Centralized Operational Analytics Dashboard

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Abstract *— This study proposes a reporting solution that centralizes multiple data collection systems using tools such as Looker Studio to evaluate and monitor data geographically distributed across the world. The solutions aim to consolidate different data sources to operational metrics, including equipment maintenance, diesel, electricity and water consumption, unifying them into a simple visual analytical dashboard where stakeholders can view. By transforming data into interactive visualizations, the solution enhances real-time visibility, supports trend analysis, and enables data-driven decision-making. The proposed solution emphasizes data accuracy, scalability, and data refresh processes to ensure timely insights. Additionally, the reporting tool can evaluate historical data to facilitate the detection of anomalies and evaluate performance benchmarking across sites, allowing the improvement of operational efficiency and resource optimization. The implementation of this tool is expected to reduce different reporting tools for each activity and provide stakeholders with easier visualization dashboards to support cost control and sustainability initiatives.*

Keywords *— Business Intelligence, Data Integration, Operational Analytics, Resource Optimization.*

Introduction

An organization operating across multiple sites distributed across the world faces challenges when attempting to consolidate and analyze data from different sources. The use of different data collection resources creates challenges such as inconsistent reporting formats, and delayed data availability. As organizations are leaning towards data driven decision making, the need for centralized, scalable and real-time (near real time) reporting solutions becomes critical.

Modern business solutions such as Microsoft Looker Studio, provide the capabilities required to integrate multiple data sources to transform raw data into complete and interactive dashboards. A centralized data visualization platform helps improve operational visibility and decision-making efficiency [1]. This article proposes the integration of multiple sources connected to one reporting solution (Power BI) to create data analytical dashboards to support monitoring, analyzing, and provide decision-making tools to optimize performance of operations.

The proposed solution utilizes a business intelligence and data visualization platform to consolidate all key raw data into a single business solution to allow the visualization of operational metrics, equipment performance, resource consumption, and cost tracking. By using dashboards linked to historical trend analysis and near real time insights, the organization can improve equipment efficiency, reduce costs, and enhance sustainability.

Literature Review

An organization operating across multiple sites distributed across the world faces challenges while trying to align multiple data sources into one solution that can support visualization, reporting, and analytical capabilities to support decision-making and operational optimization.

Data Integration is one of the main components established for Google's Looker Studio Application. Kimball and Ross emphasize that integrating data from different sources can ensure consistency and reliability when using Business Intelligence systems for reporting environments [2]. Extract, Transform and Load (ETL) processes play a critical role in the consolidation and preparation of data for analysis.

Real-time data analytics continue to grow, as modern organizations continue to increase dependency, supporting the detection of anomalies, responding to operational issues promptly, and improving decision-making processes. Dashboards are the general tool used to display said analytical reports. Furthermore, sustainability initiatives increasingly rely on data analytics to monitor resource usage and reduce environmental impact [3].

Dashboards are generally well recognized to be effective tools to present complex data in an intuitive format. A well design dashboard can support situation awareness by enabling users to identify trends and anomalies in an easier to understand way [4]. Eckerson notes that performance dashboards are essential for monitoring business operations and aligning them with strategic objectives [3].

The utilization of Business Intelligence systems such as Looker Studio still contains several challenges, such as data quality issues, integration complexity, and system scalability that can impact the overall effectiveness of reporting solutions. These can lead to inaccurate insights, integration complexity process issuing delays, and resource usage. Additionally, as data volumes increase, maintaining system performance becomes a critical concern. Addressing these challenges requires robust data governance practices, scalable architectures, and continuous system optimization.

Overall, the literature indicates that centralized BI solutions integrating data acquisition, transformation, visualization, and automation provide significant advantages for organizations. These systems enhance operational visibility, improve decision-making, and support sustainability initiatives. The findings from existing research strongly support the development of a centralized reporting solution using Looker Studio, as proposed in this study.

PROPOSED SOLUTION

The proposed solution is a centralized business intelligence and data visualization platform for the reporting environment that can collect data from all global sites utilizing different data sources. The platform supports the validation and transformation of the data using standardized rules and publishes interactive dashboards using this Looker Studio Application. This solution will serve as an analytical layer that consolidates the most critical operational metrics for decision support.

The recommended KPIs categories for the dashboard scope are summarized in Table 1.

