# Benchmark 8760 Initiative

Seeding the Evolution of Benchmarking and Performance Standards
New York, New York

## Final Report

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# 1 Executive Summary: Benchmark 8760 Initiative

This executive summary provides a comprehensive overview of the Benchmark 8760 Initiative, a NYSERDA-funded research project funded through the Innovative Market Strategies (IMS) Program Opportunity Notice (PON). Led by JB&B, the project aimed to develop a proof-of-concept cloud-based data platform capable of collecting and securely storing hourly electricity, occupancy count, local GHG-intensity, and weather data for the purposes of benchmarking and building performance evaluations. The findings, outcomes, and market implications of the initiative are summarized below.

## 1.1 Project Approach

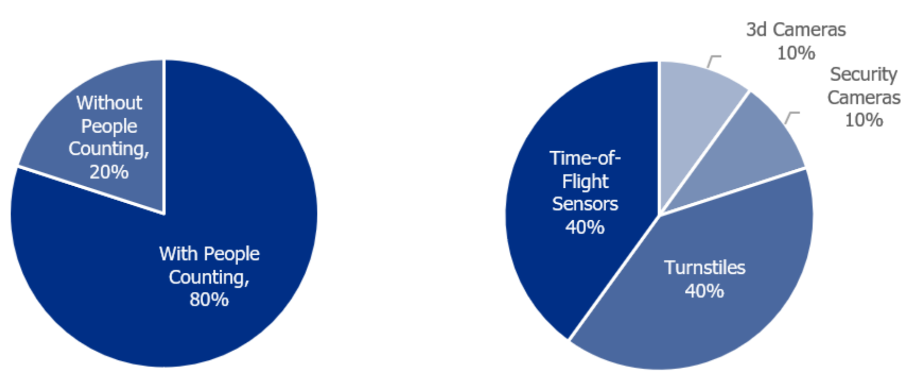
The project team focused on creating a cloud-based data platform capable of ingesting and storing hourly data from ten (10) commercial buildings in New York City. The platform aimed to test the feasibility of obtaining these data accurately, securely, and in a privacy-protected manner. Scalability and affordability of data collection were also key considerations.

In developing the Benchmark 8760 Platform, the project team closely aligned with the EPA's Energy Star Portfolio Manager (ESPM) Platform, adopting its data structure, system architecture, and transfer schema. This approach positions the project's codebase as a potential foundation for future iterations of ESPM, including the integration of hourly data for benchmarking. Additionally, JB&B conducted a comprehensive evaluation of the technical feasibility of evolving ESPM's architecture to support hourly data benchmarking.

## 1.2 Key Findings

- Hourly building electricity and occupancy data be extracted and stored in a vendor-neutral manner: The project team built four (4) standard hourly energy integrations and five (5) standard people counting integrations that can scale to other commercial buildings and allow for a wide range of sophistication in building IT and security infrastructure. Moving forward, we believe there is a pathway for vendors to develop APIs that deliver data per a pre-specified format.
- Hourly occupancy data be captured affordably and at scale: 80% of properties participating in Benchmark 8760 were able to use existing access control infrastructure such as security cameras or turnstiles to capture hourly occupancy. Building Owners can minimize the cost of installing and maintaining a new occupancy counting solution by collecting whole-building data and using in-house staff to mount hardware and run low voltage cabling.

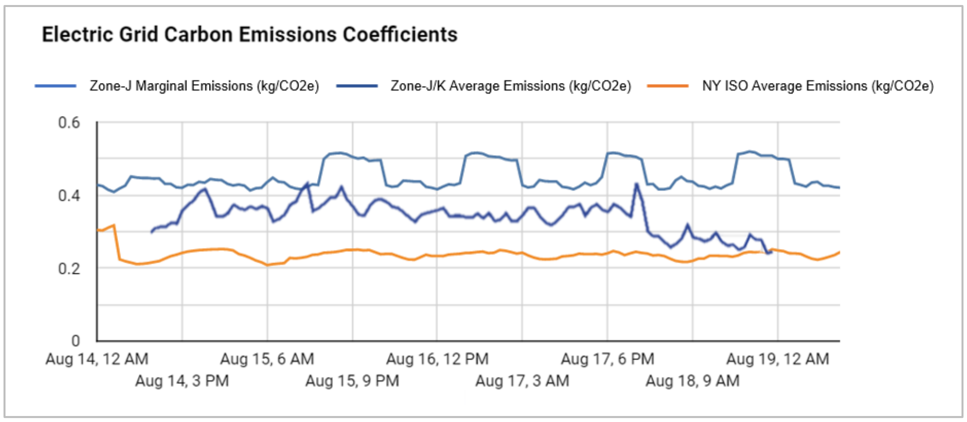
*Figure 1: Breakdown of Properties with Existing Occupancy Counting Solutions*




- Capturing hourly occupancy data does not necessarily infringe on personal privacy: There are several people counting devices that do not capture personally identifiable information (PII) and are readily available to the commercial market. 90% of properties participating in Benchmarking 8760 use people counting devices that do not capture PII.

- Hourly occupancy data can be securely stored and shared with a cloud-based data platform: Many occupancy counting vendors already have certified cyber security postures. All occupancy counting solutions deployed in Benchmark 8760 participating properties meet industry cyber security standards and the individual requirements of each building's IT team.
- Data from diverse hardware solutions and buildings typologies can be stored in a common cloud-based platform: Benchmark 8760 data integrations organize and standardize data into a format that is consistent with how the EPA's ENERGY STAR Portfolio Manager represents interval data. All data is stored in this common format within the Benchmark 8760 Platform.
- It is possible to calculate hourly average zone-specific grid emissions data for benchmarking: Benchmark 8760-contributor, WattTime, calculated Zone-J + Zone-K average hourly emissions using NYISO data sets and publicly available information on NY electricity imports and exports. While imperfect, WattTime's work proves that hourly average emissions data can be calculated and used for carbon accounting, rather than marginal emissions data.

*Figure 2: Electricity Grid GHG Intensity Metrics from Benchmark 8760 Platform*




- It is technically feasible to evolve existing benchmarking platforms like ENERGY STAR Portfolio Manager to use hourly building data: Portfolio Manager has a flexible architecture and adding new kinds of data, such as occupancy or grid emissions intensity, is achievable. EPA would need to redevelop existing data ingestion, validation, storage, and processing pipelines – a costly effort; however, a phased multi-year approach to this work is technologically feasible and can be orchestrated to manage costs and minimally impact the monthly-oriented features presently supported.

## 1.3 Key Project Outcomes

The lessons learned from the initiative were shared with policy Stakeholders, research organizations, academics, and Building Owners to promote knowledge exchange and best practices. The source code for the cloud-based data platform was released to the public through the open-source platform, GitHub, to foster further collaboration and innovation. In support of standardization efforts, JB&B convened a data standards advisory group of nine (9) occupancy counting vendors who committed to working towards standardizing building occupancy data. JB&B also applied for follow-on funding from the Department of Energy (DOE) to sustain and expand the project's impact.

### 1.4 Key Market Implications

The findings of the Benchmark 8760 Initiative provide valuable insights to Building Owners, policymakers, Design Engineers, and building data vendors interested in advancing benchmarking and building performance standards through hourly data. Key market implications include:

- Building Awareness and Knowledge: Benchmark 8760 addresses the market barrier of public officials' limited understanding of collecting hourly data and technological advancements in big data. By building a Proof of Concept (POC) platform that collects and hosts various types of hourly data, the project demonstrates the feasibility and potential of leveraging technology for comprehensive data collection. Sharing the platform's code and specifications with relevant stakeholders, such as the EPA, promotes knowledge sharing and helps to fill the gaps between existing benchmarking platforms and the Benchmark 8760 Platform abilities.
- Empowering Occupancy Data Collection: The market barrier of limited availability of hourly occupancy data is addressed in this project through the installation of occupancy counting technologies in multiple commercial buildings. By implementing these technologies and developing standards and recommendations for affordable, accurate, scalable, and privacy-protecting occupancy counting, the project enables Real Estate Owners to overcome concerns related to cost, technical complexity, and privacy. This empowers Building Owners to access valuable occupancy data for improving the predictive control of building systems and enhancing overall building performance.
- Granular Carbon Intensity Data: The project tackles the market barrier of the absence of hourly carbon intensity data for New York City's power supply. By commissioning an API of such data from WattTime, the project fills this gap and creates a model for other jurisdictions to follow. This development provides buildings with the tools they need to be more responsive and make informed decisions regarding their energy consumption. The availability of granular carbon intensity data enhances the accuracy and effectiveness of energy management strategies and facilitates the adoption of more sustainable practices.

