WHITEPAPER

Energy Management with the PI System

Reduce Your Energy Costs

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OSIsoft.

Table of Contents

Abstract

Energy is one of the largest operational expenditures for many organizations, and even marginal reductions in energy consumption can significantly impact costs. Many companies embark on energy initiatives but fail due to a lack of visibility into energy consumption, lack of baselining, and an inability to quantify benefits from energy reduction initiatives. The PI System™ by OSIsoft can help organizations understand their energy landscape, baseline energy consumptiton, create Energy Performance Indicators, and determine the impact of energy initiatives. This white paper outlines how organizations can employ the PI System to capture energy metrics to provide real-time and historical visibility on energy utilization. This enables baselining energy utilization across your enterprise, and will provide understanding on the impacts of your energy initiatives.

Introduction

Energy is a critical component for organizations, and a potentially significant operating expense. One of the standards available for energy management is ISO 50001. Many organizations have adopted (or are starting to adopt) this standard for energy management to reduce their energy costs, as part of corporate sustainability initiatives, to comply with environmental policies, or to minimize their company's impact on the community. An integral component of the ISO 50001 standard is to baseline energy use, efficiency, and consumption, and then continually monitor and measure processes to determine if energy performance matched defined objectives and report the results. The PI System is well suited in helping organizations implement these requirements. With the PI System, companies can:

- capture and consolidate energy data from assets, meters, and external systems at a fidelity that provides the needed visibility to assess energy performance.
- organize energy data and create analytics to baseline, monitor, and measure energy performance.
- provide powerful tools to analyze and share energy performance information. PI System information can be presented to users in a variety of ways and shared with other enterprise systems.

This document outlines strategies to applying concepts from the ISO 50001 in conjunction with the PI System infrastructure to improve your company's energy management, and become more energy efficient within your operations. Specifically, this paper will discuss how you can use the PI System to define a model for energy management and create analyses to capture Energy Performance Indicators (EnPIs). Lastly, this paper will outline strategies for measuring, monitoring, and reporting your energy performance.

Problem Definition

As you begin implementing an energy management strategy for your company, it is important to:

- clearly define a corporate policy and objective for your strategy.

- establish an infrastructure to baseline energy usage.
- continually monitor your energy usage against your energy management goals.

Unfortunately,the lack of clear policies and objectives frequently lead to failed energy management programs for organizations. Using a standard such as ISO 50001, which contains a clear framework and detailed steps for an energy management strategy can improve your company's chances of success, regardless of whether or not you intend to fully implement the ISO 50001 standard.

ISO 50001 is based on a Plan-Do-Check-Act continual improvement framework and incorporates energy management into everyday organizational practices.

- **Plan:** Conduct an energy review, establish a baseline, create EnPIs, define objectives, create targets, and design action plans to deliver energy performanance results for identified opportunities per your company's energy policy.
- **Do:** Implement the energy management action plans identified in the plan phase.
- **Check:** Monitor and measure processes and determine energy performance against the energy objectives and energy policy and report the results.
- **Act:** Continually improve your energy performance and EnMS.

The PI System can help organizations meet the objectives in each of these phases. For example, in the Plan phase, organizations must establish a baseline, create EnPIs, and define targets. The PI System can collect energy data from your instrumented equipment and meters to baseline energy utilization, and collect process information from 3rd party enterprise systems like Lab Information Management Systems (LIMS). These sources of information are essential in generating EnPIs such as energy/ton or energy/product. The PI System centralizes your various sources of information, and provides tools to create analyses and calculate defined EnPIs. Similarly, the Check and Act phases of the framework require continually monitoring and measuring processes to determine energy performance. This requires organizations to see both historical and current energy performance. With the PI System you continual, simultaneous, visibility into current, historical, and forecasted energy performance.

