support the growth and integration of autonomous DERs into the energy market.
- **Greater Consumer Choice:** The enhanced visibility and coordination will provide ratepayers with more options for affordable and reliable energy supply.

In summary, the FDMM project is a strategic initiative designed to bridge the data and coordination gaps identified in the risk assessment, ultimately advancing the province's energy system towards greater reliability and efficiency while offering consumers more diverse and cost-effective energy solutions.

## 2. Introduction and Goal

As mentioned in the whitepaper commissioned by the IESO<sup>1</sup>, the electricity system in the Province of Ontario is undergoing significant change due to shifting policy directives and an increasingly diverse and distributed set of electricity resources. The IESO has also formed the Grid-LDC Interoperability standing committee (GISC)<sup>2</sup> to specifically look at the ongoing coordination of system operations between the IESO, LDCs and TSO. As DER penetration and participation increases, the committee has identified the need for enhanced communication, coordination, and interoperability between the IESO, LDCs, TSO and DERs<sup>3</sup>. The committee also identified the stages of development towards a multi-market participation model, as shown below.

**Figure 1 | Stages of DER Development as identified by the IESO Grid-LDC Interoperability Committee**



<sup>1</sup> IESO, *Development of a Transmission-Distribution Interoperability Framework*, May 2020. <https://ieso.ca/-/media/Files/IESO/Document-Library/White-papers/IESO-T-D-Coordination-Framework.pdf>

<sup>2</sup> IESO, Grid-LDC Interoperability Standing Committee. [Grid-LDC Interoperability Standing Committee \(ieso.ca\)](https://ieso.ca/our-work/committees-and-groups/ieso-grid-ldc-interoperability-standing-committee)

<sup>3</sup> IESO Grid-LDC Interoperability Standing Committee, *Operational Capability Risk Assessment*, July 23, 2018. [Grid-LDC Interoperability Standing Committee \(ieso.ca\)](https://ieso.ca/our-work/committees-and-groups/ieso-grid-ldc-interoperability-standing-committee)

The GISC has also outlined the general considerations needed to facilitate a multi-market participation scenario<sup>4</sup> whereby:

- DER can participate in both IESO Administered Markets (IAM) and LDC-operated markets
- Both IESO and LDC have full visibility and coordinated control over DER that participate in their respective markets
- Potential for system integration, grid interoperability, and co optimization of transmission and distribution services

Given the multi-market model as outlined above, some of the barriers/challenges to the future of multi-market model include:

- Lack of visibility into the DER generation assets on the distribution network which impacts the ability to estimate, forecast, plan, coordinate, and control to balance the supply and demand requirements.
- Effective distribution system operations in a high DER penetration scenario will require real-time, efficient data exchange and information sharing of the current state of the distribution network between the LDCs, Hydro One, and IESO. There are technical and cost barriers to effectively and efficiently aggregate relevant distribution network data to achieve this objective.

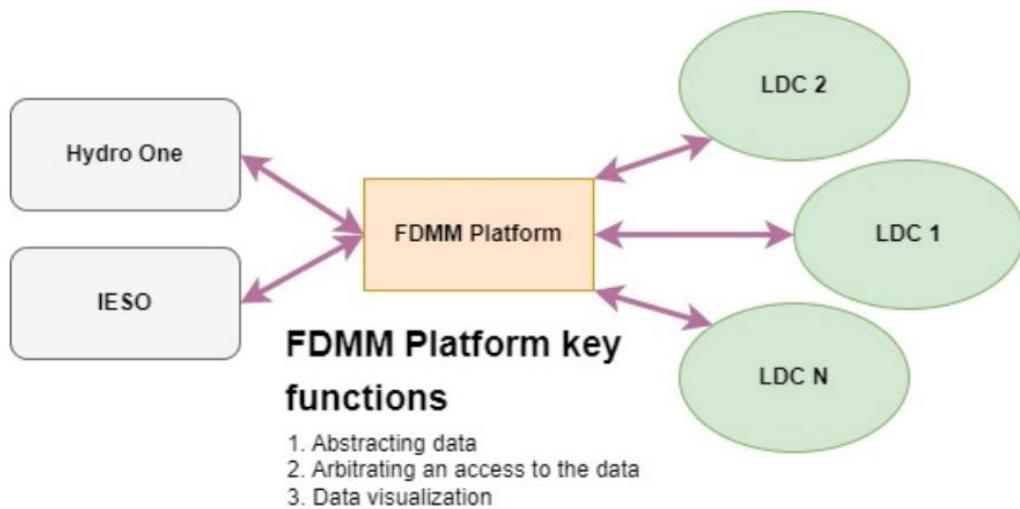
For this project, Survalent will propose a proof-of-concept platform that the IESO, Hydro One, and LDCs could use to increase their visibility and coordination of DERs in a multi-market model if this type of platform was adopted. This platform will show the pertinent data for the DERs to participate in a conceptual multi-market (e.g., analog readings, DER status, feeder status, etc.), interface with the participating utilities to get real-time updates about this data and provide a secure way for all participants to access this data (see Figure 2). From the design and showcase of this platform, this project will aim to:

- Establish the framework and approach for a real time information platform aggregating the LDCs' ADMS data to enable the growth of autonomous and market participation of DERs in the future.
- Demonstrate the platform's capability to provide real time visibility of the LDCs distribution network to support the management of the DERs asset for IESO and Hydro One, helping to improve the coordination between each entity.
- Define the data exchange requirements between the various operational systems (SCADA, OMS, DMS, ADMS, DERMS and other enterprise systems) to achieve the objectives.
  - In addition, establish the data governance for this data (who would have access to this data and when)

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<sup>4</sup> IESO Grid-LDC Interoperability Standing Committee, *Operational Capability Risk Assessment*, August 15, 2019. [Grid-LDC Interoperability Standing Committee \(ieso.ca\)](http://Grid-LDC Interoperability Standing Committee (ieso.ca))

**Figure 2 | High-level Overview of the FDMM Platform**



For this project, Survalent will be collaborating with five Ontario utilities – Hydro One, Enova Power (formerly known as Waterloo North Hydro), London Hydro, Elexicon Energy and Oakville Hydro. Survalent will be working with these utilities to gather sample data from their network (e.g., DER assets for a select number of feeders) that will be used to show how they would be represented on this platform. Additionally, Survalent will solicit their advice when designing the platform through discussions and workshops and use their best or existing practices to consider when designing this platform. Of the utilities selected for this project, Enova Power, London Hydro, and Oakville Hydro are existing Survalent customers and Survalent already has intimate knowledge on how to interface their systems.

Survalent also specifically looked to bring in utilities that are not Survalent customers to show how such a platform would interface to multiple vendor systems and the interoperability considerations needed for this (and the risks and challenges that this would entail). This was part of the reason why Survalent asked for Hydro One and Elexicon Energy to participate. Survalent also had interest in bringing Hydro One on board as they are the transmission provider of Ontario in addition to serving as a LDC for some of the more rural areas of Ontario. Therefore, they would have a unique perspective on this platform as they would already be interconnected with the other utilities for this project and that can now be represented in the platform. In addition, they would be able to contribute DERs on both the transmission and distribution side.

Hydro One's participation initially played a key role in the project's progress, with timely support and data sharing. However, internal changes, such as team restructuring and promotions, disrupted this collaboration. By Milestone 4, Survalent attempted to re-engage Hydro One, but tight timelines made it difficult to coordinate both their involvement and the necessary data migration. Faced with looming deadlines, Survalent chose to move forward independently to meet IESO's schedule, prioritizing project continuity over further delays caused by re-engagement challenges. This decision ensured progress but underscored the difficulty of relying on external partners in time-sensitive phases. The platform that will be created for this project will be intended to be used as a 'sandbox' environment

for all participants. Once established, the platform can possibly evolve (e.g., new displays can be designed based on the needs) once use cases are tested and other use cases are raised throughout the course of this project. This will provide flexibility to ensure that if new scenarios or use cases are thought of in the future, the solution for the use cases could still be considered.

## 3. Approach/Methodology

To successfully achieve the objectives of this project, Survalent implemented a structured approach divided into distinct phases. The project began with a thorough review of the architecture, deliverables, team roles, and schedule, which set a strong foundation for the project. This phase concluded with the drafting and signing of a Memorandum of Understanding (MOU), aligning all stakeholders, including Local Distribution Companies (LDCs) and the Independent Electricity System Operator (IESO), ensuring clear communication and agreement on responsibilities.

In the requirements gathering and system design phase, Survalent conducted detailed workshops to develop the architecture of the FDMM platform. These workshops facilitated collaboration with LDCs to gather GIS and network model data, essential for building the platform. During this phase, a temporary development server was provided to demonstrate the platform's initial functionality. Additionally, a preliminary data import was carried out with careful error checks and updates to maintain data accuracy and integrity.

The integration testing phase followed, focusing on verifying the connections between Survalent's FDMM platform and the participating LDCs. This phase also included importing any updated data, as necessary, to ensure all systems were accurately connected and functioning smoothly. The successful completion of this phase was critical in ensuring that the system was ready for real-time operations.

After the integration testing, Survalent moved into the installation, tuning, and commissioning phase, where the FDMM platform was installed and optimized for performance. This phase included fine-tuning the system to meet specific requirements and providing comprehensive training for both LDC and IESO staff to ensure they could effectively operate and manage the platform.

Upon project completion, data was collected from the FDMM platform, analyzed for performance evaluation, and compiled into a detailed project completion report. This report was submitted to all key stakeholders, summarizing the project's outcomes and ensuring all objectives were met. Through this structured approach, Survalent ensured a seamless and successful integration of Distributed Energy Resources (DERs) into Ontario's electricity grid.

## 4. Results

The project successfully advanced the integration of Distributed Energy Resources (DERs) into Ontario's grid, with significant progress made in data collection, AMI integration, and platform development. Challenges, such as data quality, volume management, and cybersecurity, were addressed through robust governance and secure access protocols. A high-level dashboard was created for real-time monitoring and predictive analytics, improving decision-making processes.

A crucial aspect of this project was the integration of AMI data, particularly through the experiences gained from Oakville Hydro's approach. This process revealed several challenges, including network connectivity issues, data granularity and frequency, data volume management, and ensuring data quality and security. These challenges were addressed by implementing robust data governance practices, ensuring data integrity, and maintaining a secure environment through cyber security measures, particularly with the use of jump boxes for secure access to each Local Distribution Company (LDC).

The development of a high-level dashboard has been another cornerstone of this project. This dashboard provides a unified view of grid operations, integrating data from various sources such as SCADA systems, AMI, and DERMS. It is designed to offer real-time monitoring and predictive analytics, aiding in decision-making processes across different levels of the grid.

Data governance has been emphasized through the establishment of clear protocols for data management across LDCs. This includes the subdivision of data by geography and operational needs, ensuring that the platform remains flexible and scalable. Cybersecurity and access control have been paramount, with secure methods implemented to protect the platform's integrity and the data it manages.

Training sessions for LDC and IESO were conducted to ensure that all stakeholders are proficient in navigating the platform. This has been critical in enabling effective use of the system and facilitating smoother operations across the distribution networks.

High-level data analysis was also a focus, with detailed evaluations of London Hydro's solar arrays and Elexicon's battery data. These analyses provided insights into the performance and operational strategies of these assets, highlighting areas for improvement and informing future decisions on grid management and DER integration.

LDC feedback on the FDMM platform has been instrumental in shaping the project, influencing decisions on the operational management of distribution networks. This feedback loop has been essential in refining the platform and ensuring that it meets the needs of all stakeholders involved.

Finally, reflections on platform scalability and potential expansion across Ontario were discussed, considering the lessons learned from this milestone. These reflections underscore the importance of addressing data integration challenges, enhancing cybersecurity, and developing scalable solutions that can be adapted to other jurisdictions.

This final project represents a comprehensive effort to integrate DERs into the grid, with significant progress made in data management, security, and stakeholder engagement. The lessons learned and

insights gained will be invaluable as the project moves forward, aiming for broader implementation and greater impact across Ontario's energy landscape.

Activities focused on enhancing data collection practices, promoting effective governance, and fostering collaboration among local distribution companies (LDCs), ensuring a solid foundation for future scalability and integration efforts.

On this report we will elaborate on each of the topics above to provide project stakeholders a holistic view of the experiences, lessons learned and recommendations to help visualize the future of such application reflecting on the challenges and wisdom encountered during this process.

## 4.1 The challenge of Integrating AMI Data, Experiences derived from Oakville Hydro approach

As the IESO might consider expanding its platform across Ontario, particularly with an increased reliance on Advanced Metering Infrastructure (AMI) data, several challenges must be addressed to ensure successful integration and scalability. AMI systems are critical for modern grid management, offering real-time data that helps optimize energy distribution and enhance grid reliability. However, integrating AMI data is not without its hurdles.

One of the primary challenges lies in ensuring robust network connectivity. AMI systems depend on reliable communication networks to transmit data from smart meters to central systems. Issues such as interference, bandwidth limitations, and the geographical challenges of servicing remote or rural areas can disrupt data transmission, leading to delays and inaccuracies. Another significant issue is the sheer volume of data generated by AMI systems. As the number of smart meters increases, so does the amount of data, which includes detailed metrics on electricity consumption, Load and generation profiles, voltage, and power quality. Managing this data effectively requires advanced storage solutions and real-time processing capabilities to prevent system overload and ensure data integrity.

The data availability of AMI meters should be considered. Most AMI data resolution is hourly, and usually available every 24 hours interval. When we compared to California, and the mandate for residential solar for every new dwelling, this supposes a greater challenge, given that each meter is now both a generator and a load. IESO and the province will be required to carefully strategize on residential solar expansion because either the actual AMI platforms are not ready, might not be able to provide data and the granularity of it at an operable resolution, or would suppose too much challenge and capital investment to improve or retrofit actual infrastructure.

Data quality is also a concern, as any inaccuracies or transmission errors can lead to flawed decision-making, potentially compromising grid stability or planning. Ensuring data accuracy requires robust validation processes and error-checking mechanisms. Additionally, the cybersecurity of AMI systems is increasingly important. These systems are vulnerable to cyberattacks, and protecting the sensitive data they handle is paramount. Implementing strong encryption, secure communication protocols, and regular security audits are essential steps in safeguarding this data and interfaces between systems.

Furthermore, interoperability with existing grid management systems, such as SCADA and DERMS, presents a challenge. These systems often use different data formats and protocols, complicating

integration. Developing standardized data formats and ensuring compatibility between systems are critical to overcoming these challenges and maximizing the utility of AMI data.

To prepare for the increased demand for AMI data in future project expansions, IESO should consider the following recommendations:

- Enhance network infrastructure by investing in advanced communication technologies such as 5G, ensuring reliable connectivity even in remote areas.
- Implement scalable data management solutions, such as cloud-based platforms, to handle the growing volume of data effectively.
- Establish robust data governance frameworks to maintain data quality and integrity through standardized validation and error-checking processes.
- Strengthen cybersecurity measures by adopting advanced technologies like encryption and multi-factor authentication, alongside regular security audits.
- Promote interoperability standards by collaborating with industry stakeholders to develop and implement consistent data formats and protocols.

## 4.2 Project High-Level Dashboard and Data Presentation

As utilities increasingly integrate Distributed Energy Resources (DER) and enhance their grid management capabilities, the need for robust, intuitive, and data-rich dashboards becomes paramount. For this IESO-Survalent-Participants LDC FDMM project, these dashboards serve as a central hub for monitoring, managing, and optimizing both traditional and modern grid assets, Examples provided are a minimal representation of what is possible.

A major project victory is that data integration is possible, along the project milestones the team demonstrated that multi-system, multi-platform including a variety of data types, resolution and formats can be integrated under the secure profile of supervisory systems. It is understandable for some of the drivers for the IESO to support this initiative given the diversity, technologies and even discrepancies of how utilities manage and maintain their system, and how assets are enabled sometimes with such broad objectives.

At the closing, the message is that this is possible, and in fact achievable in terms of resource economy and leveraging in trusted technology in short time horizons. We don't want a shockwave of excitement without anchoring on the concept that so much is possible, but significant planning and roundtable discussions are needed to help leverage knowledge, technology, what is relevant and at what scale.