These implications contribute to the advancement of building performance evaluation, informed policy development, improved design engineering, and new opportunities for building data vendors.

### 1.5 In Conclusion

The Benchmark 8760 Initiative successfully achieved its objectives of developing a cloud-based data platform to test the feasibility of using hourly data for benchmarking and building performance standards. Through the project, the team was able to demonstrate that collecting accurate, secure, and privacy-protected hourly data is possible, laying the groundwork for advancements in building performance evaluation methods.

JB&B would like to thank to project partners for their contributions and collaboration. Their expertise and commitment played a significant role in the success of Benchmark 8760. Additionally, we extend our appreciation to NYSERDA for their support and funding, which made this project possible.

## 2 Overview

### 2.1 Background

The U.S. faces a significant affordability challenge in meeting its decarbonization commitments. Buildings are one (1) of the largest energy users, and without the adoption of grid-interactive efficient building (GEB) technologies to manage building demand, investments in new grid infrastructure and renewable energy capacity will be substantial.

The importance of managing demand on the bulk power system is paramount. In a recent study, the Brattle Group notes that the U.S. power supply has over 200 GW of cost-effective load-flexibility potential that could defer over $15 billion in generation, ancillary services, transmission, and distribution costs through 2030. This load flexibility potential represents 20% of the U.S. peak.[1]

Buildings will play an important role in tapping this load flexibility potential. Buildings are the nation's primary users of electricity: 75% of all U.S. electricity is consumed within buildings and building energy use drives a comparable share of peak power demand.[2] With proper communications and controls, flexible building loads can be managed to reduce stress on the grid, while still meeting occupant productivity and comfort requirements. A variety of technologies are available to intelligently manage a building's energy demand with load flattening, shifting, and shaping strategies that respond to dynamic grid conditions. While successfully deploying these technologies at scale is important, there is a more fundamental issue that must be addressed first: governing bodies and the wider building industry currently lack a mechanism by which to assess if buildings are using grid-interactive efficient features.

Existing building performance assessment methodologies and metrics–notably ENERGY STAR Portfolio Manager (ESPM) and Building Performance Standards such as NYC's Local Law 97 (LL-97), do not assess when a building uses energy, nor do they collect the GHG-intensity of available power. As a result, the real estate community is not being effectively incentivized to invest in the Grid-Interactive Efficient Buildings (GEB) technologies needed to manage building demand. The solution to this key issue is to evolve existing building performance assessment methodologies to use hourly data.

## 2.2 Project Summary

To explore the feasibility of collecting and sharing hourly data with a cloud-based benchmarking platform, Jaros, Baum and Bolles (JB&B) launched Benchmark 8760, a cross-industry initiative to explore how hourly data can improve building benchmarking to be more precise, fair, and actionable in support of an affordable, resilient, and low-carbon future.

With funding from the New York State Research and Development Authority (NYSERDA), Benchmark 8760 developed a proof-of-concept (PoC) cloud-based Hourly Building Data Platform that collects hourly electricity and building occupancy-count data from buildings and ingests an hourly GHG-intensity for the local power supply and weather data.

Benchmark 8760 contributors included committed Partners and advisors who represent the depth of market interest in our mission to evolve building assessment methods to use hourly data.

*Figure 3: Benchmark 8760 Project Team*

Through the process of building the Benchmark 8760 Platform, the project team explored the most affordable, scalable, and secure means of collecting this data from a sample of ten (10) Class A and Class B commercial buildings in New York City. Additionally, the project team tested an hourly average GHG-intensity calculation for the NYC grid that can be replicated by other cities and jurisdictions. Data visualizations demonstrating the successful collection of hourly data are available on https://benchmark8760.org/.

1 Ryan Hledik, Ahmad Faruqui, Tony Lee, and John Higham, National Potential for Load Flexibility, Value and Market Potential through 2030, The Brattle Group, June 2019.

2 Jared Langevin et al., U.S. building energy efficiency and flexibility as an electric grid resource, Joule, Volume 5, Issue 8, 2021, Pages 2102-2128.

In addition to the Benchmark 8760 platform, the project team shared the platform technical specifications with policymakers around the country, and the public via the open-source platform, GitHub. The project also served to prime the market for wider-scale adoption of people-counting technologies by creating and sharing recommendations, guidelines, and best practices for the affordable, accurate and privacy-protecting collection of hourly occupancy counts from buildings.

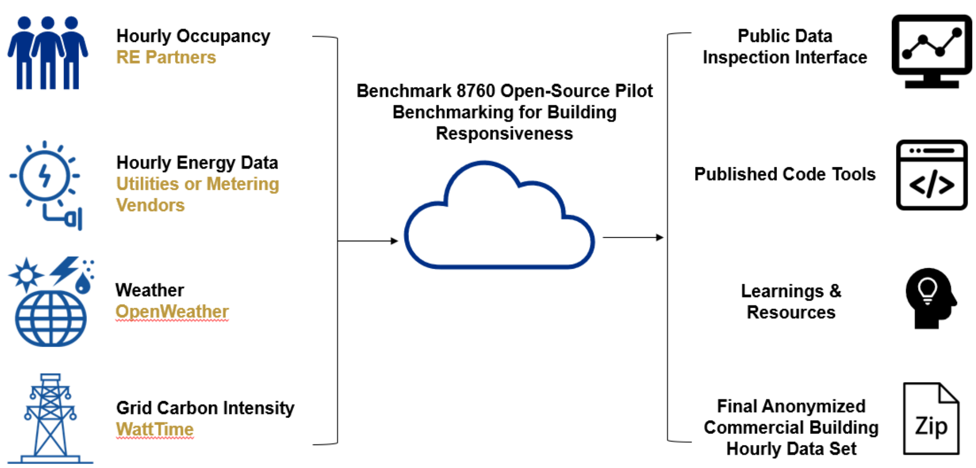
# 3 Project Development

The creation of the Benchmark 8760 Platform consisted of three (3) components:

- Data Sources
  - Hardware Systems - Sources of data physically installed in the building, such as electricity meters and occupancy counting technology.
  - Weather and Grid Intensity Data Sources – Cloud integration to third party data platforms.
- Data Extraction Pathways – Methods of data transfer from the data sources to the software platform, such as manual upload of CSV (Comma Separated Variable) files, RESTful APIs (Application Programming Interface), and SFTP (Secure File Transfer Protocol) servers.
- Cloud-based Software Platform – Created using Google Cloud and associated tools for secure data transformation, storage, and visualization.

A high-level concept of the hourly data platform as shown below in Figure 4.

*Figure 4: Benchmark 8760 Concept Diagram*




A building-by-building description of Data Sources and Data Extraction Pathways is shown below in Table 1.

*Table 1: Data Sources and Extraction Pathways*

| Property | Real Estate Partner | Building Typology | Building Size (Stories) | Building Size (Sq. ft.) | People Counting | | | Energy Metering | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Hardware | Data Extraction Method | PII Collected | Hardware | Data Extraction Method |
| Building 1 | Brookfield Properties | Class A Commercial | 15 | 550,000 | 3D Camera (Existing) | Vendor-Agnostic Middleware API (Nantum/Haystack) | Video | Con Ed Smart Meter (Existing) | Vendor-Agnostic Middleware API (Nantum/Haystack |
| Building 2 | Brookfield Properties | Class A Commercial | 67 | 1,850,000 | Security camera (Existing) | Vendor-Provided Custom Integration (HTTP POST) | Video | Con Ed Smart Meter (Existing) | Vendor-Agnostic Middleware API (Willow Twin) |
| Building 3 | Hines | Class A Commercial | 18 | 1,100,000 | Turnstile (Existing) | Manual Upload | None | Con Ed Smart Meter (Existing) | Email from BMS |
| Building 4 | Hines | Class A Commercial (Tenant Floors) | 4 | 200,000 | Time-of-Flight (New) | Vendor-Provided API (Density) | None | Satec Submeter (Existing) | Email from BMS |
| Building 5 | Rudin Management | Class A Commercial | 44 | 1,900,000 | Turnstile (Existing) | Vendor-Agnostic Middleware API (Nantum/Haystack) | None | Con Ed Smart Meter, Various Submeters (Existing) | Middleware API (Nantum/Haystack) |
| Building 6 | SL Green | Class A Commercial | 30 | 2,200,000 | Time-of-Flight (Existing) | Vendor-Agnostic Middleware API (iES Mach) | None | Con Ed Smart Meter, iES Submeters (Existing) | Con-Ed Share-My-Data API |
| Building 7 | Tishman Speyer | Class A Commercial | 40 | 1,350,000 | Turnstile (Existing) | SFTP | None | Con Ed Smart Meter, Acquisuite Submeters (Existing) | Con-Ed Share-My-Data API |
| Building 8 | Two Trees | Class B Commercial | 13 | 350,000 | Time-of-Flight (New) | Vendor-Provided API (Irisys) | None | Con Ed Smart Meter (Existing) | Con-Ed Share-My-Data API |
| Building 9 | Two Trees | Class B Commercial | 12 | 500,000 | Time-of-Flight (New) | Vendor-Provided API (Irisys) | None | Con Ed Smart Meter (Existing) | Con-Ed Share-My-Data API |
| Building 10 | Vornado Realty Trust | Class A Commercial | 57 | 2,600,000 | Turnstile (Existing) | SFTP | None | Con Ed Smart Meter SourceOne Submeters (Existing) | Manual Upload |