Table 1
KPIs for Operational Monitoring Dashboard

KPI Category	Measures	Operational Decision Supported
Equipment health	Time above threshold, active equipment alarms	Identify abnormal equipment behavior.
Maintenance	Open work orders, overdue preventive maintenance, mean time to repair, downtime hours	Prioritize maintenance work and reduce equipment risk.
Diesel	Volume consumed, diesel cost, generator runtime, consumption versus plan	Detect abnormal fuel use and support cost control.
Electricity	kWh consumed, demand peaks, electricity cost, energy intensity per operating hour	Benchmark site efficiency and detect high-energy periods.
Water	Volume consumed, water cost, consumption per site, change versus baseline	Identify leaks or process changes and monitor conservation initiatives.
Financial and sustainability	Total operating cost, cost variance, CO_2e estimate, cost per resource unit	Connect operational performance to budget and sustainability objectives.

The evaluation of the basic operational structure the Global dashboard should contain is shown in Figure 1. And the general workflow from the data collection process to the visualization of the data is illustrated in Figure 2.

This process begins with multiple data sources, including Programmable Logic Controllers (PLCs) and Building Management System (BMS) controllers, which generate operational and environmental data. The data is then transmitted through collection applications such as APIs and gateways, for centralized acquisition. Once collected, the data undergoes validation, cleaning, and standardization to ensure accuracy, consistency, and compatibility across all sources.

After processing, the refined data is integrated into a visualization dashboard that presents actionable insights to executives, maintenance teams, finance departments, and other stakeholders for monitoring, analysis, and decision-making purposes.

METHODOLOGY

This study emphasizes the design and implementation of a centralized reporting solution capable of integrating multiple data sources into a unified Business Intelligence platform. It emphasizes data accuracy, scalability, automation, and usability, ensuring the resulting system support for near-real time monitoring and data-driven decision-making.

The approach presented in this study is divided into six major phases: requirement analysis, data acquisition, data integration, data transformation, data modeling and storage, and data visualization.

The organization can begin identifying business needs, stakeholder requirements, and Key Performance Indications (KPIs). The tasks performed to organize these requirements may align to performing interviews and workshops with operational teams to determine critical metrics such as:

- Resource consumption
  - Diesel
  - Electricity
  - Water
- Maintenance Schedules and Alerts
- Consumption cost tracking

This phase outlines the requirements specification documents (SPECs) that will define the system's description, system inputs and outputs and performance requirements and expectations.

The requirements analysis identifies all stakeholders needs, reporting points, critical decisions, and required KPIs. Workshops should be scheduled with multiple operations, maintenance, finance, sustainability, IT, and site teams to address mentioned analysis. The outcome of this should align with a requirement specification that supports the definition of metric topics, such as names, formulas, source systems, data owners, security rules, accepted criteria, and others.

Priority should be given to KPIs that drive operational actions, such as overdue maintenance, resource consumption anomalies, and cost variances.