The scale is what we are reflecting on this particular session in terms of data presentation. From LDC shared comments on experiences and value observed as well as understanding the potential magnitude of how much data can be achieved, the stakeholders and the system should be ready to embrace methods to render and present data at various layers, granularity, time scales and this is where techniques such as data concentration, abstraction and graphics and charts aids, can make it manageable from and end user persona standpoint.

## 4.2.1 The Role of the High-Level Dashboard

Figure 3 | System Overview Dashboard

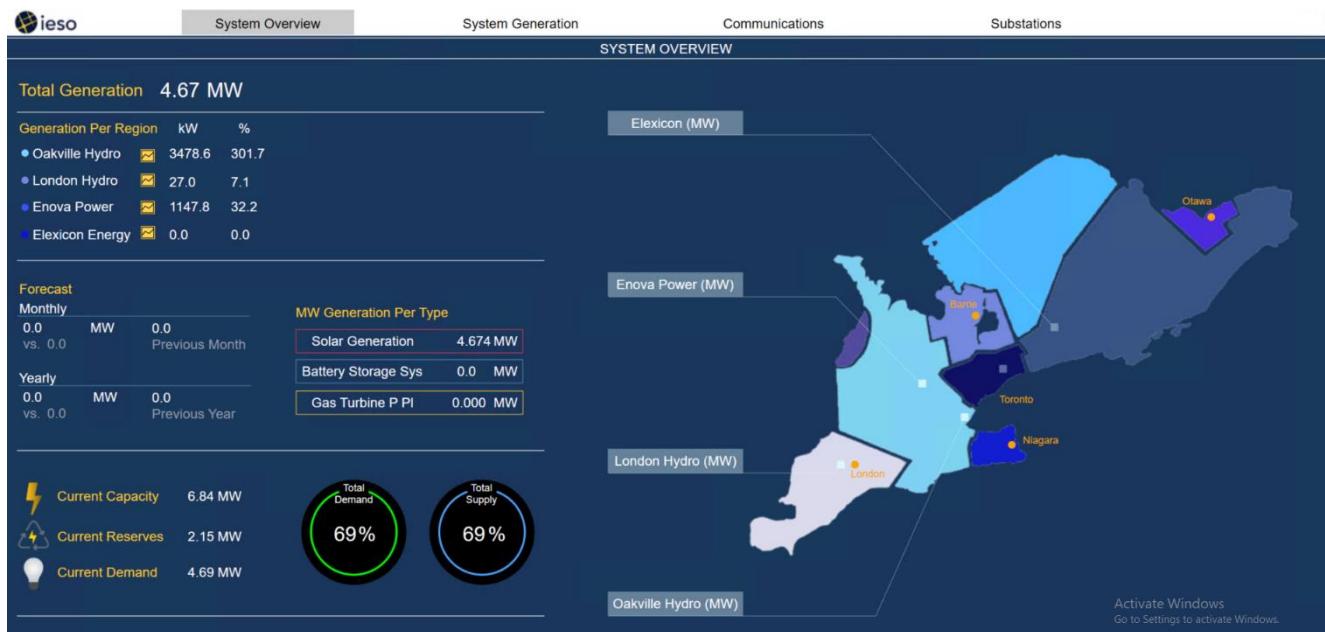


Figure 4 | Geological Breakdown of Enova Power



**Figure 5 | Geological Breakdown of London Hydro**



The high-level dashboard in this project is designed to provide a comprehensive overview of system performance, DER integration, and grid health, making it an indispensable tool for operators and decision-makers. By aggregating data from Advanced Distribution Management Systems (ADMS), Distributed Energy Resource Management Systems (DERMS), and other relevant sources, the dashboard offers a unified view of grid operations. This can include future real-time monitoring of power flow, load management, and the status of Inverter-Based Resources (IBRs) and their contribution by nodes, distribution transformers, substation feeders or substation base, as well as predictive analytics to foresee potential issues before they impact grid stability at the different levels described.

### Key Features:

- Real-Time Data Visualization:** Instantaneous display of critical metrics, such as voltage levels, power output from DERs, battery charge/discharge cycles, and load balancing across the grid when such information is available or obtained from participant stakeholders. The real-time data helps in swift decision-making, ensuring that the grid remains within operational limits. As some LDCs suggested, this capability provides them with the ability to plan their assets and understand trends, streamlining strategies for managing operations, particularly with BESS systems, which enhance grid reliability and facilitate the effective integration of renewable energy sources.
- Integrated Performance Indicators:** Customized KPIs can be achieved that could help tracking the performance of grid assets and DERs, offering a clear picture of overall system health and highlighting areas that require attention.

- **Scalability and Flexibility:** Designed to accommodate the growing number of DERs, the dashboard is scalable and flexible, allowing utilities to easily integrate new assets as they come online. This is crucial for maintaining an up-to-date view of the grid's capabilities and potential vulnerabilities.

#### 4.2.2 Data Presentation and Interoperability

- **Data Integration:** The dashboard's ability to pull data from diverse sources, including SCADA systems (London Hydro, Enova Power), AMI data (Oakville Hydro), and DERMS (Elexicon), ensures a holistic view of grid operations. This interoperability is achieved through standardized communication protocols and data models, which enable different systems to "speak the same language." By harmonizing data inputs, the dashboard reduces the risk of data silos, ensuring that all relevant information is available to operators when they need it most.
- **Streamlined Data Records:** A crucial aspect observed is the challenge of maintaining a detailed and accurate system of records. The dashboard leverages this system to track the status and history of DERs, some examples can include installation dates, maintenance schedules, performance logs, and integration milestones. This record-keeping is essential for long-term planning, regulatory compliance, and ensuring that DERs are optimally integrated as well as its ability to produce services, the magnitude of these services and further future market integration, a key gatekeeper to transition from DNO to DSO.
- **Predictive Analytics and Forecasting abilities:** Advanced algorithms can be embedded in the dashboards to analyze historical data to predict future trends in energy demand, DER performance, and potential grid disruptions and constraints. These predictive insights can benefit by empowering utilities to proactively manage their assets, reducing downtime and enhancing overall grid resilience in orchestration to TSO, Balancing or Independent system operator metrics and objectives.
- **User-Centric Design:** The dashboard is designed with the end-user in mind, featuring customizable interfaces that allow operators to focus on the data that matters most to them. Whether it's a control room operator monitoring real-time grid stability or a strategic planner assessing long-term DER integration, the dashboard's interface can be tailored to meet diverse operational needs.

#### 4.2.3 The DERMS and ADMS Integration Journey

The integration of DERMS and ADMS is a critical component of this project, aiming to create a more dynamic, resource optimization with the less moving parts, interfaces, cybersecurity concerns while achieving a high level of orchestration and synergy between systems and the overall objective of data centralization. The dashboard reflects this journey by offering tools and visualizations that track the progress of integration efforts.

- **Asset Real Time Data Tracking:** The possibilities once the data is defined and streamed can support a myriad of use cases and personas. Some LDCs expressed that observing in a centralized view allowed them to have new perspective on assets they had long run but were not deemed relevant for real time control or operations.

- **Interoperability Challenges and Solutions:** There will be challenges where data is not available or wrong, such issues can be addressed by high level visibility of items in grouped or assembled in shape of KPI's. The system can be enabled in ways that alarms when margins, State of Charge, expected generation or load reduction output is not reached upon scheduled operations or based on forecasted estimations, data compatibility issues or communication failures, the dashboard facilitates continuous improvement and adaptation of visual content to multiple stakeholders and data owners.
- **Operational Impact Assessment:** As DERMS and ADMS are integrated, the dashboard provides real-time assessments of their impact on grid operations, enabling utilities to make data-driven decisions on further deployment and scaling. Including the oversight of regulatory and balancing authorities' measurement of impact and perceived benefits which could be used to support investment and adoption strategies.

## 4.3 Data Governance and LDC Data Subdivisions Practices

In the context of integrating Distributed Energy Resources (DER) and enhancing grid management through Advanced Distribution Management Systems (ADMS) and Distributed Energy Resource Management Systems (DERMS), effective data governance and Local Distribution Company (LDC) data subdivision practices are critical. These components ensure that data is not only accurate and reliable but also accessible and secure, facilitating seamless operations and informed decision-making across the utility.

### 4.3.1 The Importance of Data Governance in a Modern Grid

Data governance refers to the framework and processes by which data is managed, ensuring its quality, integrity, and security throughout its lifecycle. In the context of DER integration, where vast amounts of data are generated from various sources such as AMI systems, SCADA, DERMS, and customer-facing platforms, robust data governance becomes essential for several reasons:

- **Ensuring Data Accuracy and Reliability:** As utilities rely increasingly on data-driven decisions, ensuring that the data used is accurate and reliable is paramount. Data governance frameworks establish protocols for data collection. This project and platform are not absent from the discussion in terms of how much and what is available. London Hydro reflected in the ownership of some of this data in the face of customer privacy and contractual terms. Future considerations beyond the data require cleaning the path and maybe even the legal letter to facilitate integration when the data or the information around it will outreach the perimeter of the LDC jurisdiction.
- **Compliance and Regulatory Requirements:** With the integration of DERs, utilities must comply with evolving regulatory standards concerning data management, particularly concerning privacy, security, and reporting. Data governance practices help utilities adhere to these regulations by defining clear data ownership, access controls, and audit trails. As per previous comment is evident there is a whole future discussion in enabling and improving frameworks to support initiatives like the one addressed on this project.

- **Data Integration and Interoperability:** From the two above, this might be the easily approachable task, the project demonstrated once data is enabled, it can be successfully integrated and used effectively. By standardizing data formats and establishing interoperability protocols, data governance frameworks enable seamless data flow between systems like ADMS, AMI and DERMS. And why not, future commercial applications relative to market, enablement and value chain.

### 4.3.2 LDC Data Subdivisions: Managing Data Across the Grid

Local Distribution Companies (LDCs) operate complex networks that require granular management of data at various levels. Data subdivisions within an LDC refer to the practice of categorizing and managing data according to specific operational needs, geographical areas, or system components. This practice is essential for optimizing grid management and supporting the integration of DERs.

The very same applies to an interoperability system like this platform; there will be requirements of staffing and ownership of the platform in terms of keeping it active, accurate and sustainable.

Some LDCs shared similar comments regarding the importance of integrating GIS data, noting that some data may not be updated for months. Additionally, this visibility raises concerns about data privacy and abstraction, which could hinder unbiased management of services and assets.

Future projects should, based on the premises of what is available and the constraints in possibly updating and maintaining such system, consider what is minimally viable; for example, substation aggregated view instead of detailed assets, SLD asset association instead of GIS, among other possible practical use cases.

#### 4.3.2.1 Geographic Data Subdivisions:

- **Regional Management:** In many utilities, data is subdivided by geographic regions or zones, allowing operators to monitor and manage grid performance at a local level. This is particularly important for LDCs that serve large or diverse areas where different regions may experience varying levels of DER penetration, load demand, or grid stress.
- The same principle should be applied at the IESO level. Early considerations can lead to an extremely difficult platform to maintain, therefore a round table defining criteria and what is minimally viable to support clear objectives is a strong recommendation.
- **Localized Insights:** By subdividing data geographically, LDCs can gain localized insights into grid performance, identifying specific areas that may require upgrades, additional DER integration, or targeted maintenance. This granularity supports more effective and efficient grid management, particularly in areas with high DER adoption. However, the contrast of how much a TSO, BAL or ISO requires exponentially is reduced, therefore the criteria of less is more will certainly help in driving strategy, adoption and stakeholders' contributions.

#### 4.3.2.2 Operational Data Subdivisions:

- **Asset-Based Subdivisions:** Data can also be categorized based on specific grid assets, such as transformers, substations, feeders, or DERs themselves. This allows for detailed monitoring of asset performance, lifecycle management, and predictive maintenance, ensuring that each component of the grid is observed to the best relevance for the problem it is intended to be addressed with such platform.
- **Real-Time vs. Historical Data:** Another important subdivision practice is distinguishing between real-time and historical data. Real-time data is critical for immediate operational decisions, such as responding to grid anomalies or managing load. In contrast, historical data is invaluable for trend analysis, forecasting, and long-term planning. Effective data governance ensures that both types of data are available and accessible according to their specific use cases.

#### 4.3.2.3 Functional Data Subdivisions:

- **Customer-Facing vs. Operational Data:** LDCs often manage data that serves different functional purposes. Customer-facing data, such as AMI readings and billing information, must be handled with stringent privacy controls and is often segregated from operational data used for grid management. By maintaining clear boundaries and access controls between these data types, LDCs can ensure compliance with privacy regulations while still leveraging operational data for grid optimization, preventing violations of data privacy when this data is used to support initiatives like this.
- **DER-Specific Data:** As DERs become more prevalent, the need to manage DER-specific data—such as generation output, battery status, and grid impact—becomes critical. LDCs must establish data subdivisions that specifically address DER data, ensuring that it is integrated at the level relevant for market or constraints management at the FDMM platform level.

### 4.3.3 Implementing Effective Data Governance and Subdivision Practices

To implement effective data governance and subdivision practices, LDCs should consider the following strategies:

- **Data Governance Frameworks:** Establish or help drive comprehensive data governance frameworks that define roles, responsibilities, and processes for data management to be shared to such platforms. This includes data stewardship roles that oversee data quality, access, and security, ensuring that governance policies are adhered to across the organization.
- **Data Architecture Design:** participate around the table with stakeholders to develop a data architecture that supports the logical subdivision of data according to geographic, operational, and functional needs. This architecture should be flexible enough to accommodate the growing volume and complexity of data as DER integration progresses.
- **Standardization and Interoperability:** Standardize data formats, protocols, and interfaces to ensure interoperability between different systems and subdivisions. This is particularly important in a multi-system environment where data from AMI, SCADA, DERMS, and other sources must be seamlessly integrated.

- **Training and Change Management:** Implement training programs and change management initiatives to ensure that all stakeholders—from data stewards to system operators—are equipped to manage and utilize data according to the established governance framework.