## 3.1 Data Sources: Hardware Systems

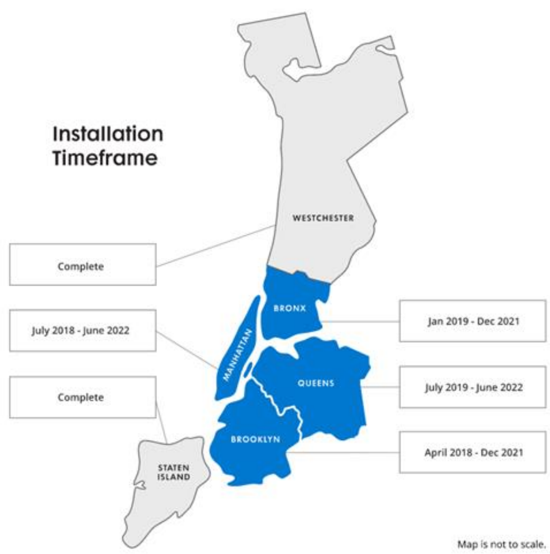
To collect hourly electricity and people count data from each building, hardware meters capable of gathering the required information were necessary. At the beginning of the project, the project team surveyed each building's existing metering infrastructure to determine the suitability of existing electricity meters and occupancy counters for data collection. In cases where new meters were needed, JB&B provided design specifications and facilitated their installation. Through a thorough review of site drawings, discussions with building staff, and on-site visits, JB&B gathered the necessary information to determine, and where needed deploy, the appropriate sources for data collection.

### 3.1.1 Electricity Meters

For accurate measurement of hourly electricity consumption, revenue-grade smart meters are the preferred choice. These meters offer a high level of accuracy and communication capabilities, making them ideal for benchmarking purposes. Revenue-grade meters meet the requirements for billing and have an accuracy of 0.5% or higher.

All ten (10) properties involved in the project already had suitable electricity metering systems in place. Nine (9) of them utilized Con Ed utility smart meters, either alone or in combination with building submeters. Con Ed has been actively implementing smart utility meters since 2017, and as this report issuance, over 5 million of these meters have been installed across New York City and Westchester County (refer to Figure 5). Additionally, one (1) group of Tenant Floors used building-installed submeters from EcostruXture.

*Figure 5: Con Edison Smart Meter and Con Edison Smart Meter Rollout Schedule*

**Requirements and Priority Items from Real Estate Partners:**

- Because all properties had existing meters, there were no installation requirements from real estate partners. Existing Con Ed smart meter rollouts, in addition to laws such as Local Law 84 requiring building submetering have created multiple sources of electricity meter data in commercial buildings in NYC.
- Direct Metering: Some large Tenants are directly metered by Con Ed, with the building not able to access the Tenant's electricity usage data. Following standard benchmarking practice, the project team subtracted the square footage of the directly metered Tenants from the building square footage.

### 3.1.2 People Counting Meters

People counters are devices that measure the number of people entering and exiting a specific location, such as doorways or elevator bays.[3] These devices are strategically deployed at relevant entrances and exits to provide real-time updates on the occupancy of a space. The scope of measurement can vary, ranging from a specific zone, room, floor, set of floors, or even the entire building, depending on the configuration of entrances, exits, and people counting devices.

Out of the ten (10) participating properties, eight (8) already had occupancy-counting hardware in place. Among these, two (2) locations had standalone occupancy counting sensors, such as Irisys time-of-flight sensors, while four (4) utilized pre-existing turnstiles. One (1) building made minor software modifications to its existing security camera system to capture hourly occupancy data, and another utilized a 3D camera designed specifically for people counting. The remaining two (2) locations required the installation of new people counting hardware. In both cases, time-of-flight sensors were selected and installed at minimal cost to the Owner.

Unlike electricity metering, there are no official standards available for evaluating the quality and accuracy of people counting solutions. Therefore, the project team needed to conduct a thorough review of various people counting solutions' specifications to ensure they met project requirements and to pave the way for wider adoption of these technologies. JB&B evaluated ten (10) common people counting solutions and, when new installations were necessary, selected those with a manufacturer-verified accuracy of 95% or higher.

To streamline the process of collecting hourly people count and align with real estate requirements for affordability and minimal disruption to building operations and Tenants, tower occupancy was used as a proxy for whole-building occupancy. JB&B confirmed this approach through a case study. In one (1) participating building, the Owner had already deployed people counting meters at all exterior doors, including service entrances and exits. The project team compared the occupancy values per square foot in this building to those where only tower occupancy was measured and determined that the differences were minor enough to justify avoiding additional costs for installing meters at these additional entrances and exits.

The installation process for newly installed people counters involved collaboration with vendors and the Owner to determine the optimal placement of devices and routing of communication cables (CAT6). These cables were connected to a pathway out of the building and onto the public internet, typically through a server, switch, or other receptacles located in the BMS Room or IT closet. The project team obtained quotes from on-site Electrical or Low Voltage Contractors and managed the project. Post-installation, the team actively conducted verification and promptly addressed any identified issues. For instance, when the occupancy data seemed unrealistically low, the team discovered outdated API documentation for the building intelligence platform. They collaborated

3 Some people counting device require special enablement for exit count.

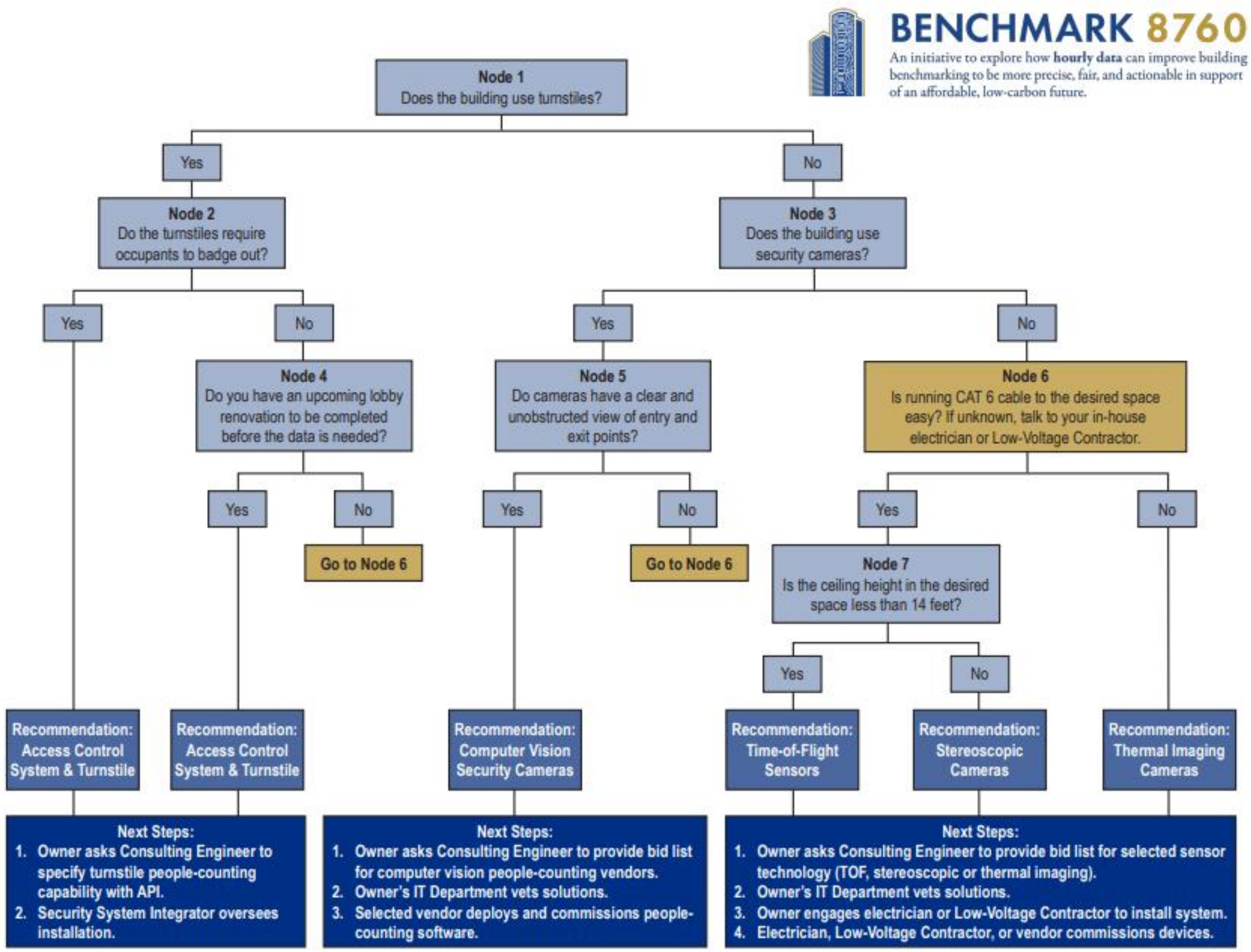
closely with the building team and Contractor to review the sightlines of the occupancy counters and successfully resolved the API-related issue.