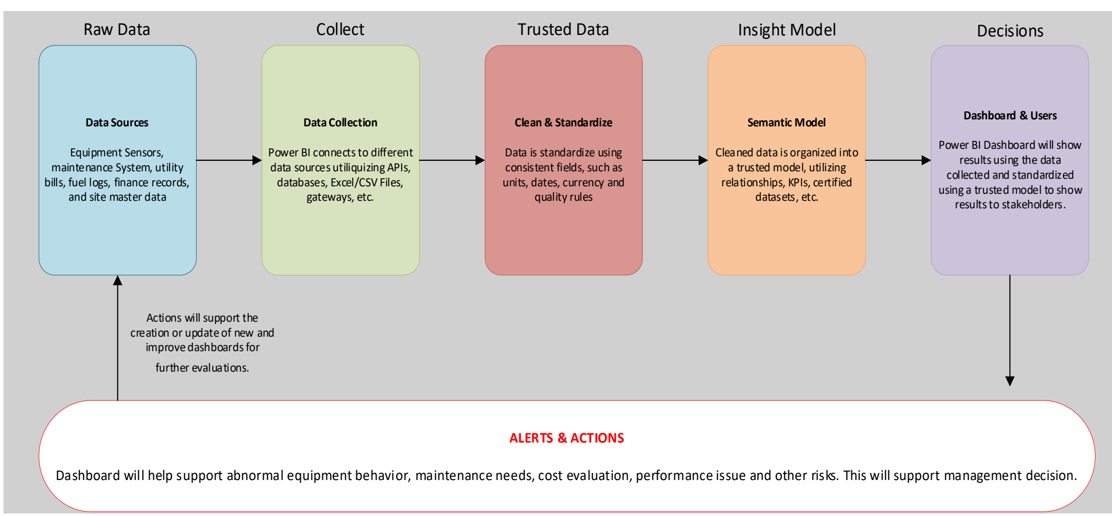

Figure 1

Centralized Looker Studio Operational Basic Structure

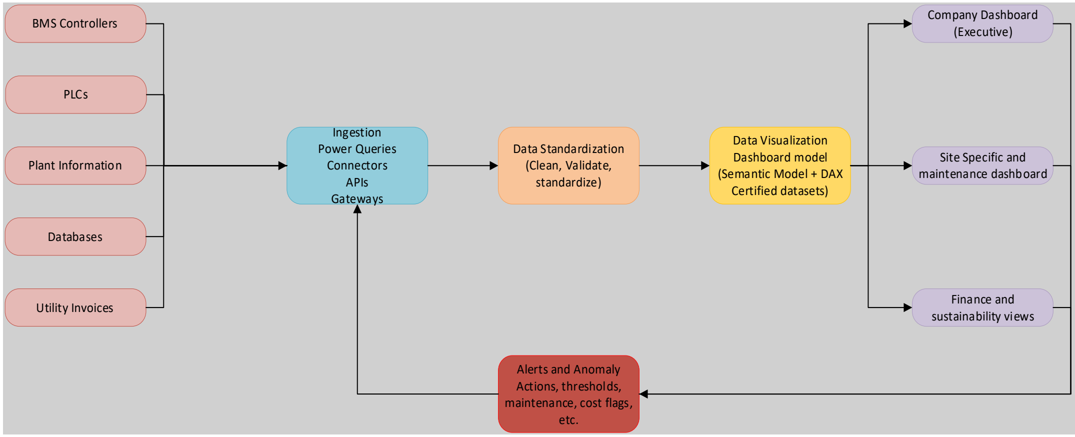

Figure 2
Data Collection Structure

In the data acquisition process the organization defines how each source will be connected to the reporting environment. Possible sources an organization can use are IoT platforms, Plant Information (PI) systems, sensor databases that may include equipment maintenance management systems, meter information for electricity and water, tank level systems or fuel logs or use on diesel or gas, cost of different sources, etc. Cloud sources can also be connected directly, while on-premises data sources can be connected securely through a standard gateway [5].

The integration phase consolidates the extraction of data into a stagging layer before modeling. Staging tables preserve source identifiers, timestamps, load dates, and exception flags so that data lineage can be maintained. This phase also separates raw data from curated data, allowing troubleshooting without changing the dashboard layer. Where multiple sites submit spreadsheets or CSV files, a controlled folder structure and naming standard should be established to reduce ingestion errors.

The data quality helps prevent inaccurate or incomplete data from entering decision-making dashboards. Recommended checks include missing required files, invalid site codes, duplicate readings, negative consumption values, currency mismatches, stale files, and timestamps outside the expected period. Failed records should be stored on an exception table with an assigned owner, reason code, and remediation status. The dashboard should be included in a data quality score so users can evaluate trustworthiness before interpreting KPIs.

There are multiple transformation standardized measurements required to be performed to maintain an even requirement for all sites established in the dashboard. For example, electricity measures can be transformed to kWh, and water into gallons or liters. Time zones should also be converted into local time and standard time, such as Coordinated Universal Time (UTC). In addition, site names, asset identifiers, and resource categories should be mapped to master data tables. The transformation also calculates derived metrics such as cost per kWh, water consumption per operating hour, diesel variance versus plan, and overdue maintenance count.

A dimensional model was utilized in this case because it primarily supports performance, reuse and understandable reporting. The fact table (centralized in Figure 3) stores measurable events, such as consumption, cost, alerts and maintenance activities. The other dimensional tables are the flowing:

- Site
- Date
- Resources
- Maintenance
- Threshold
- Equipment

This structure supports flexible analysis by region, country, site, period, resource type, equipment group, and cost center. Incremental refresh should be considered for large historical tables to reduce refresh time and resource consumption [6].

Figure 3 provides a general flowchart illustrating how data acquisition, validation, transformation, and reporting are performed throughout the data publishing process. The flowchart demonstrates how data from multiple sources is continuously collected, validated, and transformed before being integrated into reporting and visualization platforms. It also highlights the ongoing process of incorporating new datasets and additional data sources to support the creation, maintenance, and continuous updating of dashboards for accurate and up-to-date reporting.