#### 4.3.4 Case Studies and Industry Best Practices

Drawing on industry best practices and case studies, LDCs can gain insights into effective data governance and subdivision strategies:

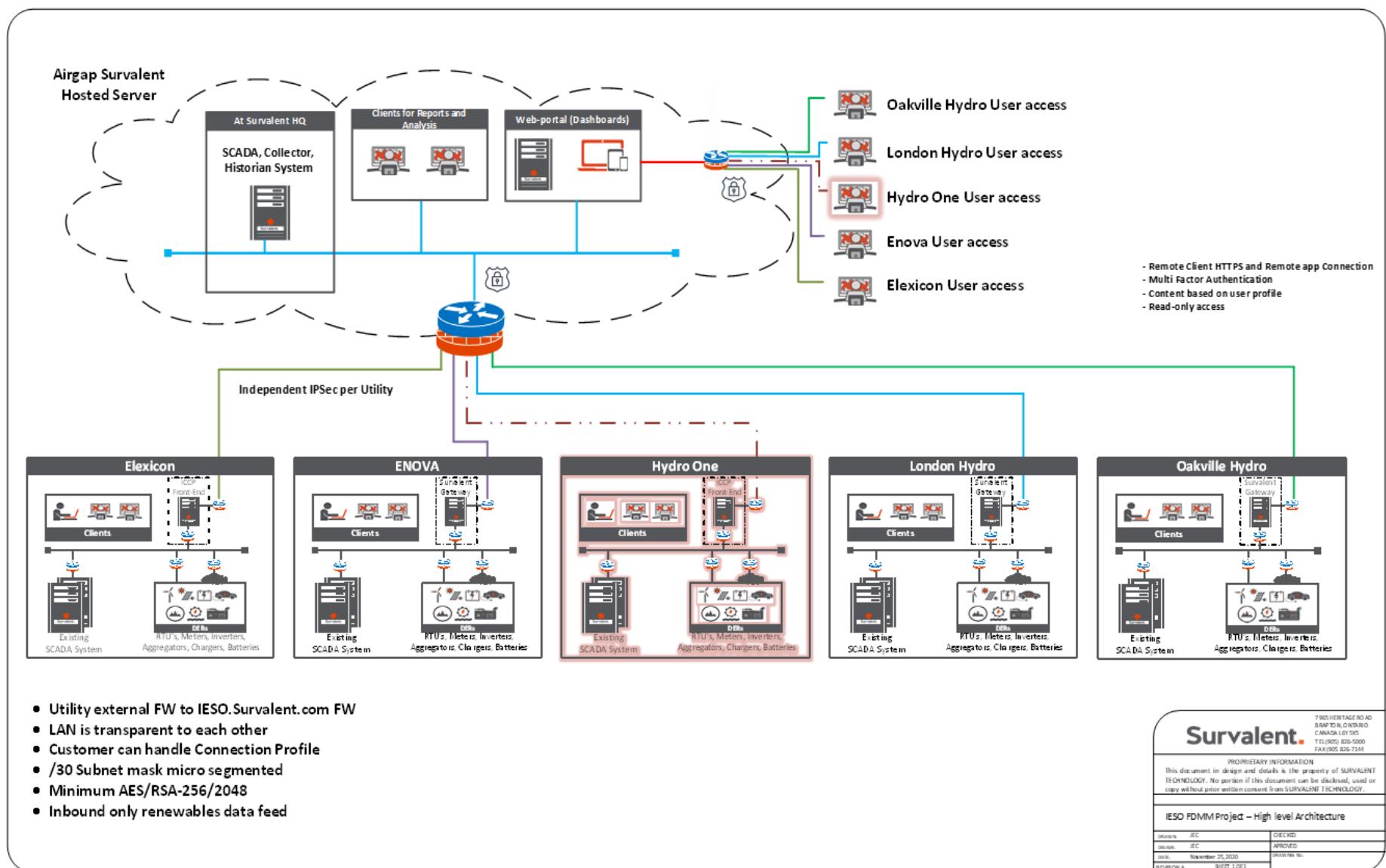
- **Utility Case Studies:** Utilities that have successfully implemented data governance frameworks often highlight the importance of cross-departmental collaboration, where IT, operations, and compliance teams work together to define and enforce data policies. For example, utilities with high DER penetration have implemented specialized data governance strategies that focus on the unique challenges and opportunities presented by DER data, customer privacy as well as jurisdictional ownership (Utilities are not entitled to share all what is asked).
- **Global Initiatives:** Industry initiatives such as the Common Information Model (CIM) and GridWise Architecture Council provide frameworks and standards that support data governance and interoperability in complex, multi-system environments. LDCs and IESO can adopt these frameworks to ensure that their data governance practices align with industry standards and support broader grid modernization goals.

### 4.4 Cyber security and access control to Jump boxes to each LDC

Building on the foundation established in the previous chapter, the platform was designed with a strong emphasis on security, aligning with the data governance frameworks and principles essential for a project of this nature. As an ISO 27001-certified organization, our focus has been on ensuring that high-quality data is consistently available throughout the entire lifecycle of processes, with robust data controls in place to support the technical and business objectives of the FDMM project.

Figure 6 highlights the initial design shared with LDC and IESO stakeholders. A significant success of this project was the minimal resistance and pushback from SME and LDC IT stakeholders, which validated the secure approach adopted by Survalent's network engineers. This approach effectively incorporated key cybersecurity frameworks and best practices, such as the NIST guidelines, demonstrating our commitment to security throughout the project.

**Figure 6 | FDMM Secure Architecture**



#### **4.4.1 Platform Fundamentals**

The project leveraged a common and secure practice used by utilities: transferring critical data from the Operational Technology (OT) network to an external environment in a unidirectional manner. This approach ensures that any potential data manipulation or risk does not impact the OT network, where critical applications such as ADMS, DERMS, and GIS reside.

Multiple industry-proven technologies were considered, with the primary objective being to replicate DER data from the OT system to an external environment, typically within a DMZ perimeter. Here, an appliance would host and act as a server, allowing external applications to access and operate on the replicated data without any risk to the original OT network.

A key requirement for this project was ensuring that once data was replicated, it could not affect the backend source—in this case, the ADMS. Therefore, it was essential that data streams remain strictly unidirectional.

To meet this requirement, the project utilized Survalent's Quality Assurance System (QAS), often paired with Survalent's data forwarding modules. These tools replicate a digital twin of the system, pushing real-time data and historical snapshots from the production environment. Such functionalities are typically employed for operator training, study modes, and playback features.

In three out of four cases, these modules were deployed within a Survalent Gateway system, which was temporarily licensed to Survalent customers for this project. Elexicon, however, used its own ICCP front-end. Had Hydro One participated, they would have implemented a similar solution, further underscoring the versatility of the Survalent platform used in this project.

#### **4.4.2 Utility IPSec**

Each utility was responsible for enabling an IPSec tunnel, with configuration details outlined in the Milestone 3 and 4 reports. The IPSec tunnels were set up at the front-facing firewalls of the LDCs. Due to standardized network practices across these appliances, the process—from conception to implementation—was completed efficiently, with LDC IT teams collaborating closely with Survalent's IT management.

Survalent's IT management ensured that high-security identities, secrets, and hashing protocols were established. Following a brief setup session, each LDC had the secure link ready for data traffic between their systems and the FDMM platform.

#### **4.4.3 Secure ICCP**

Survalent provided the option to use Secure Inter-Control Centre Protocol (Secure ICCP), which incorporates secure certificate exchanges between applications and encrypts data in transit.

Secure ICCP is an updated version of the traditional ICCP (IEC 60870/TASE.2) protocol, which has been in use since the late 1990s. ICCP is widely regarded as the de facto standard for real-time data exchange between control rooms, typically between LDCs and TSOs. However, the original ICCP protocol was designed in an era when cybersecurity was not a primary concern.

ICCP is based on the Manufacturing Message Specification (MMS or ISO 9506), enabling both client and server roles. It supports TCP/IP connections that can be inbound, outbound, or both, independent of the client/server role. In its non-secure form, data payloads are transmitted in plain text during client/server transactions. Secure ICCP enhances this by tunneling ICCP through Transport Layer Security (TLS), making it certificate-based with additional protocol message signing as defined by the IEC TS 62351-4 technical specification.

Survalent's implementation of Secure ICCP is processed within the servers rather than at the front ends, ensuring end-to-end encryption for stricter management of payload security.

#### **4.4.4 FDMM Platform**

This airgap platform creates a secure data perimeter, where the only exposed point is the primary firewall, which manages all connectivity, data streams, and user access. Within the airgap, three main applications are supported by virtual appliances: Survalent Supervisory, Data Acquisition and Historian capabilities; Survalent Maintenance and System Administration tools; and Survalent Database Replication and User Experience Interface.

These virtual appliances operate within a micro-segmented network environment, with strict security measures in place, including access control, whitelisting, and multi-factor authentication (MFA) integrated with Active Directory and group policy management.

The Survalent Supervisory subset handles Secure ICCP, data collection, and real-time access. Authorized users can log in and, using Survalent's administration tools, import and edit LDC databases, GIS, or SLD, as well as create historical tables of real-time variables.

System administrators or authorized users are responsible for segmenting customer data into submaps or data silos, ensuring that only relevant data is accessible according to user credentials or access zone delimitations. This approach ensures that only authorized individuals can view, edit, or publish data within their LDC jurisdiction.

#### **4.4.5 Jump Boxes**

In cloud and cybersecurity practices, jump boxes are widely adopted for their effectiveness in enhancing security. A jump box serves as a gatekeeper to a network infrastructure, such as the FDMM hub. Users must authenticate and access system data by first logging into the jump box, which hosts the Survalent SmartVU UX system.

Each user, whether from an LDC, IESO, or Survalent staff, must go through a multi-step authentication process: first, authenticating to the VPN, then to the jump box, and finally to the Survalent SmartVU UX. This final authentication step activates the visual content assigned specifically to that user. For example, if a user from LDC 2 accesses the jump box of LDC 1 and logs into Survalent SmartVU UX with their credentials, they will only see data from LDC 2, even when using LDC 1's jump box.

This layered authentication process provides multiple levels of login and user validation, ensuring robust protection of data and privacy.

## 4.5 High level data analysis, London Hydro Solar, Elexicon Battery and Oakville meter data

This is a high-level analysis, as the title suggests and three LDC's data examples were used. Analysis report from three LDC's is attached as an Appendix-1.

### 4.5.1 Elexicon Battery Data Analysis

The data provided on Elexicon's battery performance over the months of May, June, and July reveals several critical insights into how the battery is utilized within the grid.

#### 4.5.1.1 Monthly Charging and Discharging Trends:

- The data shows that the battery is more frequently charged than discharged, particularly in June, where there is a significant excess of charging (6000 kWh). This could indicate that the battery is primarily being used to store surplus energy during periods of low demand, which can then be released when demand peaks.
- This pattern of charging and discharging aligns with the typical behavior of batteries used in grid stabilization, where they help to balance supply and demand by storing energy during off-peak hours and discharging it during peak hours. This strategy is crucial for managing grid reliability, especially as more intermittent renewable energy sources are integrated.

#### 4.5.1.2 Hourly and Weekly Patterns:

- The analysis highlights that charging predominantly occurs during early morning hours, while discharging is more common in the late afternoon and early evening. This suggests a strategic use of the battery to support grid demands during high-consumption periods, likely coinciding with business hours when energy usage spikes.
- The discharging pattern, which peaks in the late afternoon, may also correlate with the higher energy prices typically seen during these hours, making it economically advantageous to discharge stored energy at these times.

#### 4.5.1.3 Correlation Analysis:

- The very weak positive correlation (0.036) between charging and discharging activities suggests that these processes are largely independent of each other. This could imply that the battery is being operated based on real-time grid conditions rather than a fixed schedule. This dynamic approach allows the battery to be more responsive to the grid's needs, charging when there is excess generation and discharging when there is a shortfall.

#### 4.5.1.4 Additional Considerations:

- **Operational Strategy:** The lack of a strong correlation between charging and discharging could also indicate a flexible operational strategy, where the battery is being used to address real-time grid issues rather than following a predefined cycle. This flexibility is essential in a grid with increasing levels of renewable energy, which can be unpredictable and require rapid response capabilities.

- **Data Integration:** For future analysis, integrating this battery data with other grid performance metrics, such as load profiles, energy prices, and renewable generation data, could provide deeper insights into the battery's role in grid stabilization.

#### 4.5.2 London Hydro Solar Arrays Analysis

The analysis of the three solar panels from London Hydro provides insights into their performance, but also raises several concerns regarding data accuracy.

##### 4.5.2.1 Performance Patterns:

- The solar panels, identified as Solar\_J52G-2, Solar\_N52G-1, and Solar\_M46G-1, show similar daily generation patterns, with the peak generation occurring around midday, which is consistent with typical solar output. However, the Solar\_J52G-2 panel reports negative values, which, when interpreted as generation, suggest a similar performance pattern to the other panels.
- The bell curve shape of the generation data, peaking during midday, is expected for solar panels, but the negative values from Solar\_J52G-2 indicate a potential issue with the data recording or interpretation. If these negative values are indeed a result of an error, they need to be corrected to accurately assess the panel's performance.

##### 4.5.2.2 Data Discrepancies:

- The most concerning aspect of the analysis is the reporting of generation during non-sunlight hours, such as late at night. This anomaly is observed across all panels, suggesting either a data recording error or a possible malfunction in the sensor equipment.
- Such discrepancies undermine the reliability of the data and make it challenging to draw accurate conclusions about the panels' performance. Addressing these issues is critical before any further analysis or decision-making can be based on this data.

##### 4.5.2.3 Comparative Analysis:

- Despite the discrepancies, when the data is adjusted to account for the negative readings, the panels show a similar generation pattern, which is promising. However, the integrity of this data needs to be verified to ensure that any patterns observed are genuinely reflective of the panels' performance.

##### 4.5.2.4 Recommendations for Improvement:

- **Data Validation:** Before utilizing this data for any further analysis or reporting, it is essential to validate the readings from the solar panels, particularly the negative values and the readings during non-sunlight hours. This validation could involve cross-referencing the data with other available sources or recalibrating the sensors.
- **Sensor Calibration:** If the negative values are due to a sensor calibration issue, it is recommended to recalibrate the sensors to ensure accurate data collection moving forward. This would also help in rectifying the anomalies seen during the night hours.

- **Standardized Data Reporting:** To ensure consistency across all solar panels, implementing a standardized data reporting protocol would be beneficial. This would help in minimizing discrepancies and making the data more reliable for analysis and decision-making.

### 4.5.3 Oakville Meter Data Analysis

The analysis of meter data for solar generation in Oakville reveals patterns and identifies the peak hour of maximum generation.

#### 4.5.3.1 Performance Patterns:

- There is a clear upward trend in power generation from February to June, which likely correlates with the increasing duration of daylight and solar irradiance typical of the transition from winter to summer.
- The highest power generation occurs between 12 PM and 1 PM, indicative of solar panels receiving maximum sunlight due to their orientation and the sun's position.

#### 4.5.3.2 Consistency across the meters:

- Despite differences in the magnitude of power generated the overall pattern of generation is similar across the two meters. This suggests that both meters are likely influenced by the same environmental conditions.

## 5. Conclusion

### 5.1 LDC Feedback on the FDMM platform and how it influenced distribution network operational decisions

The following questionnaire was distributed to all Local Distribution Company (LDC) participants, with response notes subsequently shared with Oakville Hydro, Elexicon, Enova Power, and London Hydro. Two participants provided their reflections, which have been compiled under each relevant question.

The questionnaire aimed to capture LDC and Independent Electricity System Operator (IESO) experiences, gathering insights into the current maturity of systems, lessons learned, and perspectives on future solutions for unifying Distributed Energy Resource (DER) operational data. It was designed to be concise and respectful of stakeholders' daily responsibilities.

Aspects of Asset visibility and planning, Data transfers, privacy and cybersecurity and AMI infrastructure were addressed by respondents as follows:

#### 5.1.1 Questionnaire:

##### On the Topic: Asset Visibility and Planning

1. How has the increased visibility of renewable assets across multiple utilities enhanced our ability to plan and forecast energy usage and storage needs?

Local Distribution Companies (LDCs) are heavily focused on their distribution systems, which can pose challenges when allocating resources to address forward-facing system challenges beyond their immediate operations. From a planning perspective, utilities tend to concentrate on inward reliability and system stability issues. Currently, at the provincial level, there hasn't been a level of DER penetration that significantly disrupts this status quo or necessitates a broader view in operational planning. Only a few utilities have invested in distribution-scale batteries, primarily for peak demand response and, in some instances, feeder or substation voltage regulation. Existing frameworks, regulations, and incentives have not yet driven substantial investments in renewables from a market participation standpoint.

Despite this, it is evident that systems like the one scoped in this project offer significant value. The Independent Electricity System Operator (IESO) can achieve better and more granular visibility into DER assets, which were previously difficult to observe or estimate. This improved visibility will benefit utilities by providing relevant data to help LDCs understand load capacity variability and the energy reserves needed for system balance. Currently, Survalent is exploring the technical case for this approach, and as we achieve a broader view and better forecasting, we expect to see how these assets start to appear and impact on the grid.

This enhanced visibility and forecasting can drive value, potentially triggering increased investment in Distributed Energy Resources (DERs). Such investments would not only address municipal or regional needs but also enable a more vertical market and value transfer. This approach could maintain or reduce taxpayer dollars and tariffs, ultimately benefiting all stakeholders involved.

2. Can specific examples of particular (LDC) or general (IESO) short term usability of such platform be elaborated based on actual DER provincial penetration?

Looking at the holistic performance of the London area, including local transmission system performance, transformer station (TS) loading/generation, and feeder DER penetration, provides valuable insights into how London Hydro (LH) affects the Bulk Electric System (BES) at any given moment. This comprehensive analysis allows for pinpointing specific areas of improvement and identifying trends that can influence operational decisions.