High-Level Solution

The Plan phase of the ISO framework requires an energy audit to measure current energy performance and identify gaps. This step is critical to understand what energy information is currently available within your organization. In many instances, additional metering is required to get to the right level of granularity to meet your energy reduction objectives. However, lack of metering should not preclude organizations from collecting whatever energy information is available, modeling it, and defining EnPIs. While this document does not cover data collection, it is worth noting that OSIsoft offers a variety of interfaces and connectors to collect information from SCADA, PLC, DCS, meters, and many other data sources that can help you obtain additional information for your initiatives. Understanding energy utilization within a site and across your enterprise can provide value to your organization in many ways, including:

- reducing energy through process improvements.
- identifying energy spikes.
- generating EnPIs such as kWh/ton or kWh/product.
- comparing specific energy consumption between technologies.
- comparing billing meter against actual and calculated energy usage.

For those with limited metering capabilities, you can pursue energy optimization plans based on your current data visibility, and as your ability to measure and track energy usage expands, implement new plans to achieve further optimization. However, before pursuing any energy reduction initiatives, it is important to use current energy consumption data to establish your energy baseline. Without a baseline, it will be difficult to quantify the effectiveness of your energy reduction initiatives and measure progress towards your overall energy goals.

Modeling Energy Performance

Designing a model for your energy usage which incorporates analytics, rollups EnPIs, calculates overall energy efficiency, presents energy usage by assets/process areas and enables visibility into real-time energy performance can help you surface the information throughout your organization and increase yields from your energy optimization efforts.

The first step in designing a model for energy management is to understand the relationships between your equipment/assets, process area, and overall organizational hierarchy. To that end, organizations can follow the ISA 88/ISA 95 standards to maintain consistency in terminology, definitions, process models, etc. Alternatively, organizations can develop their own model to structure energy performance data. In either case, the hierarchy should be sufficiently granular to capture all available energy performance information. To make maintenance and deployment of your model and its corresponding templates easier, it is essential to use a standard in developing your hierarchy.

The PI Server allows you to capture energy data from your equipment in real-time, and model and enhance that data to generate meaningful results. The PI Asset Framework (PI AF) – part of the PI Server – allows you to generate asset-centric models, hierarchies, and equipment-based definitions refered to Elements. PI AF integrates, contextualizes, references, and further analyzes data from multiple sources, including one or more Data Archives and external relational databases. Elements can contain multiple types of information known as Attributes. This information can range from calculations using Asset Analytics to process data from the PI Data Archive to name plate data from external relational databases.

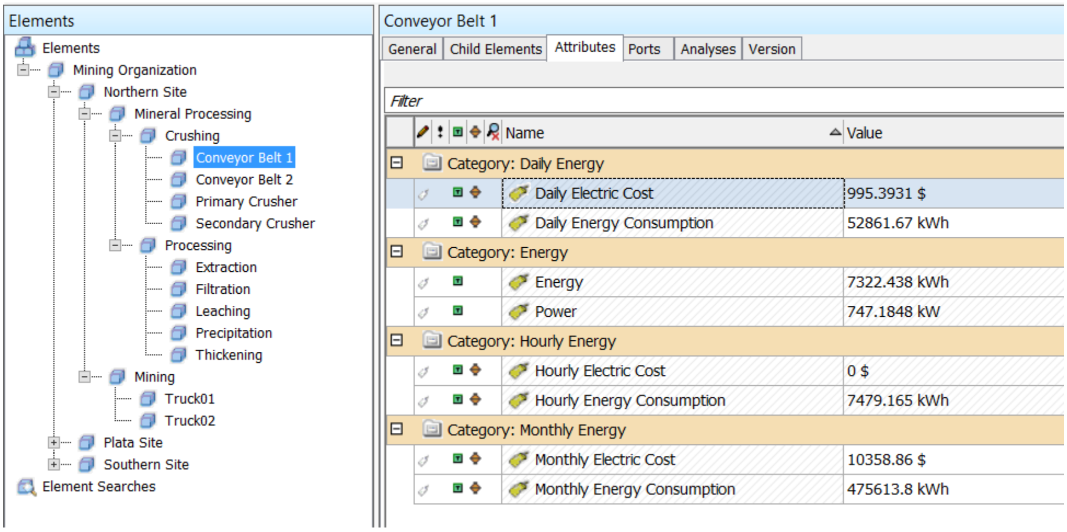

Figure 1: Energy Model Example

Figure 1 shows a PI AF model centered around energy. It shows a typical hierarchy that starts at the enterprise level, and goes down to the equipment level. This hierarchy allows visibility of energy performance from a high level organization overview, and down to individual assets. Additionally, the model allows energy performance to be aggregated from the equipment to process areas up to a site then up to the organization. In this example, energy information from assets is captured and recorded in real-time and the Asset Analytics are used to calculate an hourly, daily, and monthly energy consumption and costs.