Table 2 presents analytical measures that can be implemented within this dimensional model, including Data Analysis Expressions (DAX) formulas.

Table 2
Measures for a Semantic Model

Measure	DAX / logic	Purpose
Total Operating Cost	SUM (Cost Amount)	Shows total resource and maintenance-related cost by site, region, and period.
Energy Intensity	Electricity kWh / Hours	Normalizes consumption by activity level so sites can be compared fairly.
Cost Variance %	(Actual Cost - Budget Cost) / Budget Cost	Highlights sites or resources above budget.

The dashboard design began with the most important business requirements. Executive users require summarized views of costs across multiple areas such consumption of fuel, water and electricity, and alert notifications. Additional requirements on a technical level would be trends associated with exceptions, equipment conditions, overdue maintenance, and alerts time or age. These cases can all be supported in these views, while site users can have authorized access to their specific site if necessary [7].

The deployment phase includes workspace configuration, dataset, gateway configuration, user training, and support procedures. During the implementation phase requires identifying test users to support and evaluate application functionality and reliability. This also supports continuous improvement, and it should be managed through a backlog of enhancements, new data sources, additional critical KPIs, and additional views.

Dashboard Design and Analytics

The proposed dashboard framework is designed around a standardized, scalable model that ensures consistency across global operations while still enabling site-specific insights. Regional dashboards covering Puerto Rico, California, and Russia are built using a unified structure that includes consistent navigation filters, key performance indicators (KPIs), chart zones, resource metrics, alert classifications, and data quality indicators. This approach allows stakeholders to seamlessly compare performance across locations while also drilling down into individual site behavior.

Additionally, by maintaining a governed design, the system avoids duplication of business logic and ensures that all regions are evaluated under the same analytical lens.

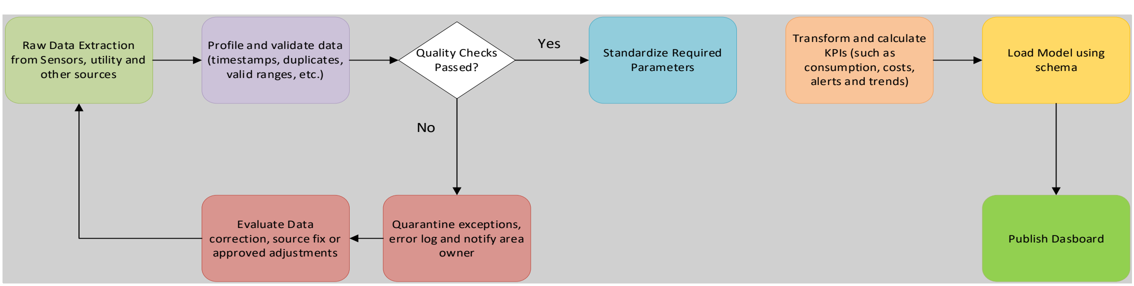

Figure 3
Data Acquisition, Validation, Transformation and Reporting Flowchart

At the core of the dashboard design is a defined set of operational parameters, including total electricity consumption, diesel usage, water utilization, operational costs, and the number of critical alerts generated. These metrics are visualized through interactive elements such as time-series trend charts, which display resource consumption patterns over user-defined periods, and comparative bar graphs that highlight cost distribution across sites. This enables users to quickly identify inefficiencies, such as unusually high fuel consumption or cost spikes, and correlate them with operational events. The inclusion of resource-specific breakdowns ensures transparency in how electricity, water, and fuel contribute to overall site performance.

The dashboard architecture is organized into single pages with overview of Site Detail, Resource Consumption, Health Equipment, Maintenance, Cost and Sustainability. The Overview provides a high-level snapshot through KPI cards and aggregated alerts, offering immediate visibility into system-wide performance. It also focuses Resource Consumption on cross-site comparisons over time, while Equipment Health monitors key indicators such as utilization, and threshold breaches. Maintenance status emphasizes work-order status and preventive maintenance compliance, ensuring operational continuity.