For instance, by closely monitoring TS loading and generation metrics, LH can optimize the balance between supply and demand, ensuring that the system operates within safe and efficient parameters. Feeder DER penetration data offers a snapshot of distributed energy resource integration, highlighting how renewable energy sources contribute to the overall energy mix and their impact on the grid.

Understanding the performance of other local area systems, such as Hydro One feeders from the same TSs, Entegrus, and ERTH, can further facilitate transactive energy or BES balancing within a Distribution System Operator (DSO) model. This interconnected approach promotes a more cohesive and responsive energy ecosystem, enabling utilities to engage in energy transactions that enhance grid stability and efficiency.

Moreover, a deeper comprehension of generation patterns and the potential for active dispatching of generation in collaboration with LDCs enables more effective load management. By leveraging real-time data and predictive analytics, utilities can make informed decisions about when and where to deploy energy resources, ultimately leading to more prolonged asset utilization and deferred

infrastructure replacements. This strategic management not only reduces operational costs but also extends the lifespan of critical assets.

In essence, the integration of such a platform equips both LDCs and the Independent Electricity System Operator (IESO) with the tools necessary for proactive and informed decision-making. It fosters a more resilient and adaptable energy system capable of meeting the demands of a rapidly evolving energy landscape. By achieving better and more granular visibility into DER assets and operational performance, the platform facilitates a unified approach to energy management that benefits all stakeholders, from utilities to end consumers.

This approach aligns with the broader vision of a sustainable and efficient energy future, where enhanced data transparency and interoperability drive innovation and investment in Distributed Energy Resources (DERs). It sets the stage for a more dynamic and responsive energy market, ensuring reliability and cost-effectiveness while supporting the transition to cleaner energy sources.

### **On the Topic: Improving Data Transfer**

3. What were the most significant challenges we encountered with data transfer between legacy systems and the new integration platform?

This question requires addressing from two standpoints based on Survalent's experience: first, the back-end perspective, which involves how our assets and their data are available to our supervisory system; and second, the data manipulation perspective, focusing on how the available data must be processed and presented cleanly to a centralized system.

- Back-End Perspective:
  - In retrospect, we could have benefited from a global strategy among LDCs to better prepare for a more integrated future. LDCs adopted DER at various stages and magnitudes while regional frameworks establishing guidelines were still being developed. The industry did not anticipate the extensive and varied scale of DER adoption we are now experiencing.
  - Telemetry and real-time access are critically important, but many assets either lack this capability or have limited access. The required infrastructure and associated costs for assets that do not actively participate in market transactions can make investment prohibitive. A practical solution would be to gradually retrofit these assets over time.
  - The question of whether a centralized SCADA infrastructure is the best approach arises, especially when many technologies are more cloud-friendly, IT-oriented, and potentially less secure. Integration of both legacy and new assets, whether through IoT technologies or supervisory methods, will be a long journey towards achieving feasible data awareness at an acceptable level.
- Data Manipulation Perspective:
  - Another challenge is the lack of data from such systems and retrofits, or instances where data is scattered among multiple systems or data lakes that do not interface with each other. This fragmentation makes data amalgamation and availability for real-time operational use a compelling challenge.

- In our case, getting data to our SCADA from our AMI network was very file-based and required substantial scripted queries and data processing to achieve the desired scale. Additionally, the complexity increased due to alternate methods of data transfer beyond ICCP.
- Moreover, the data resolution was not real-time. An acceptable scenario would be at least hourly updates, but the reality is that in many cases, data is only available every 24 hours. While this data can support some planning and dispatch scenarios, its value is significantly lower for optimization strategies and market and services value transfer when it is not real-time or near real-time.

**Conclusion:**

- Addressing these two standpoints—back-end infrastructure and data manipulation—is crucial for improving the usability and effectiveness of our supervisory systems in the face of increasing DER adoption. A unified strategy among LDCs, gradual retrofitting of assets, and enhancing real-time data capabilities are essential steps toward a more integrated and efficient future.
- All this is on the premise of using the Supervisory system as a secure and maybe the path of less resistance method. However, this is not practical or much of what can be done is limited by the boundaries of the system in place at each LDC. Certainly, more options in terms of data transfer and formats should be explored.

4. Are there any best practices or tools that IESO or LDC uses that can be found particularly effective?

The future of data transfer between entities, particularly concerning DER data, presents challenges largely dependent on the sources of this data. It is a reality that certain assets, functions, or data points may not be accessible at a centralized level. For example, reserves operating behind microgrids, the decentralization of multiple Virtual Power Plants (VPPs) outside control areas, and IoT-based demand response programs like smart thermostats and other intelligent devices may not be easily integrated into a centralized supervisory system.

For effective grid management, all this data—measurements, statuses, and more—should ideally be integrated into LDC power flow studies in real or near-real time. When this level of integration is achieved, it could open up numerous possibilities for grid optimization and management. However, in the current landscape, it is essential to implement strategies that prioritize the data necessary for system operations, operator collaboration, and market participation.

For instance, data such as weather and solar forecasts should be centralized and standardized to ensure that all stakeholders operate based on the same high-quality, precise information. This standardization could also apply to generation forecasts from LDCs, which could be based on either centralized data or publicly available weather information.

From an operational standpoint, Survalent's promotion of common, well-established protocols like Secure ICCP has proven to be a wise and secure choice. Our internal SMEs were able to set up data streams quickly, which would have been more challenging using APIs, for example.

Additionally, Survalent's prototype data consolidation dashboards have provided valuable insights, revealing realities at the LDC level that were previously unnoticed. The overall consensus is that for operational data, using mature and widely adopted industry protocols, securing networks with IPSec, and consolidating data through comprehensive dashboards offers a straightforward approach to the data integration challenges we face.

### **On the Topic: Data Privacy and Security**

5. In terms of data governance, what measures did we implement to ensure the privacy and security of sensitive information? How can these measures be improved in future projects to protect against emerging threats?

To ensure the privacy and security of sensitive information, several measures were implemented in our data governance strategy. London Hydro (LH) limited the sharing of DER asset information to cases where LH had majority ownership, due to existing contracts with DER customers that do not permit third-party data sharing. The shared information was restricted to specific DERs, such as feeder information tied directly to those assets. For broader adoption, it is recognized that agreements with all DER customers would need to be established, and a framework for submitting GIS models would be necessary, especially when integrating with systems other than Survalent products like SmartVU. Ensuring model compatibility and managing regular updates between LH and the DER repository maintainer would require significant effort and time.

The approach of moving into a nodal or a SLD approach could be easily to maintain in contrast to GIS data.

In addition to these measures, the implementation of Multi-Factor Authentication (MFA) and Virtual Private Networks (VPN) provided an added layer of security. However, it was noted that the penetration (PEN) testing could be improved by expanding its scope to include the entire LDC environment and extending into Survalent's space, thereby ensuring a more comprehensive security assessment.

The data consolidation approach, besides the permissions, needs also to assure the platform cybersecurity. The approach of data forward servers or jump boxes on each side of the tunnel greatly alleviated IT initial concerns. Survalent provided the technology to use DMZ approaches of unidirectional real time data which facilitated the approach by not introducing major changes within the actual system, as utilities commonly have DMZ facing approaches in place.

Overall, while the current measures have been effective, future projects could benefit from broader security assessments and the development of frameworks that facilitate secure and seamless data sharing across different platforms and with third parties.

### **On the Topic: Integration with Advanced Metering Infrastructure (AMI)**

6. When dealing with data behind Advanced Metering Infrastructure (AMI), What lessons did we learn about handling AMI data that could benefit future integration projects?

When dealing with data behind Advanced Metering Infrastructure (AMI), several lessons can enhance future integration projects, particularly concerning behind-the-meter inverter-based resources (IBR).

- **Prioritization and Integration:**  
A key lesson is the need for better integration between AMI and SCADA systems. Currently, AMI prioritizes billing data, often leading to gaps in operational data needed for grid management. Usually, the data mined from AMI is in excel and relational DB formats which requires massaging to a more streamlined data structure. Future approaches can benefit by addressing these data concerns, what is relevant and at what time resolution and explore the ways for automatic data transfer approaches while supporting cybersecurity approaches.
- **Enhancing IBR Visibility:**  
For behind-the-meter Inverter Based Resources IBRs, data visibility is often limited to the utility-facing meter, creating challenges in monitoring and managing these resources. Improving AMI systems to provide more granular, real-time data on IBR performance is crucial for effective grid management and load balancing.
- **Improving Data Timeliness:**  
The current AMI data cycle, often on a 24-hour delay, is inadequate for real-time grid operations. Future projects should focus on increasing the frequency of data reporting to better support real-time monitoring and control of IBRs.
- **Standardization and Interoperability:**  
Lastly, standardizing protocols and ensuring interoperability between AMI and SCADA systems will simplify integration and improve the overall efficiency of data use across utility applications.

## 5.2 Conclusion and Appreciation

This project represents a significant achievement in the ongoing efforts to integrate Distributed Energy Resources (DERs) into Ontario's electricity grid. The collaborative efforts of the IESO, in partnership with key Local Distribution Companies (LDCs) including London Hydro, Elexicon, Enova Power, and Oakville Hydro, have laid a strong foundation for future advancements in grid modernization and energy management.

Overall, the project has made significant strides in integrating Advanced Metering Infrastructure (AMI) data into Ontario's electricity grid, addressing complex challenges and leveraging successful strategies from industry partners. The creation of a high-level dashboard has provided a comprehensive view of grid operations, facilitating informed decision-making and real-time monitoring. Prioritizing data governance and cybersecurity has ensured platform integrity, while detailed training sessions have equipped LDC and IESO participants with essential skills for effective system utilization, ultimately enhancing the grid's operational efficiency and resilience.

## 6. Lessons Learned

As the project progressed, additional complexities surfaced, leading to several challenges. Through team review and options assessment, we identified key lessons, summarized below. Each lesson includes the main challenge in brackets (e.g., technical limitations, Regulatory barriers, Resource availability). A brief description and suggested solutions are also provided.

### **FDMM Network and Communication Infrastructure – (Resource Availability):**

The project's foundation was the ability to converge systems and data from various sources into near real-time for improved market, forecasting, and operational efficiency. An independent, air-gapped platform was developed to facilitate data exchange, with multiple stages addressing cybersecurity, data ownership, and governance.

Suggested approach: After discussions with Hydro One, Survalent team learned of an existing framework and service providers to manage a similar platform. Survalent recommends that by leveraging this platform, similar initiatives could benefit of significant time savings that could enhance integration, streamline processes for Local Distribution Companies (LDCs), and strengthen the cybersecurity framework.

### **Data Quality Variability – (Technical Limitations):**

Each LDC adopts processes that meet their specific technical and business needs. However, these processes often hinder uniformity in an integrated platform. Issues included data gaps, inconsistent time resolutions, and varying data formats and availability.

Suggested approach: IESO should establish minimum requirements for data uniformity, such as 1-minute time resolution for AMI data, and consistent real-time parameters like P, Q, V, and I values across utilities. The current lack of uniformity, especially with certain asset types like batteries, highlights the need for standardization.

### **Asset Visibility for Multi-Market Enablement – (Regulatory Barriers):**

LDCs continue to adopt diverse technologies, resulting in varying levels of customer data across systems. For example, demand response services like thermostat management collect different data than a single C&I solar producer, leading to differences in optimization, grid services, and market participation.

Suggested approach: Regulatory bodies like IESO should standardize data governance and parametrization across LDCs. A multilateral agreement on data collection and uniformity based on specific use cases or services would support more consistent operations.

### **Cross-Platform Data Integration – (Technical Limitations):**

The diversity of market solutions for DER operations leads to integration challenges, as systems often lack compatibility in data exchange. For example, inverter-based resources may use different nomenclature and operational modes, requiring translation of setpoints and communication protocols.

Suggested approach: Vendors, LDCs, and prosumers should follow national or provincial standards and frameworks like IEEE 1547 and IEEE 2030.5. These standards define data structures and promote uniformity across systems, reducing integration difficulties and ensuring smoother cross-platform data exchange.

### **Monitoring Data Links – (Resource Availability):**

A multi-market, multi-platform environment demands significant resources to maintain data streams, cybersecurity, and sustainability. This requires diverse skill sets and tools to ensure data link availability.

Suggested approach: To prepare for system deployment, safeguards like remote monitoring, cybersecurity protocols, and real-time notifications should be implemented to ensure data stream stability and trust in the platform.

## **7. Next Steps**

### **7.1 Reflections on Platform Scalability and Project Expansion Across Ontario**

#### **7.1.1 Introduction**

The IESO-Survalent-Participants LDC FDMM project has demonstrated significant potential for integrating and managing Distributed Energy Resources (DERs) across Ontario's grid. As the energy landscape continues to evolve, there is a clear need to expand this platform, both in scope within Ontario and possibly to other jurisdictions facing similar challenges. This chapter explores practical and conceptual opportunities for scaling the platform across the province and beyond, drawing on the insights gained from the current milestone and considering the broader context of grid modernization and energy management.

#### **7.1.2 Practical Opportunities for Platform Expansion**

##### **7.1.2.1 Enhancing Data Integration Capabilities:**

One of the most immediate opportunities for expanding the platform lies in enhancing its data integration capabilities. As the platform scales across Ontario, it will need to handle a broader range of data types and volumes. This involves adopting advanced data warehousing solutions that can efficiently store and process large datasets and employing machine learning algorithms for data cleaning and normalization. Improved data integration will enable more accurate real-time monitoring and forecasting, thereby supporting better decision-making across the grid. This capability is particularly crucial as more DERs are integrated into the grid as Utilities expand both infrastructure,

non-wire alternatives and reduction of CO2 emissions strategies, each bringing unique data that must be harmonized with existing systems.

#### **7.1.2.2 Developing Modular Platform Components:**

To facilitate the platform's expansion, creating modular components is a practical approach. These modules can be tailored to specific needs of different regions or utilities, making the platform more versatile and easier to deploy in diverse environments. For instance, one module could focus on real-time monitoring, while another could specialize in predictive analytics. This modular design would allow utilities to select and implement only the components they need, reducing the complexity and cost of deployment. As a result, the platform becomes more adaptable, enabling broader adoption across Ontario (IESO).

#### **7.1.2.3 Expanding Cybersecurity Measures:**

As the platform expands, maintaining robust cybersecurity measures becomes increasingly important. The platform must protect the integrity of the grid by ensuring secure data handling, particularly when it involves sensitive customer information and grid performance metrics. Enhancing the current cybersecurity framework with AI-driven threat detection and response capabilities can provide an additional layer of protection. Regular cybersecurity audits and updates to the platform's security protocols will further ensure that it remains resilient against evolving threats, which is crucial as more Local Distribution Companies (LDCs) come online.

#### **7.1.2.4 Open participation to other actors:**

Government both provincial and local, academia, scholars, national labs, technology providers, research and vendors are amongst multiple actors that can benefit from such a platform, each of them contributing to various aspects in supporting operation of a provincial or even at national scale. The data harvested, protected by the jurisdictional and privacy aspects as cited before, can mean a significant and unique in its class source of rich data that could help drive infrastructure, technology, strategy and capital investment. Early insertion of actors such as data owners, legal and contractual aspects of DER enrollment, services and aggregation ancillary capacities, could help shape a greener, viable, but furthermore, a solid foundation for provincial or national leadership in an orchestrated approach of emissions reduction, technology applicability, cost reduction and expanded ownership and contribution.

### **7.1.3 Conceptual Opportunities for Platform Expansion**

#### **7.1.3.1 Creating a Provincial Energy Marketplace:**

A conceptual opportunity for expanding the platform is the creation of a provincial energy marketplace. Although this is a service IESO provides, classically it had been applied to a restricted group, the reference is more end customer centric, this can certainly help the utilities transition to DSO models where local energy resources can trade energy directly with the grid or with each other. This marketplace would allow for dynamic pricing and trading, optimizing energy use and distribution across the province. The platform could serve as the backbone for this marketplace, providing real-time data and analytics that participants can use to make informed trading decisions. Smart contracts and blockchain technology could be employed to ensure transparency and security in transactions. This

marketplace would incentivize the development of local energy resources, such as community solar projects, and enhance the overall efficiency of Ontario's energy system.