**Requirements and Priority Items from Real Estate Partners:**

- Real estate participants identified four major barriers to wider adoption of people counting technology: privacy, security, affordability, and disruption.
- Privacy: Many occupancy counting solutions prioritize privacy and do not collect personally identifiable information (PII) or infringe on occupants' privacy. Most participating buildings in this initiative utilized non-PII collecting solutions. There is an opportunity to educate occupants and building professionals about the low-risk nature of people counting technologies.
- Security: Perceived security risks associated with people counting technologies are often exaggerated. Large real estate firms typically possess in-house resources and expertise to manage risks when adding new devices to their IT networks. Smaller firms may require assistance from third parties to ensure the installation of secure people counting solutions. A future hourly benchmarking platform could maintain a list of people counting vendors with certified cybersecurity postures.
- Affordability: Buildings with simple rectangular lobbies can capture whole-building people counts with minimal hardware. The number of sensors required increases with the number of entrances. Labor costs can be minimized by utilizing in-house staff for cable routing. Incentives and rebates, such as those offered in the NYSERDA RTEM program, can further reduce costs.
- Disruption: Installing ceiling-mounted people counters often involves drilling into ceilings and running CAT6 cables from the counters to switches or servers. This construction process can disrupt the Tenant experience in the Lobby. In cases where ceilings hold architectural or historical value, using turnstiles or security camera computer vision is a more appropriate solution.

### 3.1.3 Building Owner Decision Tree

The decision tree below was created by the Benchmark 8760 team to streamline the decision-making process for building teams when considering a people counting solution.



## 3.2 Data Sources: Weather and Grid Carbon Intensity

The Benchmark 8760 team successfully integrated WattTime and OpenWeather into the cloud-based Benchmark 8760 Platform. This was achieved using RESTful APIs, which allowed the team to seamlessly connect to these external databases and retrieve the data needed.

Every hour, grid emissions and weather characteristics are stored in the data warehouse. The scheme for these measurements is shown below.

*Figure 6: Data Warehouse Snapshot*

| Field name | Type | Mode | Policy Tags | Description |
|---|---|---|---|---|
| measurement_id | INTEGER | REQUIRED | energy_performance_tag_taxonomy_ : Public | Measurement identifier, internal and autoincrement |
| ref_hour_id | INTEGER | REQUIRED | energy_performance_tag_taxonomy_ : Public | Reference to hour |
| ref_participant_id | INTEGER | REQUIRED | energy_performance_tag_taxonomy_ : Public | Reference to participant responsible for the measurement |
| ref_environment_id | INTEGER | REQUIRED | energy_performance_tag_taxonomy_ : Public | Reference to an environment (group of buildings) |
| marginal_emissions | FLOAT | REQUIRED | energy_performance_tag_taxonomy_ : Project | Marginal grid emissions this hour (MOER), lbs CO2 per kWh |
| average_emissions | FLOAT | REQUIRED | energy_performance_tag_taxonomy_ : Project | Average grid emissions this hour, lbs CO2 per kWh |
| temperature | FLOAT | REQUIRED | energy_performance_tag_taxonomy_ : Project | Average ambient temperature this hour, F |
| temperature_feels_like | FLOAT | REQUIRED | energy_performance_tag_taxonomy_ : Project | Average ambient temperature real feel this hour, F |
| humidity | INTEGER | REQUIRED | energy_performance_tag_taxonomy_ : Project | Average ambient relative humidity this hour, % |
| cloudiness | INTEGER | REQUIRED | energy_performance_tag_taxonomy_ : Project | Average cloud cover this hour, % |
| wind_speed | FLOAT | REQUIRED | energy_performance_tag_taxonomy_ : Project | Average ambient wind this hour, m/s |
| wind_direction | INTEGER | REQUIRED | energy_performance_tag_taxonomy_ : Project | Average ambient wind direction this hour, degrees |
| dew_point | FLOAT | REQUIRED | energy_performance_tag_taxonomy_ : Project | Dew point, F |

Weather data were efficiently stored in a dedicated data warehouse table for this project, utilizing the OpenWeather API. Hourly metrics including air temperature, "feels like" temperature, humidity, cloud cover, wind speed, wind direction, and dew point were recorded. While all participating buildings were paired with the same weather data from New York City, the data warehouse architecture was built to allow for the integration of multiple weather sources in the future. This could include weather data from other cities, buildings with self-reporting weather stations, or public weather stations located closer to specific buildings.

To capture local electrical grid greenhouse gas (GHG) emissions intensities, the project utilized the WattTime API. A separate data warehouse table was established to store the emissions data. Like the weather data warehouse, the grid emission warehouse architecture was designed to accommodate various grid GHG emissions sources. This flexibility allows for future scenarios where hourly GHG emissions rates can be stored on a per-building basis. Buildings with on-site energy generation can then have unique and specific emissions values aligned with their fuel/energy source mix.

## 3.3 Data Extraction Pathways

Once data is collected, it must be communicated to the cloud-based software platform via a data extraction, or integration, pathway. There were a variety of integration pathways chosen for this project, based on cost, computational complexity, reliability and cybersecurity considerations.

- Five (5) methods were developed to extract hourly energy data: integration with a vendor-agnostic middleware API, vendor-specific middleware API, email from the BMS, the Con Ed Share My Data API, and a manual upload of electricity consumption log files. The most scalable and inexpensive method for Building Owners is the Con Ed Share My Data API, but all methods have merit and can securely expose and share data with the Benchmark 8760 Platform.

- Five (5) methods were developed to extract hourly people counts: vendor-agnostic middleware API, vendor-specific middleware API, manual upload, SFTP, and HTTP Post. These methods range in complexity and scalability, but all methods securely expose and share data with the Benchmark 8760 Platform.
- One (1) method was developed to extract hourly weather and grid emission data from third-party databases: RESTful API connection to data partners. This is a standard method for pulling data from cloud databases.

An important distinction for these integrations is the difference between pull and push integrations. Pull integrations occur when the Benchmark 8760 Software Platform requests data from a third-party source, such as a utility database or cloud platform. Push integrations occur when an authorized third-party uploads occupancy or electricity data in a recognized format and file type to the Benchmark 8760 Cloud Platform. This includes the manual upload option, where data collected on-site is uploaded asynchronously. The data extraction pathways as well as their classifications are shown below in Tables 2 and 3.