Template Definition

Organizations should define their PI AF templates for the various levels of their processes and assets in a manner that can be reused across sites. Templates can be built using the derived inheritance functionality in PI AF, by starting with the most general model for a piece of equipment, and then adding specific attributes based on the asset type (e.g. assets with throughput vs non-throughput). This approach will make your templates reusable across other assets/equipment and across other sites. This approach will also enable you to add appropriate calculations and analytics to your template definition thereby standardizing the calculations, analytics, and EnPIs across your organization. For example, some assets may not have a power reading but may have a current reading. By creating a separate template for these types of assets, the power calculation can be automatically included in the template definition.

Furthermore, using categories for your templates will allow you to separate templates developed for energy management from other types of templates. And your categorization can be extended to group templates with similar attributes together for improved analysis in the PI System Tools.

Another important requirement of energy management is visibility into energy utilization straight down to the asset level. Key to this visibility is an adequate timescale resolution. Asset Analytics calculations can be configured within your templates to calculate energy utilization at any timescale resolution. However, it is not always pratical or possible to calculate all EnPIs at high fidelity – for example EnPIs that require information that is only updated once per shift or daily. In Figure 2, categories have been used to classify the information in the model both in terms of data aggregation type (hourly, daily, and monthly) and process.

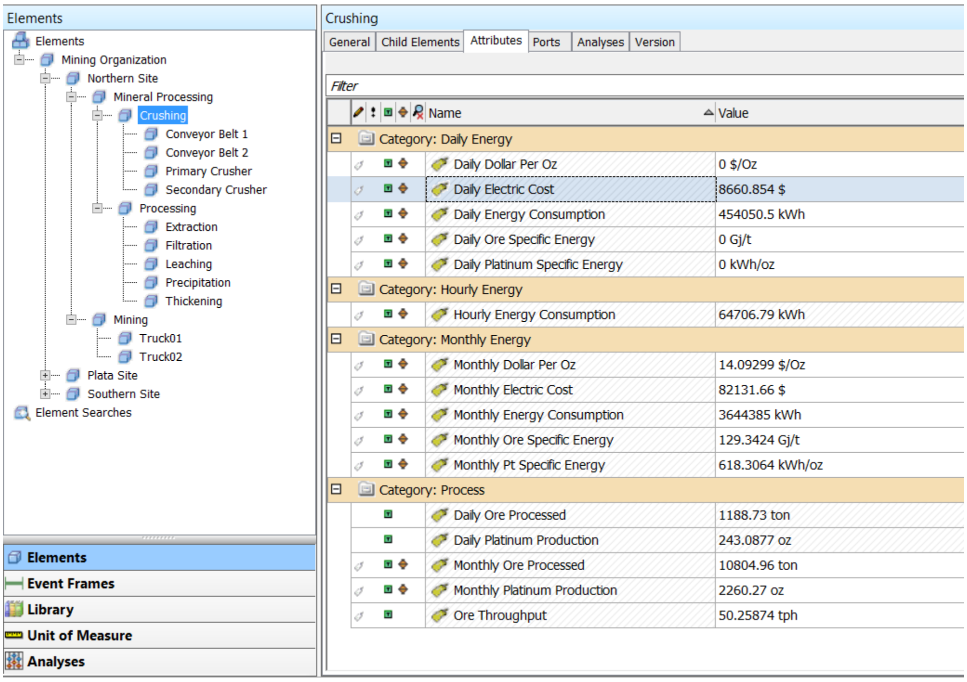

Figure 2: Area Level Energy Model Example

Energy Performance Indicators

As part of the energy management program, organizations must define EnPIs to adequately measure, benchmark, and capture energy performance. Each organization will need to capture the appropriate EnPIs to understand their energy landscape. Typical EnPIs focus on measuring energy performance as a function of total production, e.g. kwh/production or kwh/widgets made, or as a function of material processed, e.g. kwh/ton