#### **7.1.3.2 Supporting Decentralized Energy Management:**

Decentralized energy management, where local communities and even individual households can manage their own energy production and consumption, represents another conceptual opportunity. The platform could provide tools for users to monitor and manage their energy use, participate in demand response programs, and sell excess energy back to the grid. Integrating with smart home systems and other IoT devices would be crucial for this decentralized approach. Decentralized energy management could lead to more resilient energy systems, as communities become less reliant on centralized power plants and more capable of managing their own energy needs.

#### **7.1.3.3 Leveraging AI for Predictive Maintenance and Optimization:**

Artificial Intelligence (AI) offers significant potential for enhancing the platform's capabilities, particularly in predictive maintenance and optimization. AI models can analyze data from the grid to predict equipment failures before they occur, reducing downtime and improving efficiency. Additionally, AI can be used to continuously optimize grid operations based on real-time data, minimizing energy losses and enhancing overall system performance. Predictive maintenance and optimization not only improve the reliability of the grid but also reduce operational costs and extend the lifespan of critical infrastructure.

#### **7.1.3.4 Adapting to Climate Change and Extreme Weather:**

As climate change leads to more frequent and severe weather events, the platform must adapt to these challenges by providing tools for resilience and disaster response. Integrating climate models and real-time weather data into the platform can help predict and mitigate the impact of extreme weather on the grid. The platform could also offer utilities the tools needed to quickly respond to outages and other disruptions caused by severe weather. Enhancing the platform's capabilities in this area will improve the resilience of Ontario's energy infrastructure, ensuring that it can withstand the increasing challenges posed by climate change.

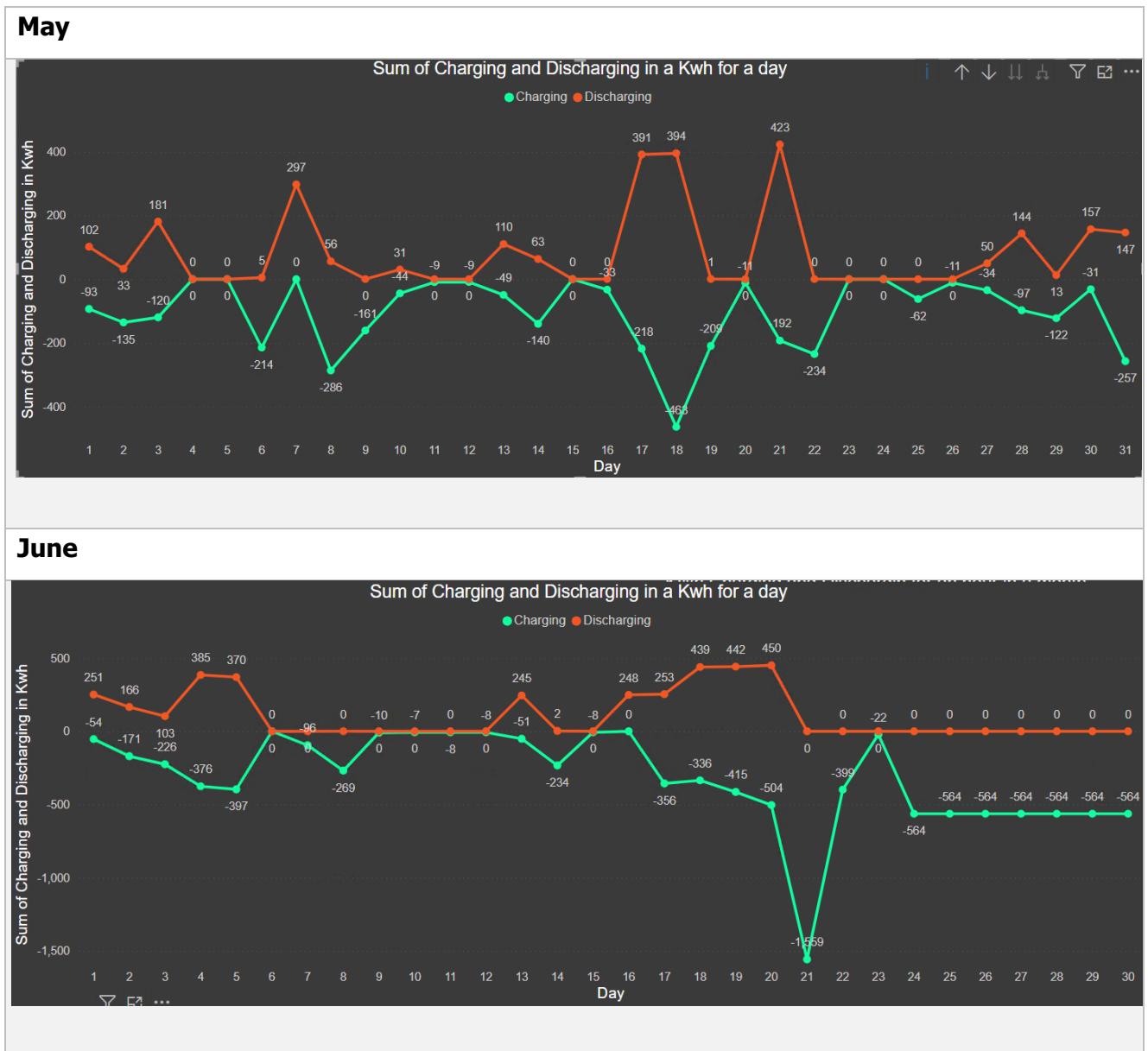
#### **7.1.3.5 Exploring Opportunities for Global Export:**

Finally, once the platform has been successfully expanded within Ontario, there is potential to adapt and export it to other regions and countries facing similar challenges in energy management and grid modernization. Collaborating with international partners and customizing the platform to meet the regulatory and operational needs of different regions could open up new markets. Additionally, the platform could be tailored to address specific challenges, such as integrating large-scale renewables in regions with different energy landscapes. Exporting the platform could position Ontario as a leader in energy management technology, driving economic growth and contributing to global efforts to modernize energy systems and combat climate change.

# 8. Appendix 1 – Analysis Report

## 8.1 Report on Battery data for Elexicon

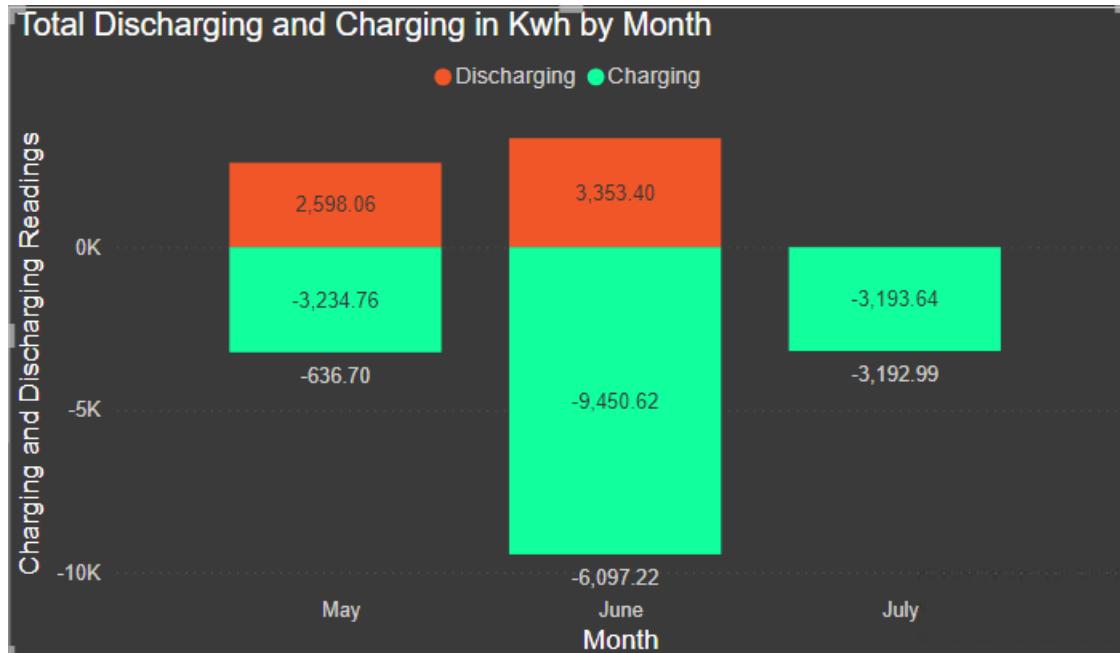
All the graphs below show kWh reading Monthly, Weekly, and Hourly for charging and discharging. In the end, correlation is discussed between charging and discharging reading.



### 8.1.1 Monthly Energy Charging and Discharging readings

It is observed that in May, most of the charging and discharging occur around the first seven days and days from 16 to 22. In June, charging and discharging occur simultaneously for the first six days and from 17 to 20. In July, it's mostly discharging that occurs.

Further, the below graph shows Total charging and discharging by month.



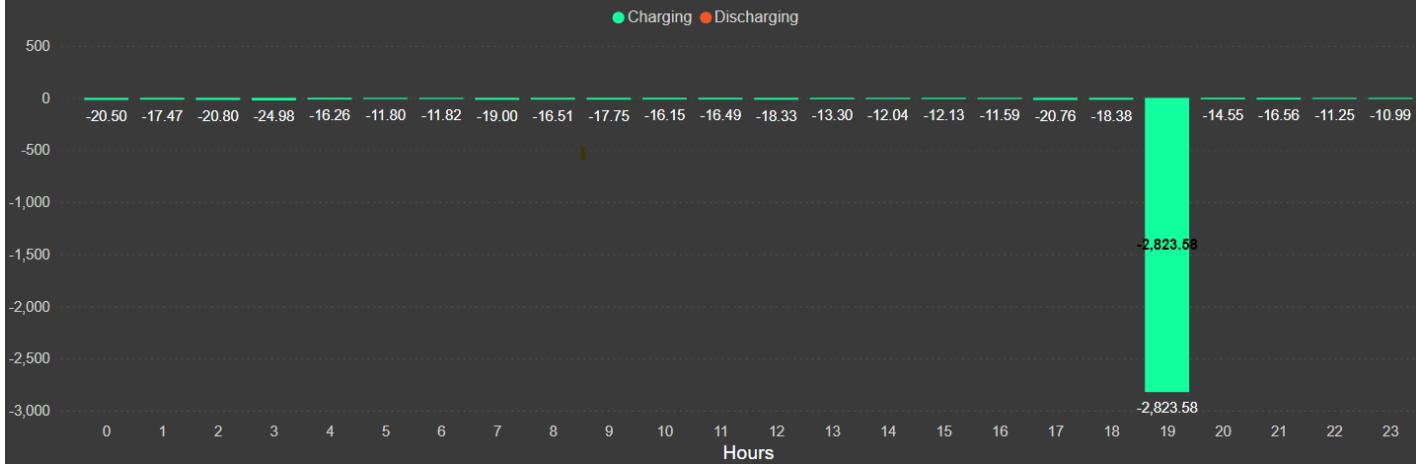
We observe that overall, the battery receives more charging than discharging. In May, we had an excess of 636 kWh charging and 6000 kWh for June. For the month of July, charging is reported most of the time, and the total is 3192 kWh of charging.