*Table 2: Pull Integrations*

| Real Estate Partner Name | Floor | Weather Integration Connector | Energy Integration Connector | People Count Integration Connector | Currently Used API Version |
|---|---|---|---|---|---|
| **Hines** | Floors 4, 5, 10, 16 | WattTime: Marginal – v2 Average – v2<br><br>OpenWeather – v3.0 | -- | Density | v2 |
| **Brookfield** | Whole Building | | Nantum | Nantum | Not specified |
| **Brookfield** | Whole Building | | Willow | -- | v2 |
| **Rudin** | Whole Building | | Nantum | Nantum | Not specified |
| **SL Green** | Whole Building | | Con-Ed | iES Mach | v1, v1 |
| **Tishman Speyer** | Whole Building | | Con-Ed | -- | v1 |
| **Two Trees** | Whole Building | | Con-Ed | Irisys | v1, v1 |

*Table 3: Push Integrations*

| Real Estate Partner Name | Floor | Weather Integration Connector | Energy Integration Connector | People Count Integration Connector | Currently Used File Type |
|---|---|---|---|---|---|
| Hines | Floors 4 ,5 ,10 ,16 | | EcoStruxure | -- | Excel document |
| Hines | Whole Building | | EcoStruxure | Orion | Excel, CSV (manual upload) |
| Brookfield | Whole Building | | -- | Facit | JB&B meter XML format |
| Vornado | Whole Building | | SourceOne | braXos middleware via FTP server | Dynamic HTML tables, CSV |
| Tishman Speyer | Whole Building | | -- | Orion | CSV (manual upload) |

**Lessons for Policymakers:**

- Push Integration Architecture for Scalability and Platform Owner Benefits: Adopting a push integration architecture is crucial for a scalable national hourly benchmarking platform. By shifting data retrieval responsibility to data sources, such as software-first vendors, the platform can efficiently receive data directly into a cloud bucket. This approach reduces maintenance overhead, promotes scalability, and demonstrates superior performance, resulting in reduced troubleshooting and maintenance efforts for Platform Owners and enabling sustainable and effective operations. Policymakers should recognize the advantages of push integrations in achieving these goals.
- Vendor Participation and Standardized APIs: Policymakers should establish standardized middleware APIs that define data collection requirements to encourage widespread vendor support. These APIs act as interfaces between the cloud platform and data sources, enabling vendors to offer their services and compete effectively.
- Caution with Manual Data Upload Option: While push integrations are preferred, policymakers should provide a manual data upload option when real estate cybersecurity measures restrict direct connectivity. However, rigorous controls, robust quality assurance measures, and validation processes are necessary to mitigate the risk of data loss or inaccuracies in the setup of manual data upload options.

## 3.4 Development of Proof-of-Concept Hourly Benchmarking Platform

### 3.4.1 Software Development Process

The development of the proof-of-concept hourly benchmarking platform involved several key steps:

Software Development Work Plan: The project team validated the functional requirements of the hourly Benchmark8760 Platform and devised a work plan to guide the development process.

Cloud Environment Architecture and Configuration: Cloud architecture was designed to ensure portability, reusability, scalability, and to address performance and privacy concerns specific to the project.

User Access Strategy: A comprehensive user access strategy was formulated, considering the specific use-cases, functionalities, and necessary permissions for each major user group. The project team followed the principle of least privilege to ensure secure access.

Integration with Weather and Grid Carbon Intensity Sources: The project team developed the integration with OpenWeather and WattTime's APIs first, enabling the platform to retrieve weather data and grid carbon intensity information. The architecture was designed to accommodate future scalability, allowing for the inclusion of additional greenhouse gas emissions sources.

Initial Operation and Service Uptime Evaluation: The project team then brought the platform online and began data collection. The uptime of each service was evaluated, and necessary improvements were implemented throughout the data collection period. New integrations and services were subjected to a similar test operation mode upon completion.

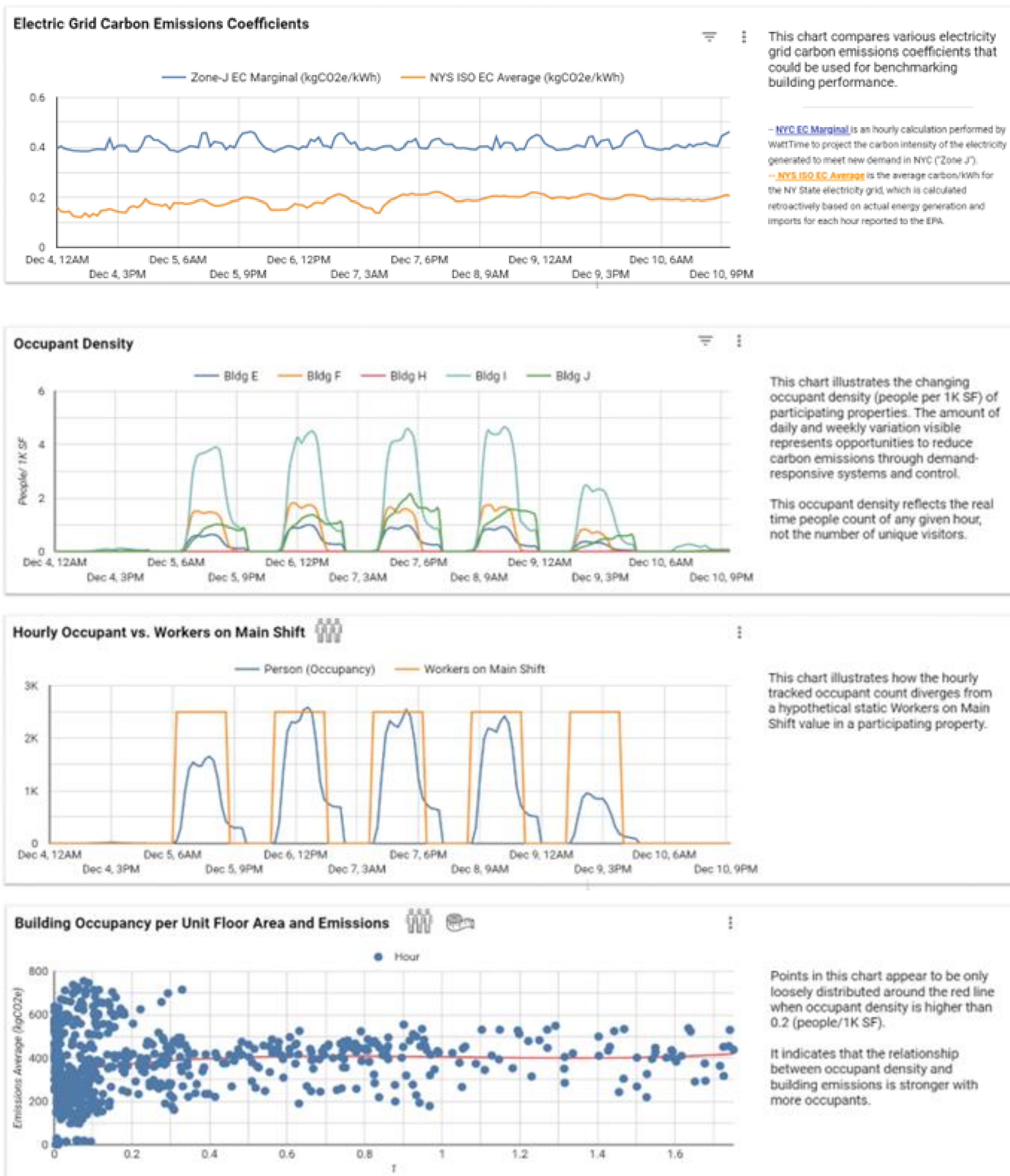
Integration of Electricity Use Meter Data: A standardized approach for transmitting electricity data was established, and integrations with various sources of electricity data were developed, thoroughly tested, and implemented.

Integration of Occupancy Count Data: Similarly, a standardized method for transmitting occupancy count data was defined, and integrations with different sources of occupancy data were created, rigorously tested, and deployed.

Finalization and Prototyping of Data Inspection Interface Requirements: The project team created a prototype data dashboard, which was then carefully reviewed and refined in response to user feedback.

Completion of the Data Inspection Interface: The data inspection interface requirements were finalized and incorporated prior to public launch. Please refer to Figure 7 for screenshots showcasing the interface.

*Figure 7: Data Inspection Interface Screenshots*




## 3.4.2 **Architecture and Design Choices for Data Repository**

JB&B and the software development team meticulously considered the architecture and design of the data repository to ensure it fulfilled the project's performance and data privacy requirements. The software platform was built as a cloud-native serverless solution specifically tailored for Google Cloud Platform. To prioritize the security and privacy of the data, the software development team implemented various measures including encryption applied to data during transit and at rest and strict access controls to restrict data access to authorized users only.

