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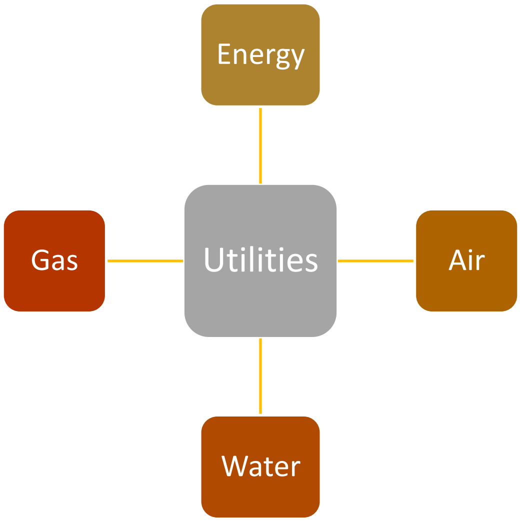
WHITEPAPER

IIoT for Utilities in Manufacturing

Be it a large-scale manufacturer or a small-scale production unit, they all require one thing in common, and that is the primary plant utilities, like energy, air, water, and gas. Though considered to be basic, utilities are the essential amenities for the effective functioning of any manufacturing unit, facilitating the production process. Utilities can also be one of the key contributors to the overhead cost of manufacturing.



This white paper discusses the typical challenges with managing utilities in an industrial setting, and applicability of IIoT interventions to overcome these challenges and enable improved overall plant efficiency, performance, cost of operations, quality, and safety.

Utilities in Manufacturing

Manufacturing facilities are the major consumers of energy comprising approximately 32% of the energy end use in the US. Efforts to improve energy efficiency are an increasing concern for many facility engineering managers. [1]. Energy or power is at the heart of any manufacturing facility hence energy shortages during production can disrupt the manufacturing process and even lead to damage or significant scrap. In addition, increasing power costs also pose a barrier to managing the bottom line and profitability. A data from US reported that 21% of the manufacturing plants suffered a financial impact of $100,000 and more in a single outage. [2]

An HVAC- Heating Ventilation and Air conditioning system, which includes chillers, pumps, air handlers, and compressors is a critical utility in highly sensitive manufacturing industries like pharma to maintain the right operating conditions like temperature, pressure, humidity and control contamination, all necessary to assure manufacturing of high-quality products. HVAC systems display a wide range of problems, including thermostat malfunctioning, clogged filters, mechanical wear and tear, dirty condenser, water leaks, which require constant surveillance and maintenance. HVAC systems contribute to almost 25% of the energy consumption in a typical factory facility, and therefore, efficient operation and maintenance is always a critical priority for facility managers.

In addition to Energy and Air, most industries utilize water in some form. Water has unique chemical properties due to its polarity and hydrogen bonds. This means it can dissolve, absorb, adsorb, or suspend many different compounds, including contaminants. Thus, it needs to be of high purity, and it is of great importance that its composition analysis is carried out to identify contaminants that may interfere with its quality and compromise the efficacy and quality of products in the manufacturing process. In some industries, treatment of water like distillation and reverse osmosis is required and critical for the manufacturing process. These water treatment techniques are quite expensive and energy intensive. An extensive monitoring of water consumption and the performance of the equipment involved in water treatment is mandatory for the smooth functioning of the unit.

Gas, which is mostly consumed as fuel for power generation, is also an energy source for several other industries like pulp and paper, metals, chemicals, petroleum refining, stone, clay and glass, plastic, pharma, and food processing. Apart from its use as an energy source, natural gas has a variety of functions, including feedstock for manufacturing, metals preheating (particularly for iron and steel), drying and dehumidification, glass melting and food processing.

Significance of Utilities Across Industries

Utilities can have a direct or indirect impact on product quality, cost, as well as on operational productivity and reliability. There are industries where a minor deviation or error in the primary plant utility directly affects the product, resulting in expensive losses and serious consequences.

For example, in the pharma industry, clean steam is used as a sterilizing agent, so it is essential to maintain the desired temperature and flow rate throughout the Sterilize In Place (SIP) cycle. Any change in this process results in incomplete sterilization affecting the quality of the product drastically.

Likewise, in Food & Packaging Industries, a continuous supply of compressed air is used for vacuum sealing of food packages. Lack of compressed air or indifferent amount of air pressure will affect the packaging, hence the shelf life and food quality directly.

Apart from the direct impact on product build and quality, utilities also affect the unit efficiency and cost if not managed well. For example, in the automotive industry, under-utilization of press and welding machines, or frequent power shut down, and startup raises the energy consumption due to wastage of energy, leading to additional overhead cost, affecting the final competence of the plant.

As another example, the HVAC system provides a better environment for machines for sustainable operation, and workers with a comfortable atmosphere. The absence of an HVAC system leads to a reduction in the life of a machine resulting in frequent disruptions and error in the production environment.

Likewise, in refractory manufacturing, continuing the kiln firing with the same amount of fuel energy when there is no product moving in, leads to high energy consumption with lower productivity.

We have established a clear need for a system to monitor, control, and maintain utilities continuously. The following sections describe the challenges of the existing systems and how to overcome those challenges leveraging Industrial IoT solutions.

Key Challenges in Utilities Management

There are many standalone systems in the market for utility management, deployed for monitoring and control of the plant utilities. However, these systems tend to be purpose-built and OT centric with little interoperability.