### 8.1.2 Hourly trend of charging and discharging by month



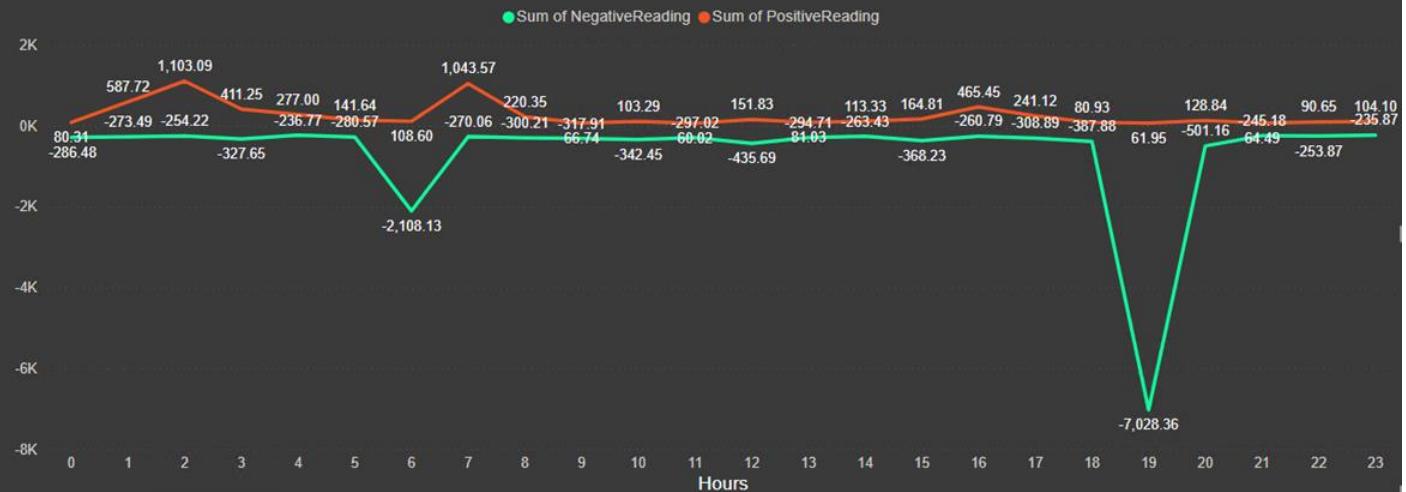
## July

KWh Charging and Discharging for an hour in a month



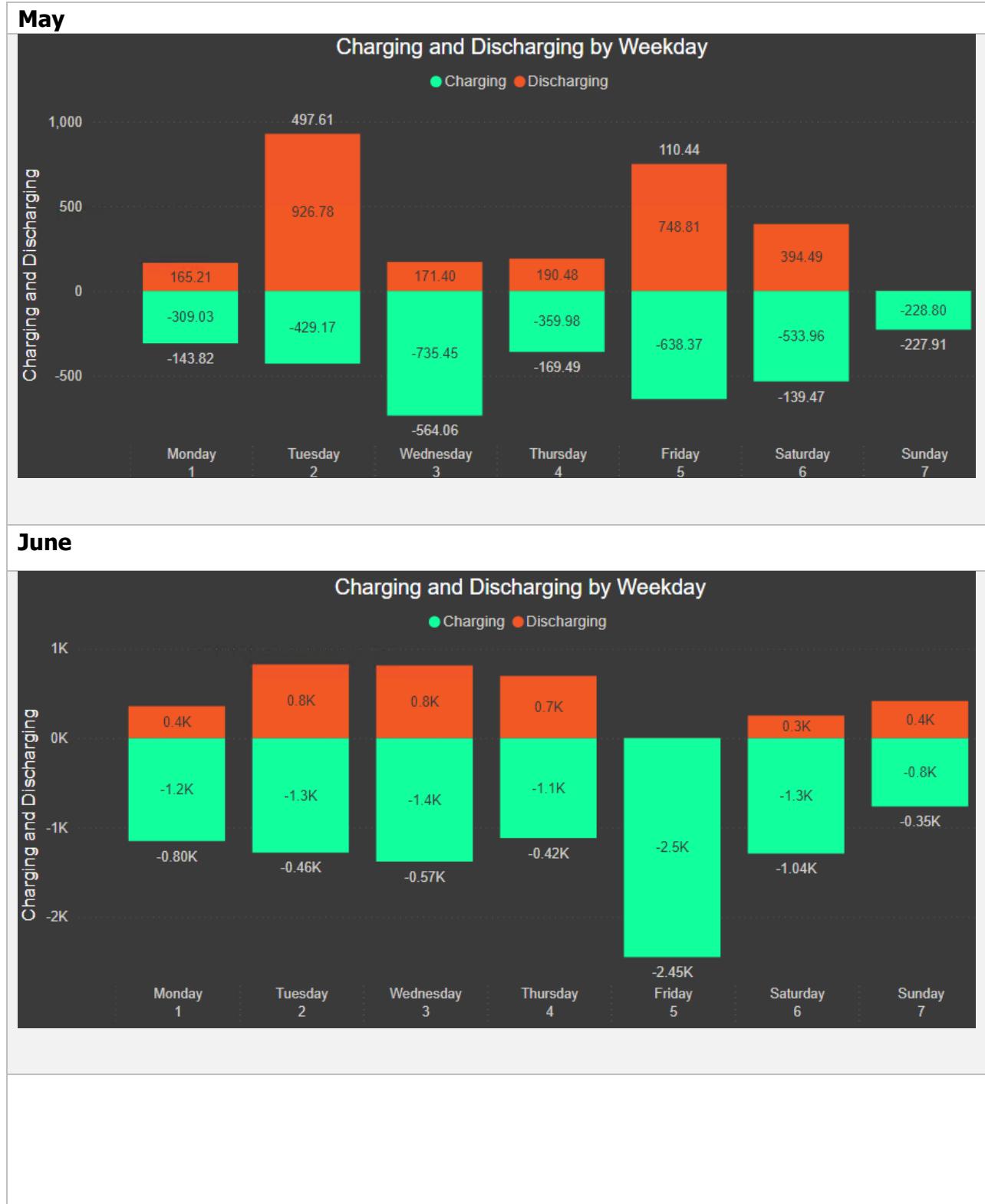
## Overall Trend by Hour

Trend of Charging and Discharging by hour

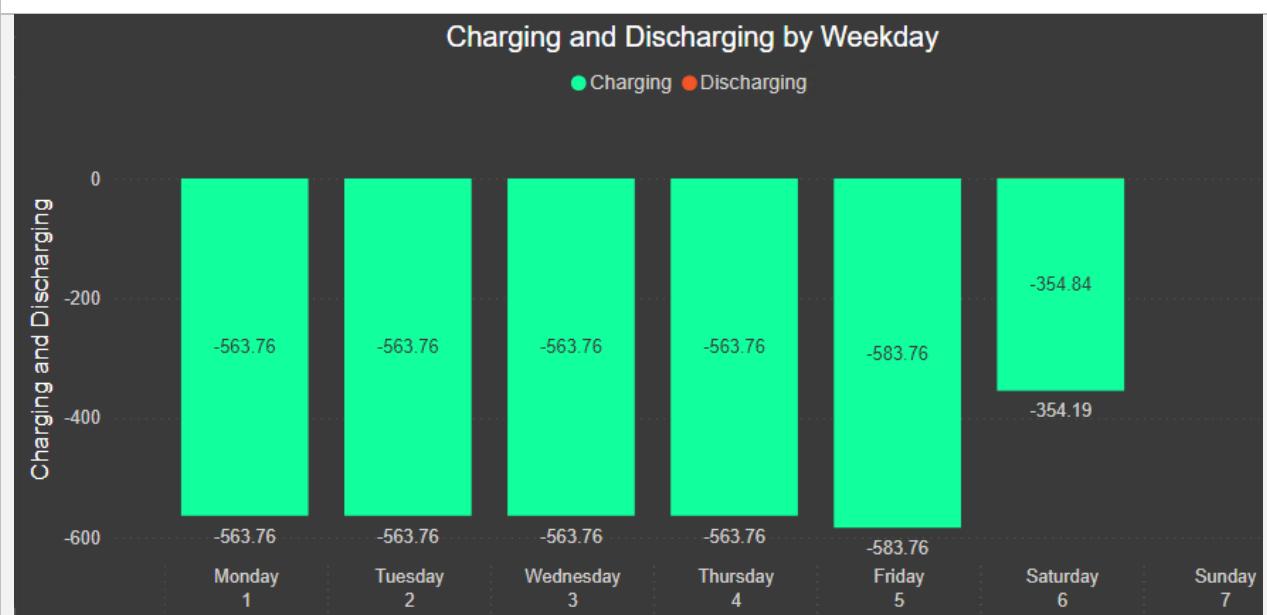


It is observed that in May and June, most of the consumption occurs during the first three hours of the day, which are midnight, 12 a.m. to 2 a.m., and 5 a.m. to 8 a.m. Discharging for both months happens mostly between the 18th and 19th hour. This suggests that during peak morning office hours, consumption is high, and in peak evening office hours, charging is high. This suggests that at the end of office hours, the battery starts charging.

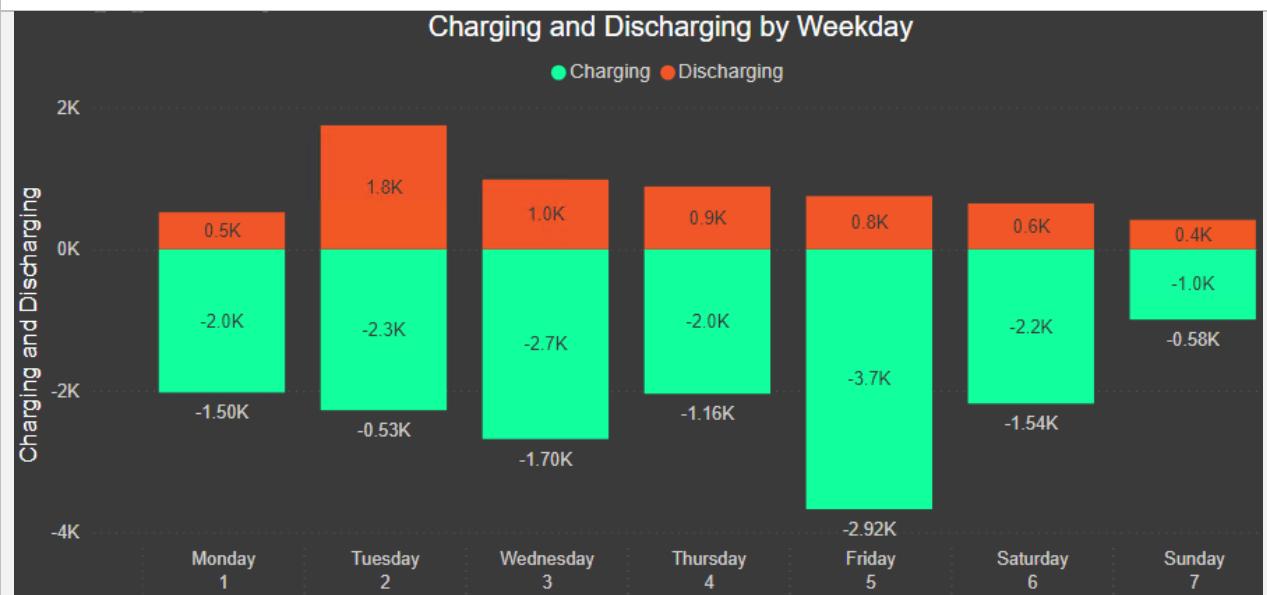
### 8.1.3 Charging and discharging patterns by weekdays in a month



**July**



**Overall Trend**



There is no set pattern for the common charging or discharging of weekdays in months. For the month of May, maximum consumption happens on Tuesday and Friday, while in June, it's on both Tuesday and Wednesday. For July, it's mostly charging.

Overall, Tuesday is the day when discharging happens mostly.

#### 8.1.4 Correlation between charging and discharging times

##### Interpretation of the Correlation Coefficient:

- **1:** Perfect positive linear relationship.
- **0:** No linear relationship.
- **-1:** Perfect negative linear relationship.

The correlation between the positive readings (discharging) and negative readings (charging) in the entire dataset is approximately **0.036**. This indicates a very weak positive correlation, suggesting that there is almost no linear relationship between the discharging and charging events of the battery.

##### Interpretation:

- **Operational Independence:** This very weak correlation implies that the charging and discharging activities of the battery are largely independent of each other. This could mean that the battery is being charged and discharged based on external grid demands rather than following a specific pattern.
- **Grid Support:** The battery might be used to support grid operations in a more dynamic and flexible manner, charging when excess power is available and discharging when there is demand, without a strong link between the two actions.

This insight suggests that the battery is likely being used in a responsive manner to the needs of the grid rather than following a fixed charging/discharging schedule.

## 8.2 Report on London Hydro Solar panels (Sample of 3)

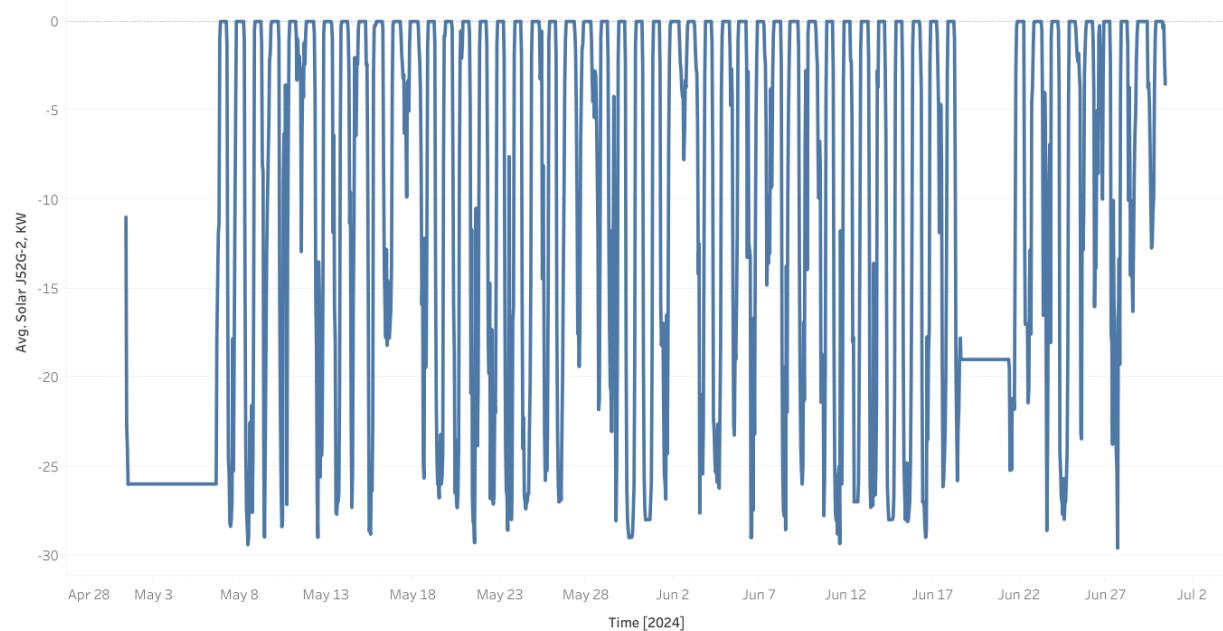
In the graphs below, we see data from London LDC for three solar panels.

1. Solar\_J52G-2
2. Solar\_N52G-1
3. Solar\_M46G-1

The solar panel Solar\_J52G-2 reads negative values only, while the other two report positive values. All the panels report readings from May to June. Though the Solar\_J52G-2 reports negative values, its pattern is quite similar to the other two solar panels if negative values are considered as a generation for this panel only.

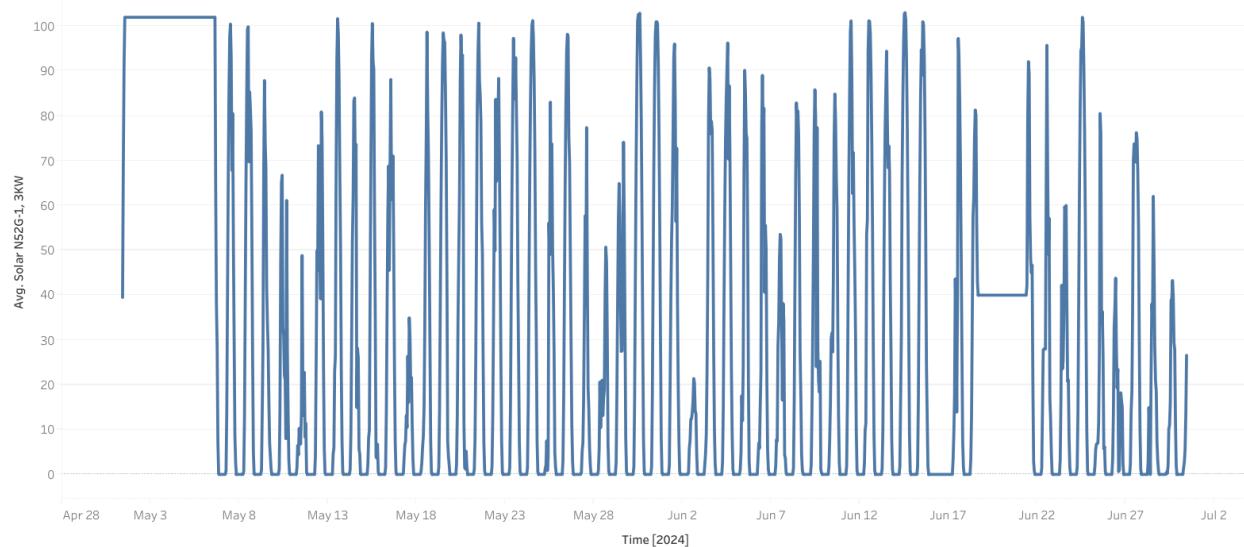
**Figure 7 | May and June reading for Solar\_J52G-2**

Sheet 3



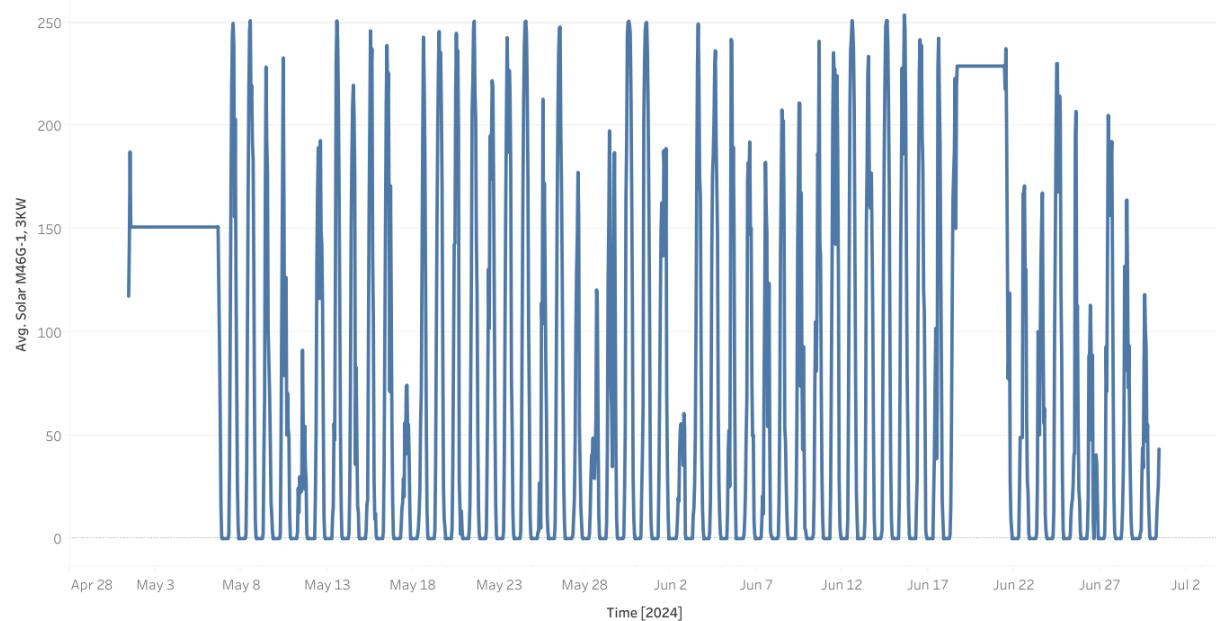
**Figure 8 | May and June readings for Solar\_N52G-1, 3KW**