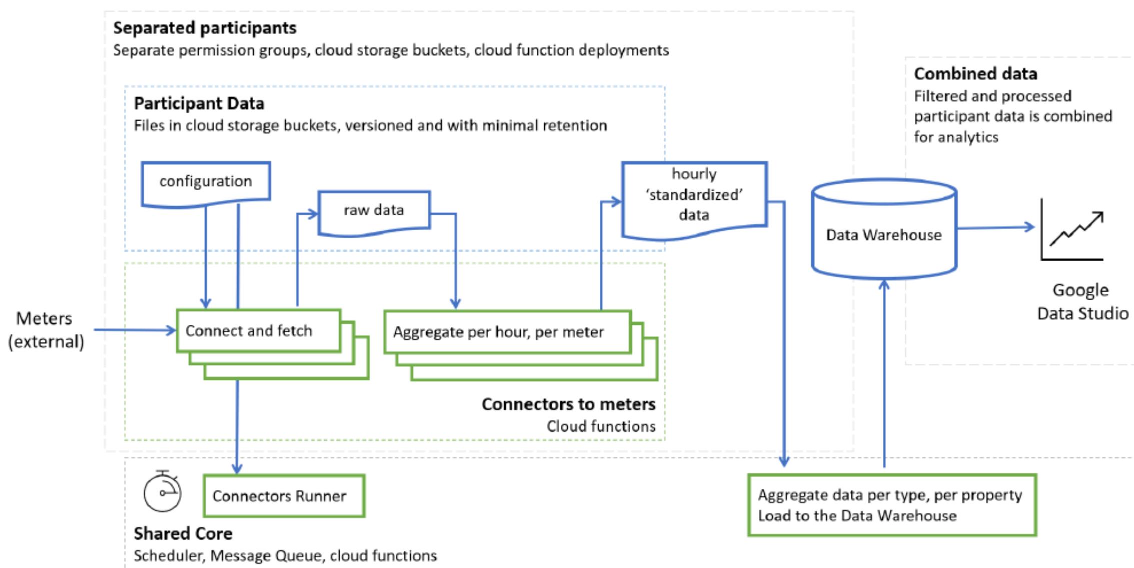
### 3.4.3 Cloud Platform Service Design

- Google Admin was used for all user and groups management.
  - "Participants" are defined as the Building Owner groups.
  - Participants are segregated with separate user groups and separate GCP cloud storage buckets
- Cloud storage buckets were used for all data storage.
- Cloud functions were used for all computing needs.
- BigQuery was used as the data warehouse.
  - To ensure an added level of data protection, the accessibility of data from BigQuery was restricted based on the participant groups defined in Google Admin. This means that each participant, such as Building Owner 1, was only granted access to their own building data and not the data of other users. This measure ensures that data remains securely segregated, maintaining the privacy and confidentiality of each participant's information.
- Google Data Studio was used for visualization and analytics.

### 3.4.4 Architectural Description

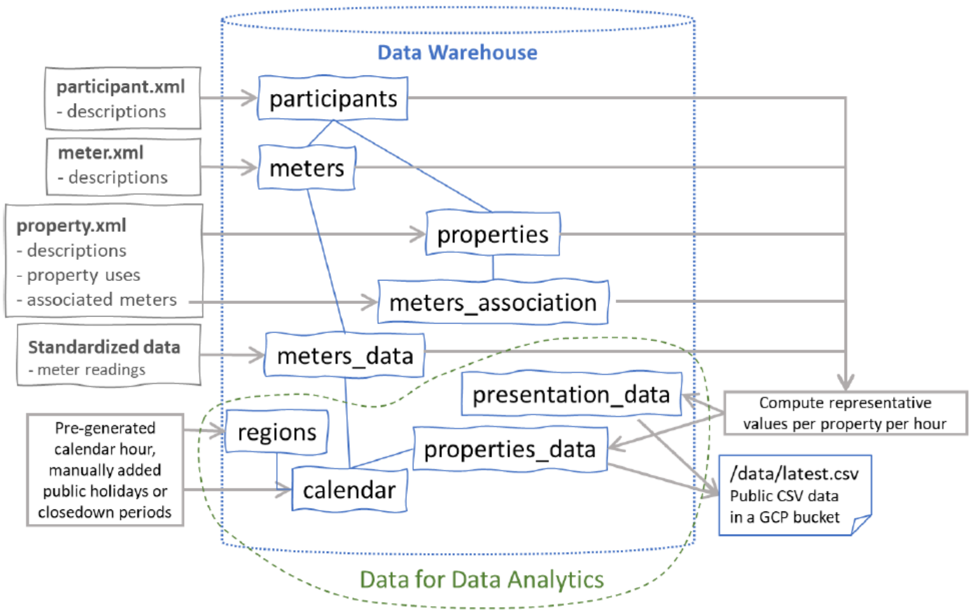
The project executes production workloads within a single Google Cloud Platform (GCP) account and project. Figure 8 shows the high-level architecture of the platform.

*Figure 8: Platform Architecture*




A cloud scheduler triggers connector functions to retrieve data and store it in a Cloud Storage bucket. Subsequently, an event is generated, invoking another cloud function to format the data and store it in the BigQuery Data Warehouse. Figure 9 shows a detailed diagram of the logical configuration of the data warehouse.

*Figure 9: Data Warehouse Architecture*




A Client Portal, hosted on a static website within another Cloud Storage bucket, queries the data warehouse and displays the results. The system is further supported by a Cloud Load Balancer, which serves dynamic content, and a Cloud Function triggered by an event. PubSub is utilized to manage events related to data being automatically fetched or manually uploaded by the user. Default monitoring and logging are set up for traceability.

### 3.4.5 Cybersecurity and Anonymized data

An external cybersecurity expert, independent of the project team, conducted an initial internal review of the cloud platform to assess vulnerabilities and potential risks related to cyberattacks or data leakage. The objective was to identify any unauthorized access to data by participants or external parties. The findings from this review highlighted potential areas of concern, and the software development team implemented appropriate measures to address and mitigate the identified risks.

*Table 4: Security Review Findings*

| Finding | Severity | Mitigation measures | Residual risk |
|---|---|---|---|
| Bucket web-portal-static-content accessible by "allUsers"<br>Risk that this bucket will be used to store non-public data. | High | This construction is required to allow the bucket for serving static public web content. Public permissions are appropriately restricted to allow viewing only.<br>Measure: Assign the bucket to the `participant_public` group that holds all Platform permissions used when processing public data, as an additional layer of security. | Acceptable |
| Buckets with Logging Disabled<br>Ability to audit bucket access and other operations that may help in troubleshooting. | Low | Enable logging for participants buckets before releasing into production. | Acceptable |
| Buckets with Versioning Disabled<br>Risk of unintended modifications or deletion of bucket data. | Low | Enable versioning for participants buckets before releasing into production. | Acceptable |
| Unused default network with default firewall rules<br>Various risks from allowing certain common types of access. | Low | Remove the default network, since it is not used in the project. | Acceptable |

All risks are acceptable and do not prevent ingesting participant data into the Platform.

After the initial review, the project team engaged Allied Digital, a Cybersecurity Consultant, to conduct a Well-Architected Review, a recognized cloud security practice. This assessment focused on the production environment, which operates within a single Google Cloud Platform (GCP) account.

Utilizing the AWS Well-Architected Framework, the Consultant thoroughly evaluated the GCP infrastructure supporting the Client's application and workloads. This framework, built upon the pillars of operational excellence, security, reliability, performance efficiency, and cost optimization, provided a structured approach for evaluating architectures and implementing scalable designs.

The security assessment highlighted the project's adherence to various best practices, such as mandatory multi-factor authentication, role-based access controls, and effective identity and access management. However, it also identified areas for further enhancement. Specifically, the need to bolster alerting and logging capabilities to detect and investigate security incidents was identified as an area of improvement. To address this, the project team created a separate scope for the software development team to identify the necessary log requirements and implement corresponding alerts.

The review also recommended considering the use of Cloud Armor, a service designed to protect the Cloud Load Balancer from Distributed Denial of Service (DDoS) attacks. While this would provide an additional layer of security, it was determined that, given the project's proof-of-concept nature and non-critical status for commercial deployment, the cost of implementing Cloud Armor was only deemed appropriate for an advanced version of the platform. Since DDoS attacks primarily impact service availability rather than data exposure, the project team concluded that the current level of protection provided by the system was sufficient for the project's scope.

# 4 Project Maintenance and Continuous Data Collection

## 4.1 Maintenance and Troubleshooting

The project team extended their support for the software platform beyond the initial development phase into an uninterrupted data collection period. This maintenance period proved valuable in uncovering and addressing unforeseen software bugs. The team conducted audits of data flows to ensure continuity and implemented patches and bug fixes as necessary. They also engaged in regular discussions with Contractors to assess the status of hardware at each property.

To evaluate the incoming data for reasonableness, completeness, and complexity, the project team performed rigorous testing, quality control, and quality assurance procedures including end-to-end testing to identify and resolve any issues. Additionally, the team compared the data with existing ESPM LL84 public database figures as a validation measure.