of raw meterial. This requires production and energy information to be aggregated into a single system for analysis. It is important to note that production data may not be available at the same fidelity as energy data. That is to say, production data is typically reported on a per shift or per day basis, while energy data is available at second/minute frequency. Therefore, it is important to define realistic timescales for your EnPIs while still ensuring they provide value to the organization.

Visualization and Reporting

Once energy data is captured and analytics have been configured to generate EnPIs, the next step is making the data available to individuals in your company in whatever format that provides the most value to them. To that end, the PI System includes a number of analysis, visualization, and integration capabilities. Consider the following scenarios:

- Users who need to to generate weekly or monthly reports to track energy utilization and assess the impact of energy initiative can bring the data they need into Microsoft® Excel® reports with PI DataLink.
- Standard interactive reports can be created with tools like Microsoft PowerBI or SQL Server Reporting Services, and data can be feed to these reports/tools with the PI Integrator for Business Analytics.
- Energy dashboards or process displays can be created in PI Vision™ to provide real-time visibility into your energy landscape, which can be leveraged by your users on any platform be that a phone, tablet, or computer. These dashboards/displays can convey a wealth of information in a graphical format making it easy to consume and understand.

Solution in Action – a Mining example

The methods described earlier are applied to a pratical example within the mining industry.

Energy consumption for the crushing equipment (Conveyor Belt 1/2 & Primary/Secondary Crushers) at the Northern Site is collected in real-time and aggregated into a daily total at the equipment level. This information is rolled-up to the parent level – in this example the Crushing area element. Similarly, the energy data from the Processing area equipment is collected and aggregated to a daily total which is then rolled-up into the Processing area element. The Crushing and Processing area information are then rolled-up to the Mineral Processing level, and this pattern continues until all data is aggregated to the Organization level.