From an analytics perspective, the dashboard supports three levels of insight. Descriptive analytics provide visibility into historical performance, such as monthly energy consumption and the number of active maintenance alerts. Diagnostic analytics go a step further by identifying root causes, for example, linking increased diesel usage to extended generator runtime. Prescriptive analytics offer actionable recommendations, such as scheduling equipment inspections or addressing overdue maintenance tasks. Additionally, the global dashboard extensions incorporate contextual analytics, alongside standard KPIs. This layered analytical approach ensures that decision-makers are equipped not only with data, but with meaningful, actionable intelligence tailored to both global and local operational. Figure 4 presents an overview of the Global Management Dashboard for all sites, including data such as energy consumption, gas usage, water usage, work orders, and maintenance status.

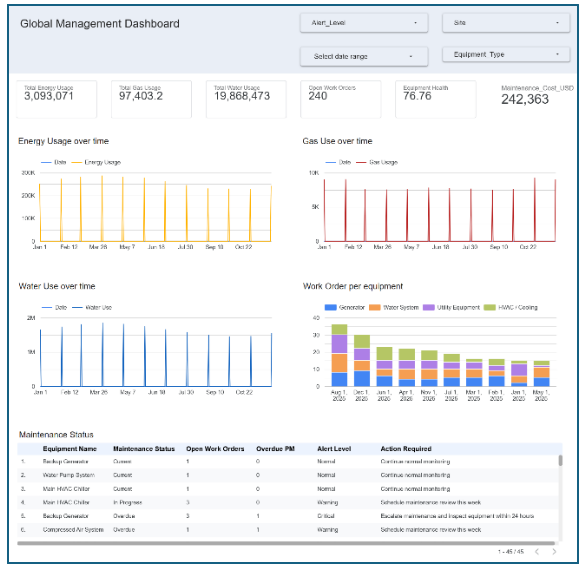

Figure 4
Global Dashboard Display

The dashboard solution has been implemented within a centralized Looker Studio environment that provides both a global comparison view and localized views for each operating site. Rather than creating separate, independent dashboards, each local page functions as a filtered extension of the global dashboard. This ensures that all pages retain the same structural components, including the filter bar, page navigation, KPI row, chart panels, map status logic, and alert tables. By preserving this consistent layout, stakeholders can directly compare performance metrics, such as total electricity, diesel consumption, water usage, operating cost, critical alerts, and data quality across all regions without discrepancies in presentation or logic.

The standardized implementation reinforces alignment between global and site-level analytics, enabling seamless transitions between aggregated and localized insights. Every dashboard page follows the same visual and analytical framework established in the global model, ensuring that users interact with identical data structures regardless of the selected region. While the displayed values currently represent sample or prototype data, the framework has been designed to support real-time operational inputs. Regional adaptations are incorporated through contextual thresholds and operational priorities, allowing each site to reflect its unique environmental and infrastructural conditions without altering the underlying dashboard architecture.

The Puerto Rico filter in Figure 5 exemplifies this implementation approach by maintaining the global dashboard structure while applying localized analytical emphasis. Within the same standardized layout, the Puerto Rico view highlights factors such as multiple anomalies and refreshing data reliability. These contextual indicators are integrated into the existing KPI and alert framework, ensuring that local risks are visible without deviating from the global design. This implementation demonstrates how a governed, reusable dashboard model can support both consistency and regional specificity, enabling effective performance monitoring and decision-making across diverse operational environments.

The California and Russia filters shown in Figure 5 and Figure 6, respectively, utilize the same KPI Cards, chart, map rules, and alert tables as the Puerto Rico dashboard but with the local thresholds and recommended actions according to the area.

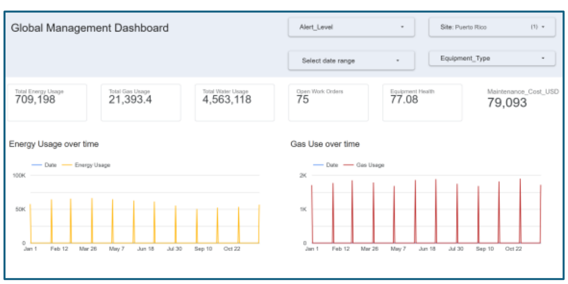

Figure 5
Puerto Rico Filtered Dashboard

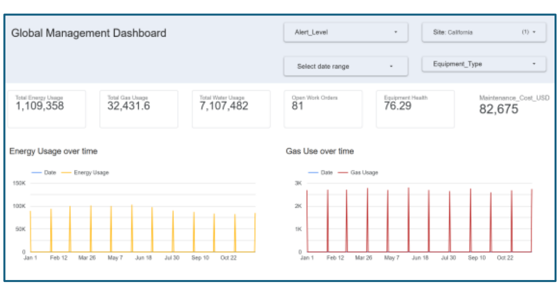

Figure 6
California Filtered Dashboard

The California and Russia filters shown in Figure 5 and Figure 6, respectively, utilize the same KPI Cards, chart, map rules, and alert tables as the Puerto Rico dashboard but with the local thresholds and recommended actions according to the area.