Throughout this process, a total of seventeen (17) issues surfaced. Here are a few noteworthy highlights:

- Google Chrome Login: Initially, the public dashboard required users to log in to a Google Chrome account, resulting in an error when accessed through other web browsers. Although the bug was reported to Google, no resolution was provided. As a workaround, the software development team adjusted user membership and permissions. Benchmark 8760's private dashboard still requires login to access non-anonymized data.
- Missing Data for Various Buildings: Connectivity interruptions, downtime of cloud solutions, and changing API requirements led to short gaps of missing data in many buildings. To address this, the data storage architecture was critical, and historical data was retrieved, regenerated, and the gaps were retroactively filled.
- Blank Data for Building H: Occupancy data from Building H was found to be blank. After verifying the API request's functionality, the project team held discussions with building staff and real estate contacts and inspected the occupancy sensors. Upon collaboration with the middleware provider, it was discovered that a deprecated API system was reporting a successful connection but was unable to provide data. The integration was promptly updated to the correct endpoint, and the vendor removed the erroneous endpoint.
- Due to initial setup issues, multiple months of data from security systems were lost as the log continuously overwrote the previous day's data. This highlights the importance of commissioning integrations and conducting periodic data reviews.

## 4.2 Formalization of Continuous Data Collection

To enhance scalability, transitioning the integrations to a push architecture offers substantial benefits by minimizing overhead and transferring upkeep and maintenance responsibilities from the Platform Owner to vendors. This shift is particularly impactful as most troubleshooting issues arise from unanticipated changes in API formats, outdated documentation, and recurring permission expirations. Managing these issues consumed significant management time and software development resources during this proof-of-concept project. Conversely, push integrations experienced significantly fewer troubleshooting challenges since the vendor assumed responsibility for configuring and maintaining the data pathways.

While the availability of a manual data upload option is essential, especially when real estate cybersecurity measures restrict direct, real-time connectivity to on-site hardware equipment via the internet, it is important to exercise caution and implement robust controls. Errors in the setup of data collection may only surface upon attempted uploads, potentially leading to data loss. Therefore, stringent measures, rigorous quality controls, and thorough validation processes should be implemented to mitigate the risk of data inaccuracies or loss.

# 5 Project Learning Dissemination

In addition to the proof-of-concept Benchmark 8760 Platform, the project team shared the platform technical specifications with the ESPM team, policymakers around the country, and the public via the open-source platform, GitHub. The project team also primed the market for wider scale adoption of people-counting technologies by creating and sharing recommendations, guidelines, and best practices for the affordable, accurate and privacy-protecting collection of hourly occupancy counts from buildings.

At the conclusion of the project, Benchmark 8760 leaders presented the work done-to-date and findings to several industry groups across California, Colorado, New York, and Washington, D.C., to solicit feedback on how to continue to build the case for hourly benchmarking as a tool for incentivizing real estate investment in GEBs technologies.

*Table 5: Benchmark 8760 Learnings Roadshow*

| Organization | Location | Audience |
|---|---|---|
| **REBNY** | NYC | Owners |
| **NYC DOB** | NYC | Policymakers |
| **NYSERDA** | NYC | Policymakers |
| **DCAS** | NYC | Public Entity |
| **DOE** | NYC | Public Entity/ Policymakers |
| **NYC MOS** | NYC | Policymakers |
| **Urban Green** | NYC | Research |
| **USGBC** | DC/NYC | Research |

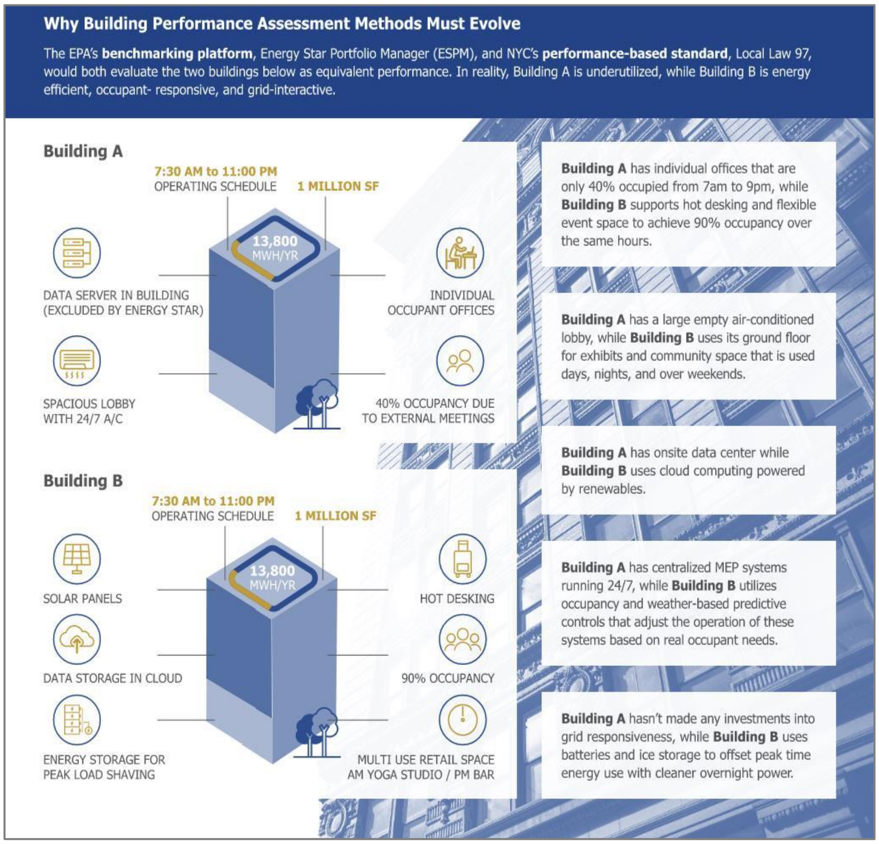
| Organization | Location | Audience |
|---|---|---|
| **National BPS Coalition** | DC | Policymakers |
| **EPA** | DC | Public Entity/ Policymakers |
| **IMT** | DC | Various |
| **CUSP** | NYC | Thought Leader |
| **RER** | DC | Owners |
| **LBNL** | CA | Research |
| **RMI** | CO | Research |
| **Google** | NYC | Owner/Product Developer |

Feedback from the above-listed industry groups included recommendations to:

- Expand the quantity and diversity of buildings in the Benchmark 8760 Platform to build a more robust data set.
- Explore an hourly building performance rating calculation in the context of an ESPM pilot program that provides additional recognition to buildings using grid-interactive efficient technologies.
- Prime the real estate market for adoption of grid-responsive building features (batteries, optimization platforms, etc.) by identifying and evaluating technologies that will be able to capitalize on an hourly benchmarking or building performance standard in the future.

In December 2022, Benchmark 8760 submitted a Concept Paper to the Department of Energy (DOE) Grid Resilience and Innovation Partnership (GRIP) Program for follow-on funding. The DOE encouraged the project team to submit a full application, which was completed and submitted in February of 2023. Response to our funding request is expected in Summer 2023.

*Figure 10: Sample Marketing Material*




## 5.1 Summary of Next Generation Benchmarking Methodologies Workshops

To establish a scalable and effective hourly data collection methodology that incorporates the lessons learned from the project, the project team took a collaborative approach and invited occupancy counting vendors to participate in Next Generation Benchmarking Workshops. This initiative resulted in the formation of the building industry's first working group dedicated to aligning data standards and practices specifically for hourly data collection, with a particular emphasis on occupancy data.

A total of nine (9) companies specializing in various types of occupancy counting technology actively participated in these workshops. This diverse group encompassed all major occupancy counting technology types, ensuring comprehensive representation and expertise within the industry.

*Table 6: Occupancy Counting Vendors in New Industry Group*

| Company Name | Occupancy Technology Type |
|---|---|
| **Vergesense** | Time of Flight Sensor |
| **Irisys** | Time of Flight Sensor |
| **Sharry** | Security System Integration |
| **Xkorp** | Radar Based Sensor |
| **GE Current** | Multiple occupancy standalone sensors including thermal |
| **Avuity** | Time of Flight Sensor |

| Company Name | Occupancy Technology Type |
|---|---|
| **Butlr** | Time of Flight Sensor |
| **Orion** | Turnstile Manufacturer |
| **Facit** | Computer Vision |

The purpose of these meetings was to foster alignment among Key Stakeholders in the occupancy counting industry regarding the adoption of a data export standard that is compatible with benchmarking platforms like Energy Star Portfolio Manager. In addition to developing the framework for this data standard, all participating companies demonstrated their commitment by signing a letter of support for the utilization of hourly occupancy data in building benchmarking efforts. Furthermore, they expressed their willingness to support a common data standard if the Environmental Protection Agency (EPA) implements a benchmarking strategy that aligns with these goals.

# 6 Summary of Project Lessons Learned

Lessons Learned across surveyed properties have been synthesized into the following comprehensive list. This list incorporates feedback from building management teams, IT departments, people counting vendors, external consultants, and the Benchmark 8760 project team's experiences during development.