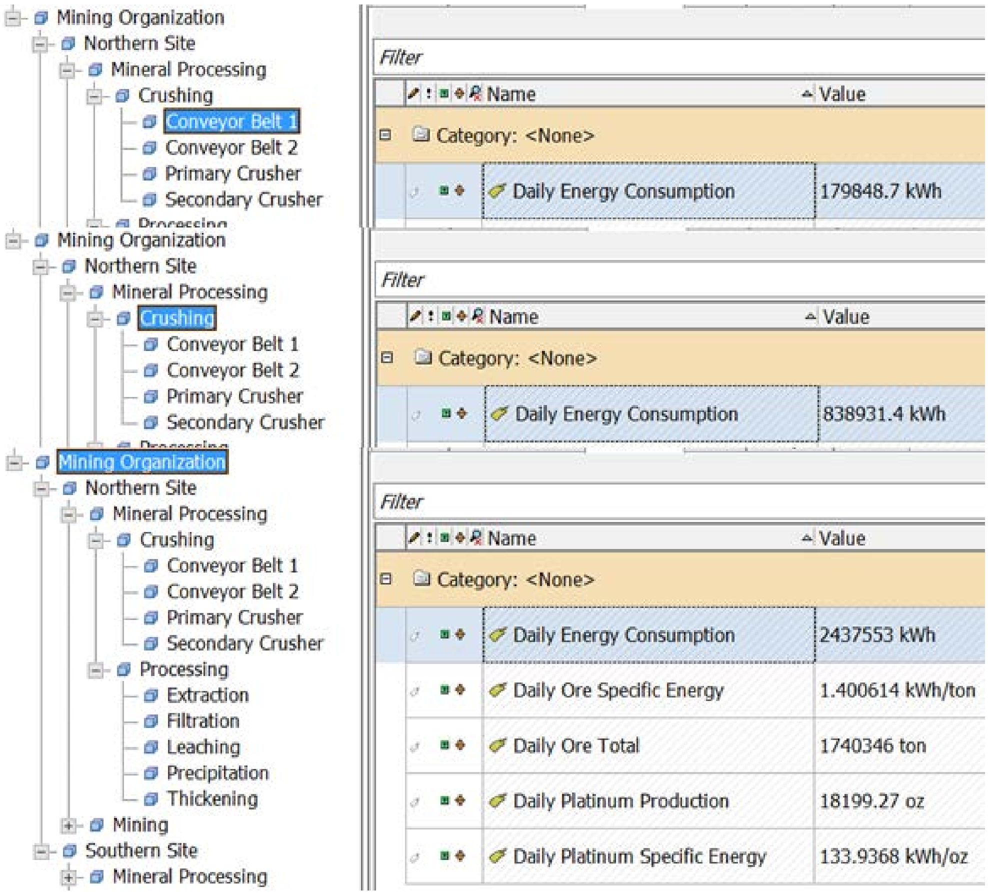

Figure 3: Energy Model Example for a Mine

Additionally, information can be reported at only one level of the model, but by required EnPIs at various levels of the model. One such example would be the amount of ore produced for a mine site. For this example, we are using platinum but the concepts would apply to any mined material. Typically this would reported at the mine level, but the information would also be required at the process and area level to calculate EnPIs such as specific energy of platinum ounces produced (kwh/oz) or specific energy of ore processed (kwh/ton). The model allows this information to be captured once, at the appropriate level, and then be referenced by other levels using PI AF substitution parameters as shown below.

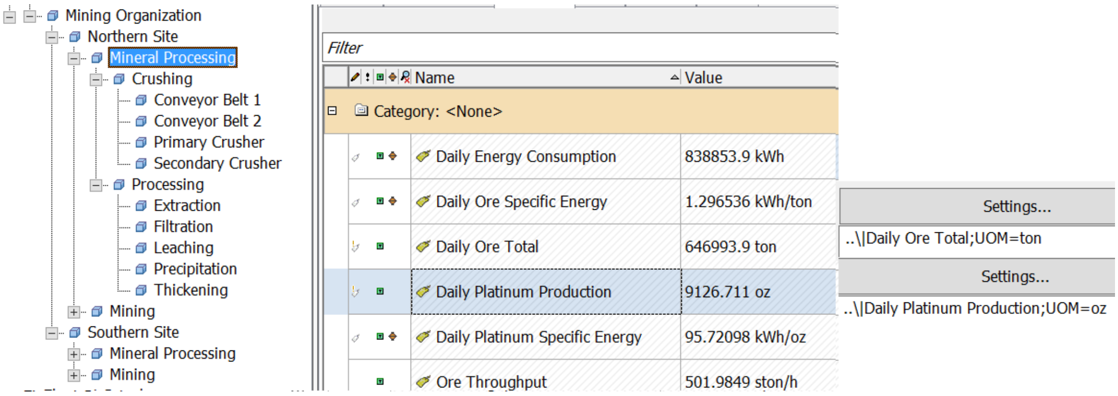

Figure 4: Substitution Parameter to Retrieve Daily Production

This example shows the daily platinum production, and the total daily ore processed at the Northern Site. This information is captured at the Site level and referenced in the Processing and Area levels to generate Daily Ore and Daily Platinum Specific Energy calculations, respectively.

The Elements of the PI AF model are based on Element Templates to ensure consistency in the element definition as well as the types of analysis that are being captured within the element. In this model, energy calculations were created for each level of the model. Specifically, two analyses were created to calculate EnPIs to correlate the impact of ore and ore blends on energy utilization.