Sheet 1



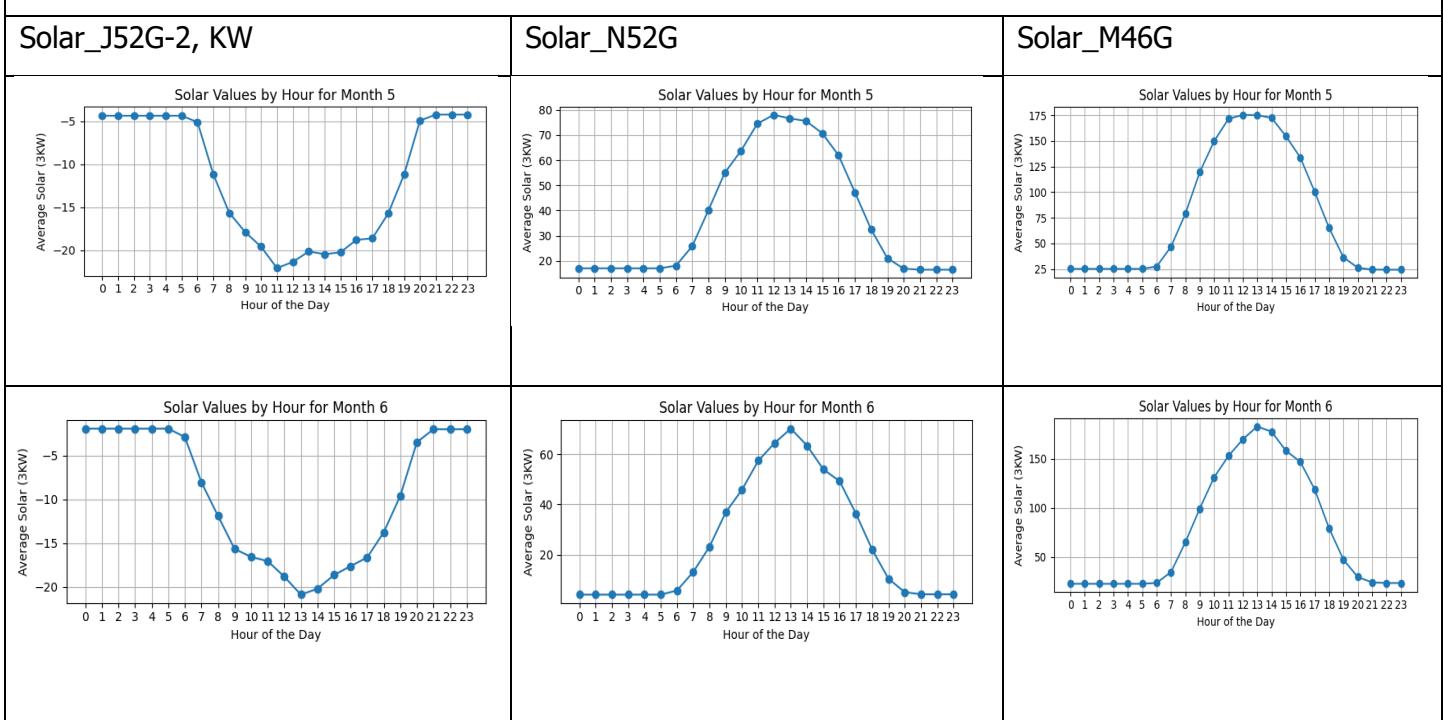
**Figure 9 | May and June readings for Solar\_M46G-1, 3KW**

Sheet 2



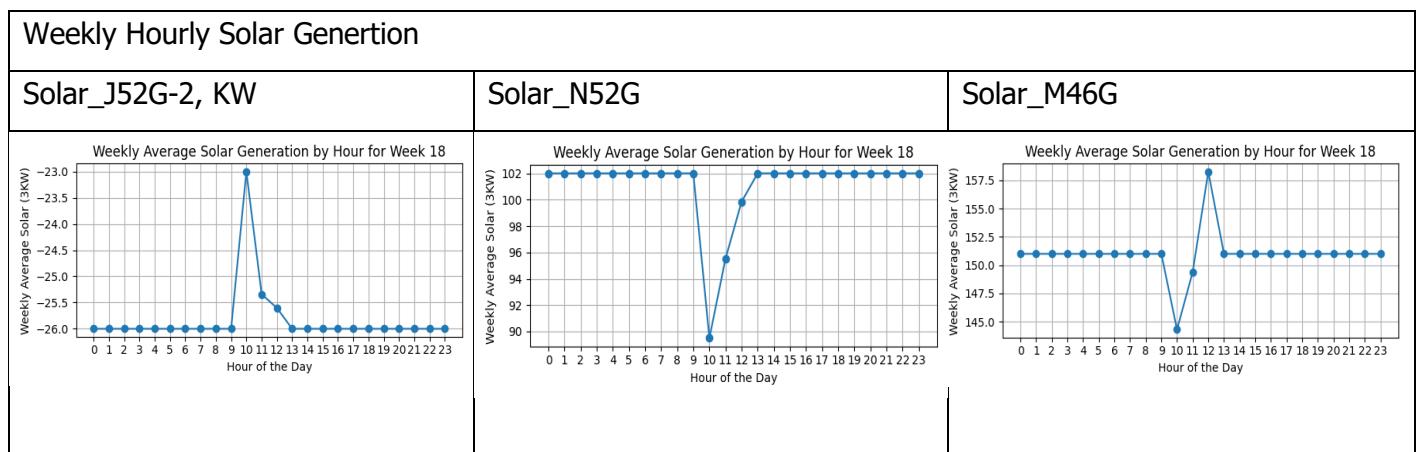
From the above graphs, we can see that the reading remained constant from June 18 to June 21, though the quantitative value was different for all three.

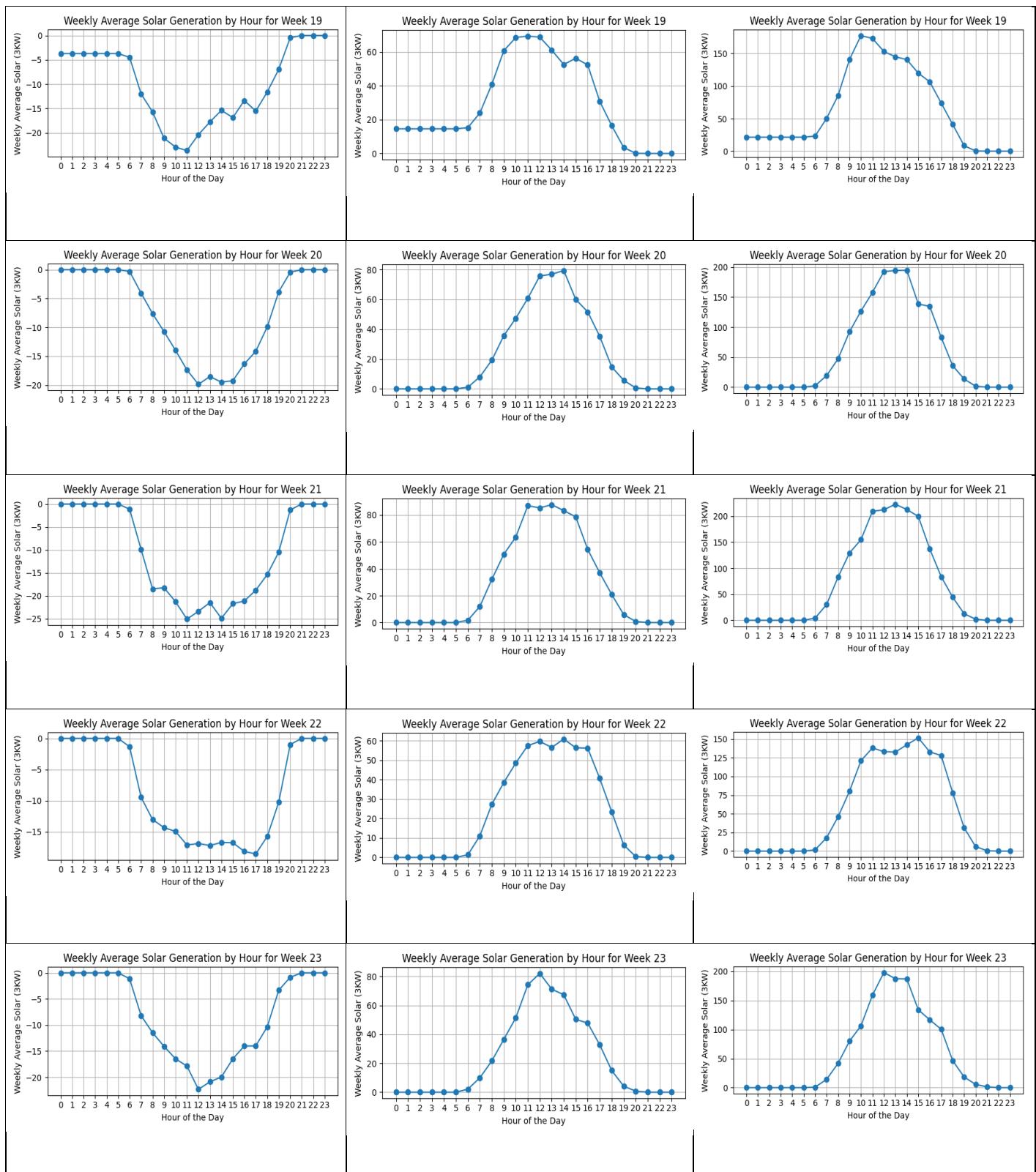
## Month wise hourly plot for generation

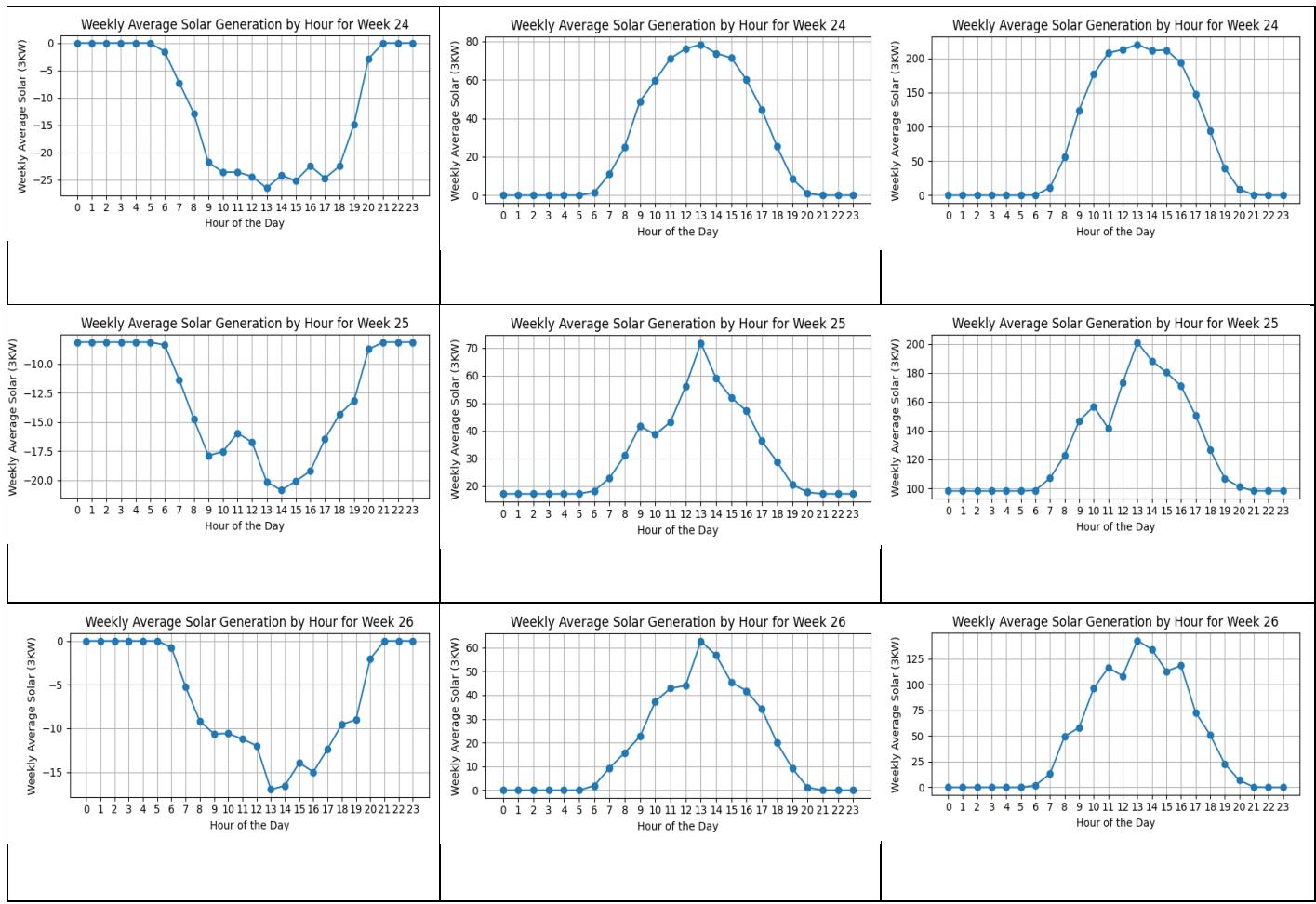


From the above table, we can see the comparison for the generation hourly for each month among the available panels. It is observed that the shape of the bell curve is similar for the solar panels Solar\_N52G and Solar\_M46G. On the other hand, the shape of the bell curve for Solar\_J52G-2, KW is inverted and not flat for the month of May, but the generation hourly is very similar if we consider -ve as power generated. It starts with readings close to zero but increases as the day goes on and decreases starting the 13th hour of the day.

Next, we will look at the hourly generation by weeks.







From the above hourly comparison by week, we can see the pattern is similar for all three panels, considering solar Solar\_J52G-2, KW -ve equated to generation. The day starts with the lowest generation and reaches its peak around 13 th hour and reduces the generation after that. It is also interesting to observe that the bends in curves are also similar among all the solar panels.

Below is the count of days when hours showed positive generation without sunlight (Hours:10 pm,11 pm, 12 am, 1 am,2 am)

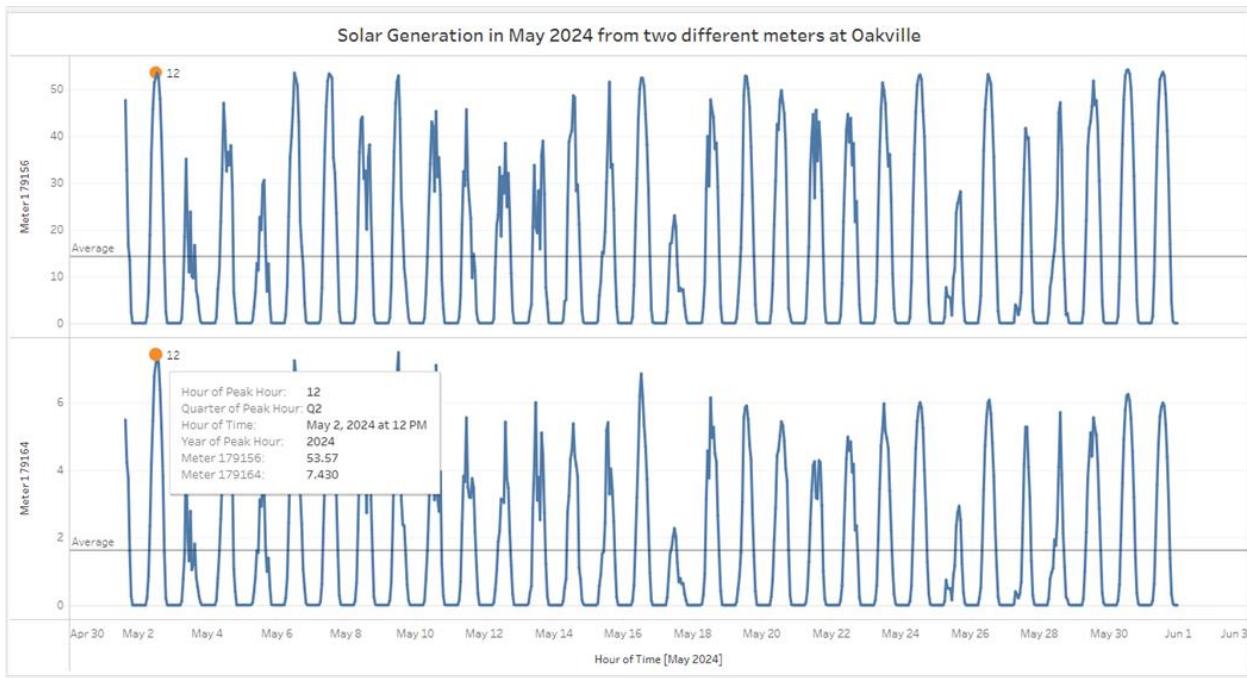
Hours with no sunlight showing non-zero data related to generation								
Solar_J52G-2, KW			Solar_N52G			Solar_M46G		
Month	Hour	Count <=-1	Month	Hour	Count >=1	Month	Hour	Count >=1
5	0	5	5	0	5	5	0	5
5	1	5	5	1	5	5	1	5
5	2	5	5	2	5	5	2	5
5	21	5	5	21	5	5	21	7
5	22	5	5	22	5	5	22	5
5	23	3	5	23	5	5	23	5
6	0	3	6	0	3	6	0	3
6	1	3	6	1	3	6	1	3
6	2	3	6	2	3	6	2	3
6	21	3	6	21	3	6	21	11
6	22	3	6	22	3	6	22	3
6	23	5	6	23	3	6	23	3

From the above, we can see there were some discrepancies in the reading when the solar panels reported positive readings even without the sun.