## 6.1 Lessons for Building Owners

### 6.1.1 Decision to Install People Counters

Occupancy data has multiple uses beyond benchmarking: Leasing departments can utilize the data to inform leadership about the asset's vitality, while building management staff can use it for staffing plans, procurement of building supplies, and occupant-responsive energy-saving measures.

Privacy concerns from Tenants are less prevalent than expected: Most occupancy counting solutions protect Personally Identifiable Information (PII), and in the rare cases that they do not, the project team found that Tenants opt-in anyway for streamlined ingress/egress experiences.

Specifying engineers can contribute to wider adoption: Specifying engineers should include language in the access control system specifications requiring turnstile hardware capable of pushing log data for reporting purposes.

### 6.1.2 Installation of People Counters

Lobby renovations present an opportunity for people counting implementation: Building Owners should work with Architects or Interior Design Consultants to ensure the selection of turnstiles or alternative solutions with people counting capabilities during Lobby renovations.

Granularity of whole building data: Existing people counting solutions often overlook service personnel and retail traffic, but their impact on occupancy per square foot is minimal. Retail space square footage can be subtracted if the data is not available.

Flexible approach to people counting tech: Building Owners should maintain flexibility in occupancy hardware deployment strategies due to the uniqueness of each building.

### 6.1.3 Integration of People Counters

Integration challenges affect people counting selection: Accuracy of data collection alone is not sufficient; the ability to connect data to a Building Management System (BMS) or cloud platform is crucial. The front-end software solution is also as important as the sensor type.

Incentives for IT departments are lacking: Cybersecurity risks deter IT departments from adopting people counting technologies. Increasing incentives tied to data access can help overcome this barrier.

Reporting occupancy data from an on-prem solution is challenging: On-premises solutions without internet access or data extraction mechanisms pose logistical and technical difficulties. Owners should consider on-premises solutions with outbound mechanisms for data reporting (e.g., HTTP POST). These solutions use standard communication ports that IT departments are more comfortable managing.

### 6.1.4 Electrical Metering

Integrated submeters offer additional benefits: Submeters that are integrated with the BMS or other smart building platforms enable Owners to more actively leverage building data. Integrated meters can support demand response, carbon accounting services, and building upgrade insights in addition to tenant billing.

## 6.2 Lessons for Policymakers

### 6.2.1 Data Accuracy and Access

Granularity of whole building data: Retail traffic, which significantly contributes to a building's energy profile, is not readily captured. Benchmarking should allow the removal of Retail space square footage and associated energy and occupancy.

Direct-metered Tenants pose challenges: Access to direct-metered Tenant utility data requires additional authorizations. Easier access to electricity metered data is needed for benchmarking building energy performance.

### 6.2.2 Integration of People Counters

Incentives for IT departments are crucial: Cybersecurity risks hinder the adoption of people counting technologies. Incentives explicitly tied to data access can help overcome these concerns.

Limited support for BMS APIs: Pull-based or push-based data sharing solutions are not widespread. Automated email reporting is a more common alternative for accepting data for hourly performance benchmarking.

Limiting the number of integrations supported is essential for scalability: A benchmarking platform should focus on standardizing data and allow private platforms to push data using industry-standard middleware APIs.

### 6.2.3 Need for Streamlined Process

Most of the Real Estate Partners participating in the Benchmark 8760 initiative are large organizations with departments and resources dedicated to rolling out new technologies and products. They have internal departments focused on security, technology, and sustainability as well as access to vendor expertise in selecting and rolling out hardware solutions. Most mass market buildings will not have these resources available. To achieve wide-scale adoption of occupancy counting, a step-by-step process for evaluating, selecting, financing, installing, and commissioning occupancy counting solutions should be made available.

## 6.3 Lessons for Consulting Engineers

### 6.3.1 Installation of People Counters

Lobby Renovation: Incorporate people counting as part of planned Lobby renovations to minimize disruptions and leverage existing renovation budgets. This approach allows for the addition of people counting capabilities at minimal cost.

Utilize Existing Hardware: Evaluate existing hardware, such as turnstiles, and make slight adjustments to enable net people counting with minimal cost and disruption to building operations.

Access Control System Specifications: Include language in specifications requiring turnstile hardware capable of pushing log data to a local FTP site or an ESPM-like platform for reporting purposes. This facilitates wider adoption of occupancy counting during Lobby renovations and turnstile replacements.

Communication Protocol: While BACnet protocol support is limited, most people counting solutions offer APIs, which are increasingly used by system integrators. Ensure compatibility with existing Building Management Systems (BMS) by selecting solutions with compatible APIs.

Commissioning: Clearly define functional commissioning requirements in proposal language. Assign responsibility for the project to one (1) Subcontractor, preferably the BMS vendor or system integrator, to ensure successful data collection.

Scalable Data Collection with Haystack: Adopt the Project Haystack standard, which includes standardized tags for building data (e.g., occupancy and meter data) and a uniform API for requesting building data. This allows for consistent data retrieval regardless of the underlying BMS infrastructure.

### 6.3.2 Integration of People Counters

Limited Internet Access for Building Systems: Building systems like the BMS may have internet access, while others like the turnstile system are air-gapped for security reasons, preventing automatic data sharing with third-party platforms. Integrating turnstiles with the BMS may also face security concerns.

People Counters on Isolated Networks: Some people-counting solutions operate on dedicated networks with 4G modems to isolate them from the base building network. This prevents unauthorized access to the base building network but poses a management challenge as base building IT may not have access or control over the dedicated network. The emerging practice involves vetting proposed hardware by corporate IT/IoT domain experts and integrating the devices into the corporate network, overseen and managed by Owner IT departments.

## 6.4 Lessons for Vendors

### 6.4.1 Installation of People Counters

Prioritize Occupant Experience: Building owners emphasize the importance of Lobby aesthetics and occupant experience. Leveraging existing hardware like turnstiles and cameras is advantageous. For new equipment installations, closer collaboration with Lobby designers and Engineers is recommended to ensure hardware fits various lobby aesthetics and delivers a positive occupant experience.

Software Differentiation for Turnstile Manufacturers: Many turnstile manufacturers require complex custom integrations to enable people counting functionality and data integration with external systems. There is a market opportunity for turnstiles with advanced software features to differentiate their product.

Integration as Part of Planned Lobby Renovation: Implementing people counting as a stand-alone project can be challenging, impacting occupant experience, daily operations, and requiring additional funds. A more successful approach is to include people counting in planned Lobby renovations, where the cost is minimal compared to the total renovation budget and expected by building occupants. People counting vendors should engage with Lobby fit-out designers to streamline system specification.

### 6.4.2 Integration of People Counters

Ease of Integration as a Primary Driver: User-friendly platforms and streamlined integration processes between hardware and software are crucial decision-making factors. The front-end software solution used daily by the building team is equally important as the type of sensor, considering factors such as cost and accuracy.

Support of BACnet Protocol: BMS systems heavily rely on the BACnet protocol, which is poorly supported by the people counting solutions in this study. There is an opportunity for people counting solutions that can communicate via BACnet, differentiating themselves in the market.

Scalable Data Collection with Haystack: Project Haystack defines standard tags for making building data searchable and a uniform API for requesting building data. Using the Haystack API ensures consistent data retrieval, regardless of the underlying BMS infrastructure or building-specific complexities.

Addressing Cyber Security Concerns: Due to cyber security risks, IT teams may prefer older protocols like SFTP for reporting data, as opening additional network ports can increase the attack surface. Considering this preference, providing secure data reporting options aligning with older protocols can alleviate concerns and foster adoption.

# 7 Conclusion

The Benchmark 8760 Initiative has made meaningful strides in advancing benchmarking and building performance standards by advocating for the utilization of hourly data. The project successfully developed a cloud-based data platform, demonstrating the feasibility of collecting and securely storing various types of hourly data for benchmarking purposes. The key findings and outcomes of the initiative provide valuable insights to Building Owners, policymakers, Design Engineers, and building data vendors, with important market implications.

By addressing market barriers such as limited understanding of collecting hourly data, the project enhances building awareness and knowledge. The open-source release of the platform's code and specifications fosters knowledge sharing and collaboration, helping bridge the gaps between existing benchmarking platforms and the hourly capabilities of the Benchmark 8760 Platform.

The development of standards and recommendations for affordable, accurate, scalable, and privacy-protecting occupancy counting enables Building Owners to access valuable data for improving building performance. Furthermore, the project establishes a model for developing an hourly average emission factor for the electricity grid that other jurisdictions can follow.

JB&B would like to thank Project Partners for their contributions and collaboration. Their expertise and commitment played a significant role in the success of Benchmark 8760. Additionally, we extend our appreciation to NYSERDA for their support and funding, which made this project possible.

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