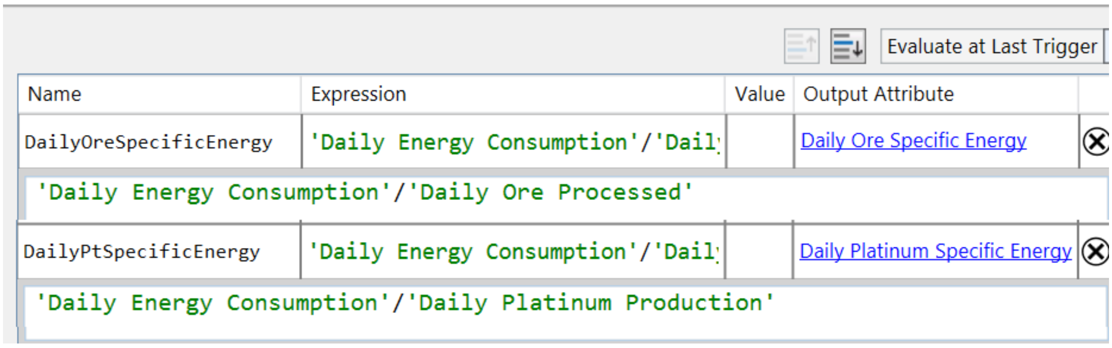

Figure 5: Specific Energy Analyses Example

The first EnPI looked at assets that measured throughput (Daily Ore Specific Energy), in this case tonnage of processed ore, while the second (Daily Platinum Specific Energy) looked at overall energy utilization per day divided by ounces of platinum produced. The kWh/ton EnPI is useful in understanding the effect of ore grades, ore blends, and throughput on energy consumption. Some ore blends can lead to higher throughput resulting in a lower Ore Specific Energy, but this does not necessarily correlate to higher platinum yields. The kWh/ton calculation was created in the area template. Two variables are used for this analysis:

- “Daily Energy Consumption”, calculates the daily energy consumption for the area by rolling up the equipment energy consumption.

- “Daily Ore Processed”, is a measurement available at the Mineral Processing level of the model.

Furthermore, in order to understand the impact of ore grades on energy, a kWh/Oz_Pt specific energy EnPI was created to normalize energy utilization per ounces of platinum produced. This EnPI is useful in understanding the effects of ore grades and ore blends on energy utilization and provides a metric to compare energy utilization across mine sites. The PI AF energy model also includes an analysis at the area level, which is scheduled on a daily basis. The calculation has two variables as inputs: daily energy utilization and daily platinum production (see Figure 5 above). Lastly, a new Unit of Measure was defined in AF to support the resulting specific energy measurement generated by the analysis (kwh/Oz).

Specific Energy

Filter

Name	Abbreviation	Class	Canonical
British thermal unit per pound	Btu/lb	Specific Energy	2326 J/kg
foot pound-force per pound-mass	ft-lbf/lbm	Specific Energy	2.98907 J/
gigajoule per ton	Gj/t	Specific Energy	1000000 J,
joule per gram	J/g	Specific Energy	1000 J/kg
joule per kilogram	J/kg	Specific Energy	1 J/kg
killowatt hours per tonne	kWhr/t	Specific Energy	1 J/kg
kilocalorie per kilogram	kcal/kg	Specific Energy	4186.8 J/k
kilojoule per kilogram	kJ/kg	Specific Energy	1000 J/kg
kilojoule per pound	kJ/lb	Specific Energy	2204.6226
kilowatt hours per ounce	kWh/oz	Specific Energy	12700000(
Megajoule per Ton	MJ/T	Specific Energy	1 J/kg
meter kilogram-force per kilogram	m-kgf/kg	Specific Energy	9.80665 J/
MJ/Mt	MJ/Mt	Specific Energy	1000 J/kg
mOhm	mOhm	Specific Energy	1 J/kg

Figure 6: Specific Energy UoM

The Daily Platinum Specific Energy and Daily Ore Specific Energy EnPIs are first calculated in the Area level and aggregated all the way through to the Organization level. Additionally, daily measurements are used as inputs to calculate the monthly measurements with a simple analysis automatically totatilzing the result.

Once all the energy data has been aggregated in the PI System and the analytics have been created to generate EnPIs, information can be made widely available to users throughout the organization through dashboards and reports. For example, a high-level mining dashboard can convey energy utilization for major assets in the process, key production data, and the EnPIs as shown in Figure 7 below. The dashboard in Figure 7 was created in PI Vision™, which allows end users to access the displays through any platform be it a phone, tablet, or computer. The information conveyed in this display shows real-time energy consumption for the larger pieces of equipment such as the conveyor belt, primary and secondary crushers, and filtration system. Furthermore, in green we have the production information for the site such as daily platinum production, daily ore processed, and current ore throughput. Lastly, the energy performance indicators are shown in the dark blue boxes.