In Summary, all three solar panels mostly reported maximum generation during the 13th hour of the day. For Solar\_J52G-2, KW negative values mean generation, and their generation pattern is also similar. Things that need clarification further are the days where we received generation without sun

### 8.3 Report on meter data for solar assets in Oakville

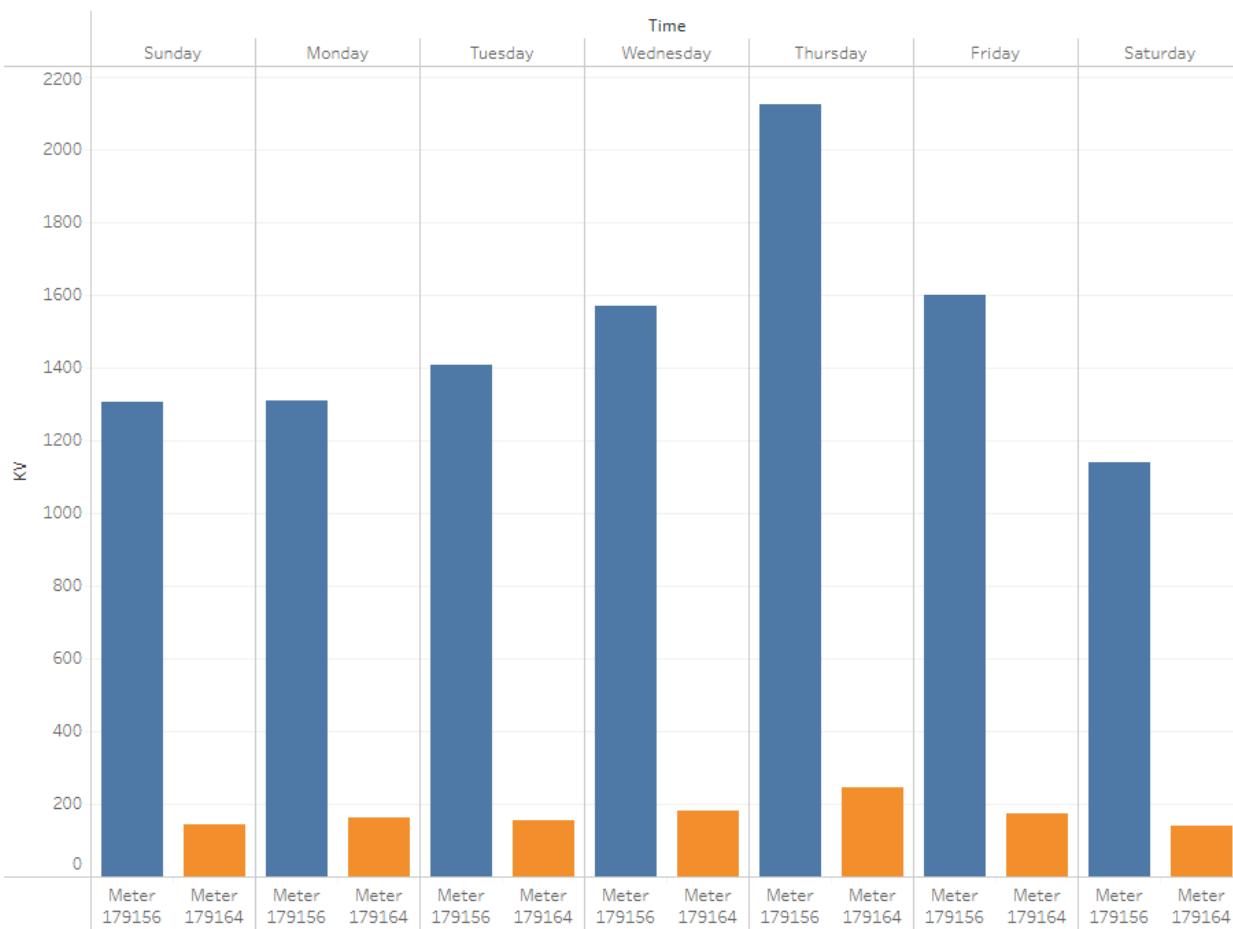
Solar Energy Generation Overview for May 2024, as shown below.



The graph presents meter readings from two distinct solar assets in Oakville for May 2024. The peak energy output for both meters occurred on May 2nd, 2024, at noon. Additionally, the data indicates reduced energy generation on May 7th and May 25th. The generation patterns observed in both meters are consistent with each other, suggesting similar operational behaviors or environmental conditions impacting both assets in the same way.

### 8.3.1 Analysis of total solar generation for May 2024 categorized by days of the week

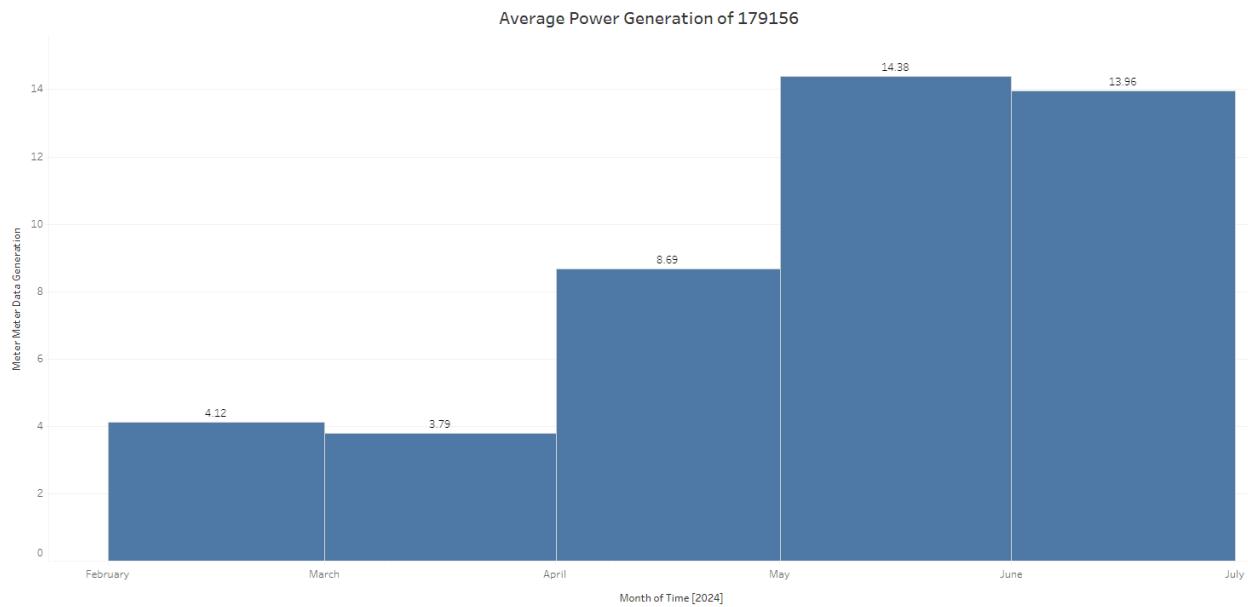
Weekly Solar Generation Analysis for Meters 179156 and 179164 - May 2024



The analysis of total power generation in May 2024 for meters 179156 and 179164 reveals a significant disparity in energy usage across the days of week. Meter 179156 consistently records higher consumption, with its peak on Thursday at 2,123.3 representing a **52% increase** compared to its lowest consumption of 1,138.9 units on Saturday. In contrast, Meter 179164, which consistently shows lower consumption, peaks on Thursday at 243.6 units, a **72% increase** from its minimum value of 141.4 units on Saturday. This analysis highlights the substantial variance in energy usage patterns between the two meters, with Meter 179156 showing a more pronounced fluctuation in consumption.

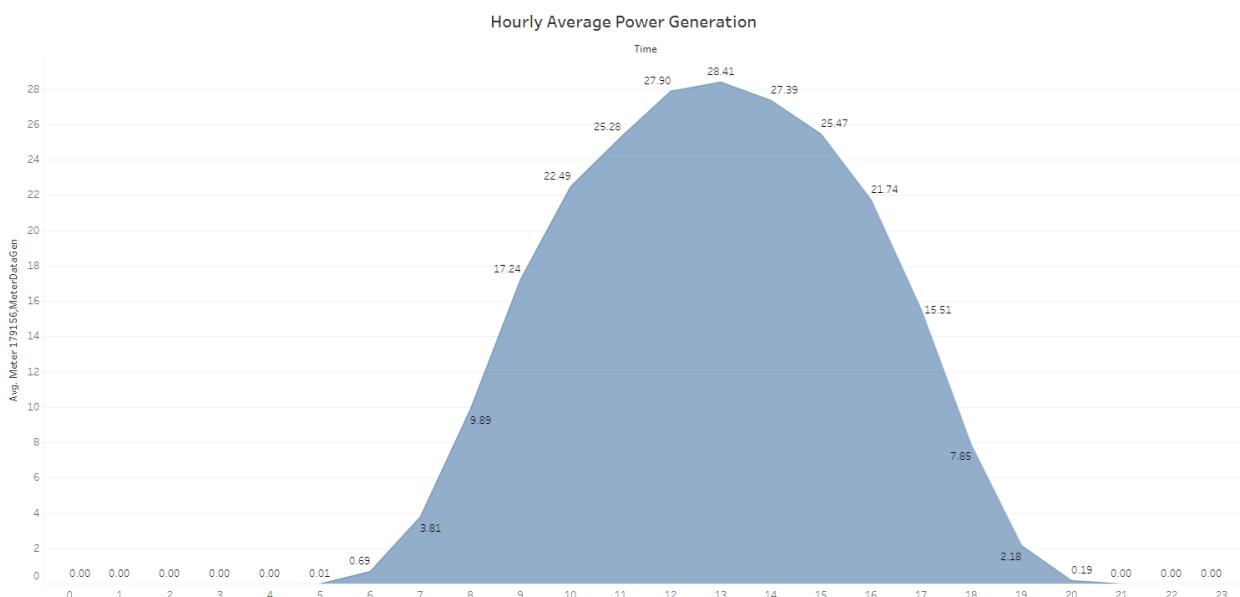
It is assumed that the generation data provided here reflects the net amount after load consumption recorded in the meter. Higher solar energy generation on Thursdays suggests that load consumption on those days is lower compared to weekends.

### 8.3.2 Average Power Generation of Meter 179156 for Oakville from February 2024 till June 2024



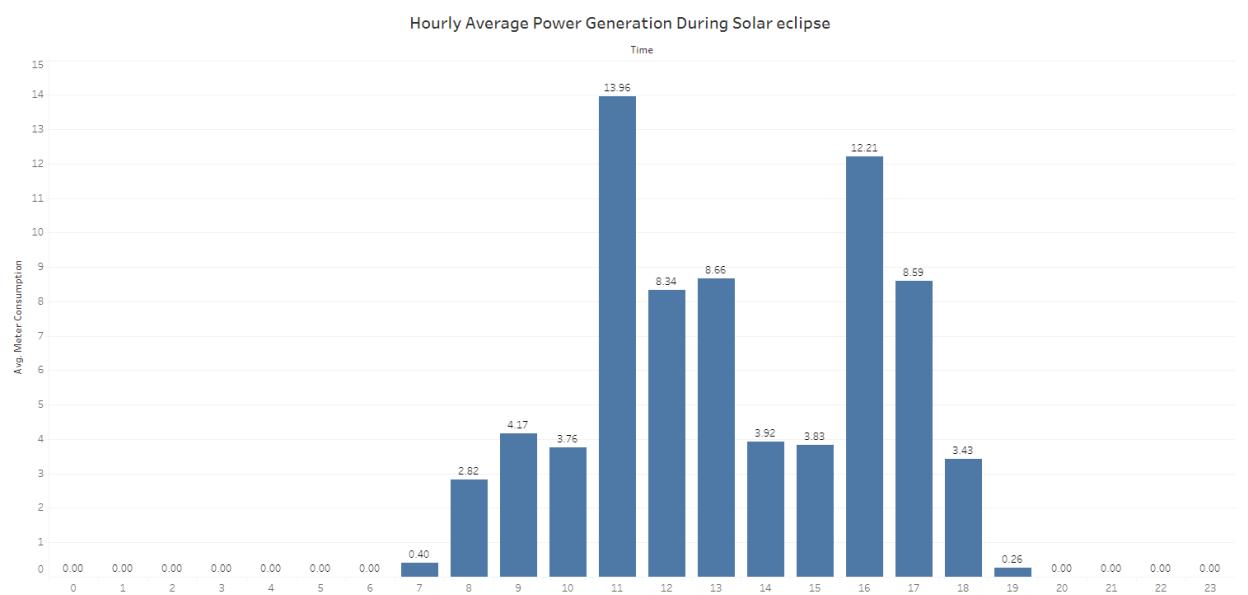
Meter 179156 demonstrates a progressive increase in power generation from February to July 2024, with the most dramatic rise occurring between April and May (109% increase). This trend suggests a growing capacity for power generation during this period, culminating in a nearly threefold increase from February to July.

### 8.3.3 Hourly Average Power Generation of Meter 179156 for Oakville from February to June 2024



The hourly average distribution graph for Meter 179156 reveals a bell-shaped curve, with peak power consumption occurring between 12 PM and 1 PM. This suggests that solar power generation is most efficient during this time, likely due to optimal sunlight conditions. The curve illustrates a clear midday peak, indicating that the solar panels are capturing the maximum amount of sunlight during this hour, leading to the highest power output. This insight can be used to optimize energy usage and further investigate factors contributing to peak generation times.

### 8.3.4 Hourly Power Generation Analysis for Meter 179156 on April 8, 2024: Impact of Solar Eclipse



The hourly average power generation data for Meter 179156 on April 8th, 2024—a day of a solar eclipse—reveals a notable drop in solar power generation from 12 PM to 3 PM. The data shows a decline in generation from 13.96 kW at 11 AM to a low of 3.83 kW by 3 PM. This decrease corresponds with the eclipse period, where generation dropped significantly from 12 PM (8.34 kW) to 1 PM (8.66 kW) and further declined to 3.92 kW at 2 PM and 3.83 kW at 3 PM. The power generation then rebounded to 12.21 kW by 4 PM. This pattern illustrates the direct impact of the solar eclipse on solar power generation, highlighting the temporary reduction in sunlight and its effect on energy output.

- Decline from 11 AM to 12 PM: Approximately 40.2%
- Increase from 12 PM to 1 PM: Approximately 3.8%
- Decline from 1 PM to 2 PM: Approximately 54.7%
- Decline from 2 PM to 3 PM: Approximately 2.3%
- Recovery from 3 PM to 4 PM: Approximately 218.5%

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