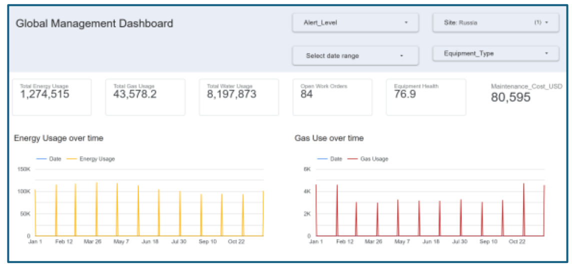

Figure 7
Russia Filtered Dashboard

IMPLEMENTATION

A phased implementation solution provides a structured process that can align and manage technical, operational, and governance boundaries. The process begins with a discovery process to identify key variables, performing activities such as stakeholders' assessments, source inventory evaluation, required KPIs, and security requirements, providing a Scope of Work (SOW).

Based on the findings on the discovery phase, a pilot dashboard can be developed using connected selected resources, and configure basic data flow or query transformations, building a semantic model and dashboard prototype. This part of the process can be considered the pre-implementation phase.

Entering the implementation phase, dashboards are reconciled using source reports, test data quality rules to validate requirements evaluated in the discovery phase and perform a User Acceptance Test (UAT). After the validation phase is completed, the organization can deploy the dashboard to one region/site, setting Row-Level Security (RLS) roles, train users, and provide documentation support process.

After successfully deploying and evaluating user acceptance and continued usage of the tools, the next step is to scale the tool for other sites/regions, this can lead to other improvements such as atomization additional resources, improve data governance, and evaluate more predictive analytics due to the increment in data.

The implementation phase is completed and proceeds post-implementation, it adds processes like hypercare, tool maintenance evaluation, troubleshooting activities, and evaluate implementing upgrade for future versions. Table 3 presents a general overview of the expected implementation process for creating or updating a dashboard, including data integration, validation, transformation, visualization development, and deployment.

Table 3
Implementation Phase Workflow

Phase	Estimated timeline	Key deliverables
1. Discover	Months 1-2	Stakeholder interviews, source inventory, KPI dictionary, workshops, security requirements, dashboard wireframes.
2. Build pilot	Months 3-4	Connect selected sources, configure dataflows or Power Query transformations, build semantic model and dashboard prototype.
3. Validate	Month 5	Reconcile dashboard values against source reports, test data quality rules, tune thresholds, perform user acceptance testing.
4. Deploy	Month 6-7	Publish app, configure refresh, set RLS roles, train users, and document support process.
5. Scale	Month 8+	Add sites, automate additional sources, enable incremental refresh, improve data governance, evaluate predictive analytics.

Evaluation of Criteria and Expected Benefits

The expected benefits aligned with the implementation of the centralized dashboard solution are assessed using key evaluation areas such as data latency, manual reporting effort, alert response time, dashboard adoption, cost control, and sustainability visibility, as summarized in Table 4. These areas provide a general measure of system performance, including how quickly data is made available after updates, the reduction of manual effort required for reporting, improvements in response times to operational alerts, and the level of user engagement with the dashboards. They also reflect improvements in financial oversight through better cost tracking and variance identification, as well as enhanced visibility of sustainability-related metrics across all sites.

Table 4
Expected Benefits

Evaluation area	Metric	Success indicator
Data latency	Time from source update to dashboard availability	Aligned with use case: hourly/daily for operations; monthly for invoices.
Manual reporting effort	Hours spent collecting and reconciling recurring reports	Reduction versus baseline after dashboard deployment.
Alert response time	Time from dashboard alert to owner action or ticket creation	Reduced response time for critical alerts.
Dashboard adoption	Monthly active users and report views by role	Increasing usage among targeted stakeholder groups.
Cost control	Resource cost variance and avoided over-budget events	Improved visibility and faster investigation of variances.
Sustainability visibility	Electricity, diesel, water, and gas trends by site	Improved ability to monitor conservation initiatives.