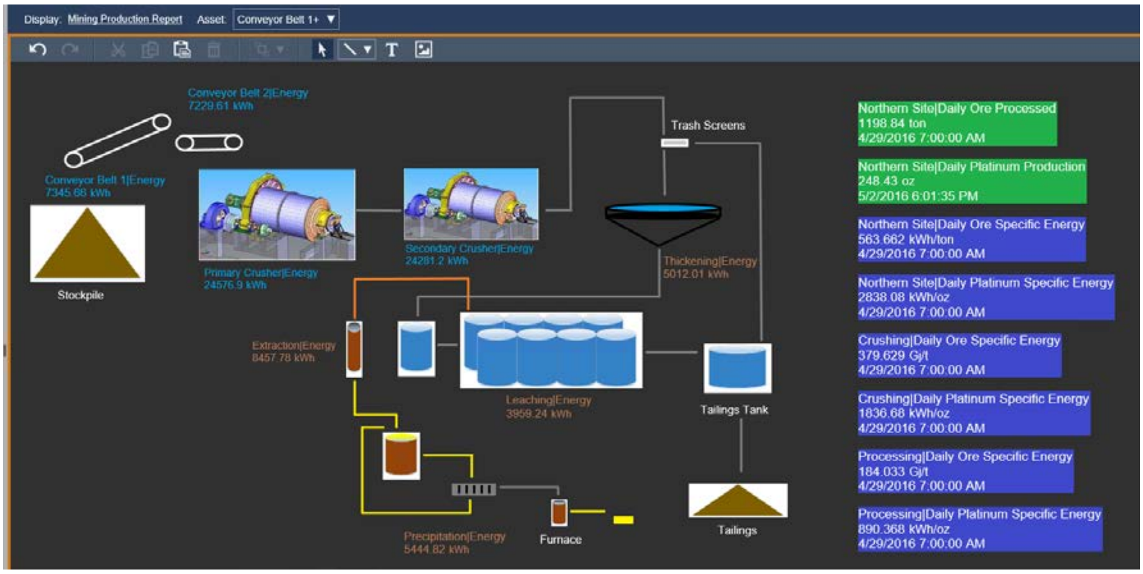

Figure 7: Site Level Energy Dashboard

This information can also be delivered via reports in Microsoft Excel, PowerBI, or using reporting services such as SQL Server Reporting Services. This is especially useful when users need to interact with the information or tailor it to their specific needs. An sample Microsoft PowerBI report is shown in Figure 8. In this example, the current month's platinum production, average platinum specific energy, and and average ore energy for the entire organization are shown. The bar graphs show the monthly energy consumption and electric cost at a daily interval for the organization. The table at the bottom has similar information presented in tabular format, which can be sliced by mine sites. The data used for the report was configured and delivered with the PI Integrator for Business Analytics.

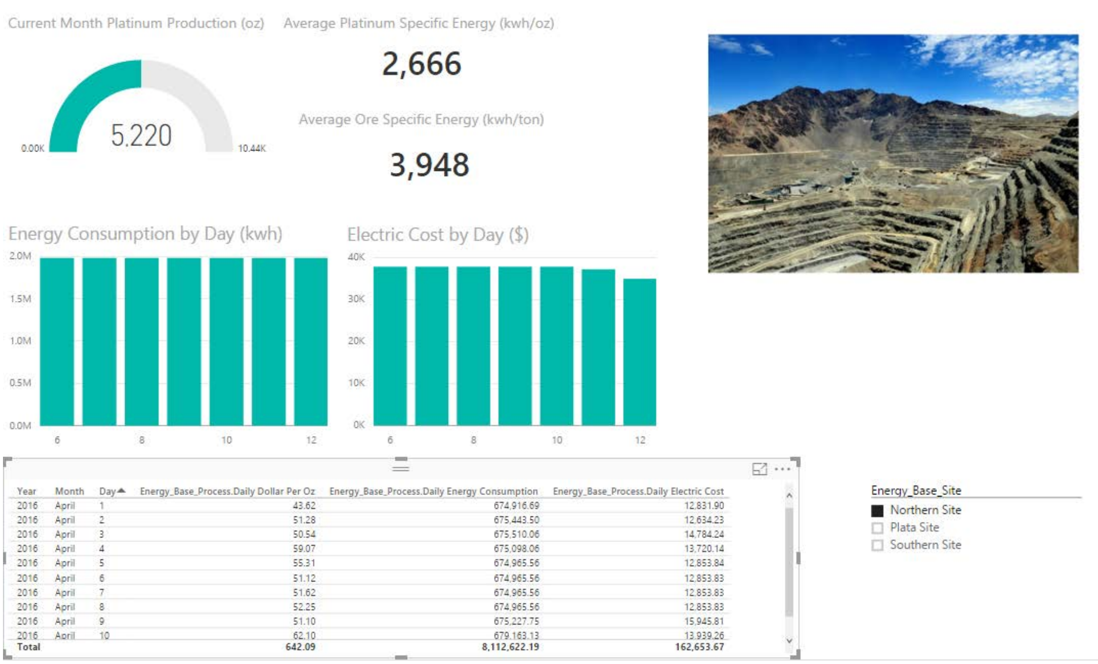

Figure 8: Site Level Energy Report

Business Benefits

Energy costs are a large operational expenses for most industries. Understanding your energy utilization is extremely important for driving process improvement and efficiency as well as to adopting an energy conscious culture within your organization. With better visibility into energy usage, it is easier to understand how operational practices impact energy consumption. But reducing energy consumption is not just good for the bottom line. Reducing energy consumption can also minimize an organizations carbon footprint, reduces overall societal impacts, and a improve (or maintain) company's reputation as a good environmental steward.

For example, Anglo American Platinum used the PI System to provide visibility of power consumption, and to enable various energy management initiatives. They achieved a 1% reduction in electrical power consumption simply by making the data visible across the organization. This reduction was due in part by providing real-time feedback to end users, allowing them to see the impact of changes they made to the process. Carnegie Melon University embarked on a project to monitor facilties with the PI System and Microsoft Azure Machine Learning. Through their work, they concluded that they could reduce energy costs by 20% by implementing their solution. Similarly, MOL Group, an international Oil and Gas company, is utilizing the PI System to generate EnPIs to monitor energy data. They expect a reduction of 2% steam and fuel gas consumption as well as a 20,000 ton/year reduction in CO_2 resulting in €3.5M per year in operational cost reduction. These are just a few use cases that PI System users have been presented at the OSIsoft Users Conferences. Additional stories can be found on www.osisoft.com.

Summary

In conclusion, energy is one of the largest operational expenses for many organizations any reduction in energy consumption can result in significant savings. Companies in a variety of industries can benefit significantly from understanding their energy landscape. The PI System can help your company baseline its energy consumption, drive process improvement, increase efficiency, and provide visibility into the impact process descisions have on energy initiative goals. Companies that wish to leverage the PI System for energy optimization projects can work on adopting the strategies outlined in this whitepaper by contacting OSIsoft and inquiring about ourPI AF Workshops.

About OSIsoft, LLC

OSIsoft, a global leader in operational intelligence, delivers an open enterprise infrastructure to connect sensor-based data, operations, and people to enable real-time and actionable insights. As the maker of the PI System, OSIsoft empowers companies across a range of industries in activities such as exploration, extraction, production, generation, process and discrete manufacturing, distribution, and services to leverage streaming data to optimize and enrich their businesses. For over thirty years, OSIsoft customers have embraced the PI System to deliver process, quality, energy, regulatory compliance, safety, security, and asset health improvements across their operations. Founded in 1980, OSIsoft is a privately-held company, headquartered in San Leandro, California, U.S.A., with offices around the world. For more information visit www.osisoft.com.