The main expected benefit is a shift from fragmented reporting to a governed analytical environment. Instead of sending spreadsheets through email, stakeholders access a certified dashboard that uses the same data model and calculations. This reduces duplicate reporting work, improves consistency, and increases confidence in the information used for operational and financial decisions.

A second benefit is faster detection of abnormal conditions. Unusual diesel consumption, excessive water use, high electricity costs, or overdue preventive maintenance can be flagged visually and assigned to responsible owners. Historical trends also allow teams to distinguish normal seasonal variation from operational anomalies.

A third benefit is benchmarking. When all sites use the same definitions and units, stakeholders can compare performance across regions, identify best practices, and focus improvement efforts on sites with the highest cost, consumption, or alert frequency. Benchmarking is especially important for resource optimization because raw consumption alone can be misleading unless normalized by operating hours, production level, climate, or site size.

RESULTS

The implementation of the centralized operational analytics dashboard demonstrated that integrating multiple operational data sources into a single reporting environment significantly improves visibility, consistency, and analytical capabilities across geographically distributed sites. The dashboard environment successfully consolidated operational metrics related to electricity consumption, diesel usage, water utilization, equipment maintenance status, and operational costs into a standardized analytical platform.

The resulting dashboard framework enabled stakeholders to evaluate global and regional operational performance using a unified KPI structure. The implementation confirmed that maintaining identical dashboard logic across all regions improved comparability between sites while reducing inconsistencies previously caused by fragmented reporting methods. The global dashboard view allowed executive users to identify operational anomalies, compare resource consumption trends, and monitor alert conditions across all locations simultaneously.

The implementation also demonstrated improvements in operational monitoring efficiency. Historical trend visualizations enabled stakeholders to identify abnormal increases in diesel usage, spikes in electricity costs, and overdue maintenance activities. These analytical capabilities improved the organization's ability to detect anomalies earlier and investigate operational issues more efficiently. The dashboard's integration of descriptive and diagnostic analytics provided users with both historical visibility and contextual understanding of operational conditions.

From a performance perspective, the use of staged transformations, semantic modeling, and incremental refresh strategies supported efficient handling of large historical datasets while maintaining near real-time visibility for operational metrics. The architecture validated that separating source systems from the analytical layer improves scalability and simplifies future integration efforts for additional sites and operational resources.

Overall, the results demonstrate that the proposed centralized operational analytics dashboard successfully supports operational monitoring, cross-site benchmarking, sustainability tracking, and data-driven decision-making through a governed and scalable Business Intelligence architecture. The implementation confirms that standardized dashboard environments integrated with automated data acquisition and transformation processes can significantly enhance operational visibility across globally distributed sites.

RISKS AND MITIGATIONS

The key implementation risks including data quality, integration, performance, security, and user adoption, along with their potential impacts are presented in Table 5.

Table 5
Risk, Impact, and Mitigation Strategies

Risk	Potential impact	Mitigation strategy
Poor source data quality	Dashboard values may be inaccurate or incomplete.	Implement validation rules, data quality scorecards, owner notifications, and exception handling.
Integration complexity	Different formats, systems, and may delay implementation.	Start with a pilot, prioritize high-value sources, and use standardized templates
Refresh performance issues	Large datasets may refresh slowly or fail.	Use incremental refresh, appropriate storage modes, staged transformations, and model optimization.
Security and confidentiality concerns	Users may see data outside their authorized sites.	Implement row-level security, workspace roles, access reviews, and governance policies.

Low user adoption	Stakeholders may continue using spreadsheets.	Involve users early, provide training, align visuals to decisions, and publish certified reports.

CONCLUSION

This article presents a centralized reporting solution for global operational monitoring. The solution integrates equipment maintenance, diesel/gas, electricity, water, and cost data into a governed semantic model and interactive dashboard environment. By combining data acquisition, validation, transformation, modeling, refresh automation, security, and dashboard visualization, the proposed system improves operational visibility and supports data-driven decision making.

The proposed approach is scalable because it separates source systems from the analytical layer, uses reusable data semantic modeling, and supports phased deployment. It also aligns operational analytics with cost control and sustainability objectives by enabling leaders to monitor consumption, detect anomalies, compare sites, and track improvements over time. The added Puerto Rico, California, and Russia dashboard pages further demonstrate scalability because a common semantic model can support different local views while preserving shared definitions for cost, consumption, alerts, and data quality.

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