Challenges in Utilities System

- No centralized monitoring at a facility or across facilities
- Minimal capablity to predict equipment failure using machine learning
- Systems are disparate and purpose built e.g. BMS, EMS, MES etc
- Lack of data interoperablity, IT/OT integrations
- Lack of integration with production data /machines
- Lack of infrastructure to handle big data

For example, an Energy Management System mostly focuses on Energy/Power meter integration, monitoring, and reporting of energy consumption. Similarly, a Building Management system (BMS) focuses on connecting with AHU and HVAC, providing operational insights about cooling and HVAC assets. These individual systems may not be interoperable and do not offer an aggregated view of utility consumption. Legacy system infrastructure and processing power cannot handle large volumes of data, storage, and processing. Moreover, the lack of IT/OT integration through these monitoring systems result in manual work that includes feeding energy data into an ERP system.

There is a need for a single IT/OT converged system that:

- connects with existing BMS, EMS systems, gather
- analyzes data to provide central & remote monitoring function, and
- provides advanced analytical capabilities.

This can be achieved with Industrial IoT solutions that leverage and enhance current systems and provide a smarter way to centrally manage most utilities while enabling the business to drive additional competitiveness.

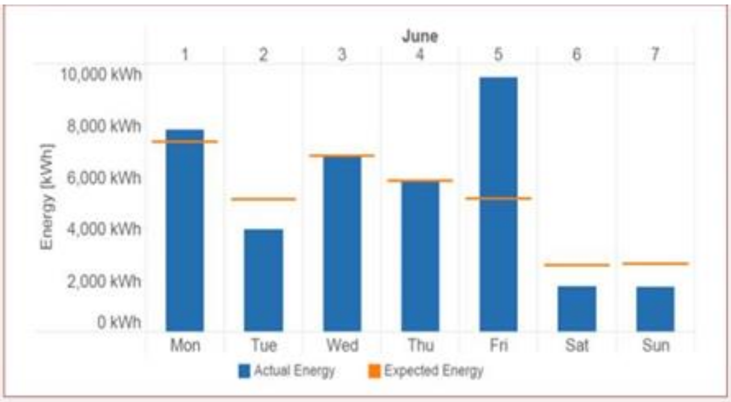
Industrial IoT as an enabler in Utility Management

Energy/Power

As energy/power is one key component that impacts productivity and cost, it is essential to have a competent IIoT based Energy Management System (EMS). In a plant, the EMS mainly corresponds to adequate, uninterrupted power distribution to the required areas and monitoring the power consumption by different equipment in these different areas or departments. In many industries, conventional EMS exists as an energy monitoring and consumption reporting tool. However, we need to have a system that can give more in-depth insights on forecasting demand and recommending necessary configurations to help the user to make faster decisions in a cost-efficient manner, all of which can be achieved by using AI/Machine Learning technologies.

IIoT technology can enable such a system. IIoT based smart meters provide visualization and essential information on the energy usage of the different areas of the manufacturing unit in real-time. With these systems in the process, we can predict usage patterns and energy demand, receive real-time alerts, and identify methods for energy consumption, energy-consuming hotspots, power loss, or overload deduction.

One of the key use cases is demand forecasting, which by leveraging IIoT, helps the plant team to run efficient planning and operations; thus, it can be used to minimize energy waste, reducing overall cost spent on energy consumption and resource utilization.

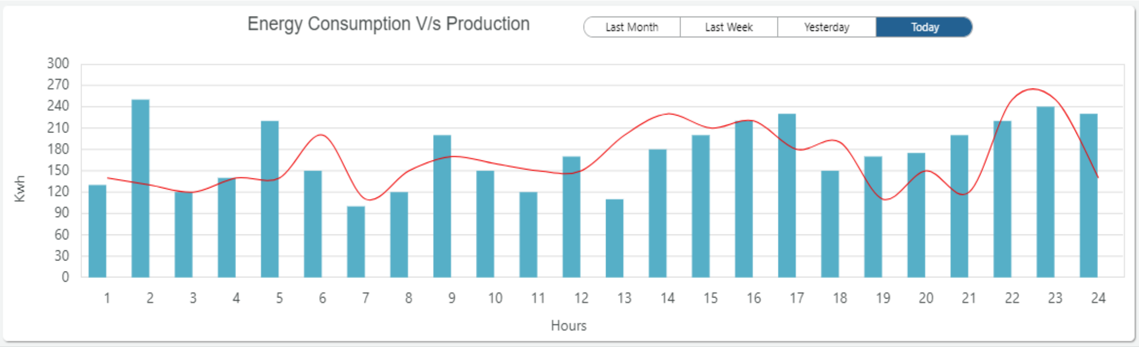


Demand forecasting makes better predictions of energy demand with more accurate forecasting models based on more data from more sources, including smart meters and weather stations. Automatically track model accuracy and easily update models to reflect changes.

The trends shown in the above picture, help the user to run a root cause analysis of energy consumption gone beyond the expectation on a particular day.

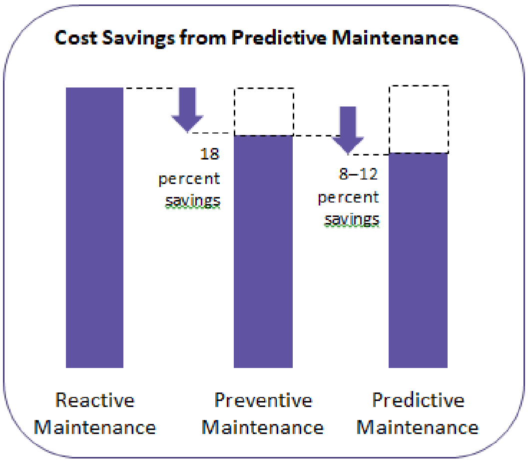
Another key use case is the integration of the IIoT system with production facility assets is that it helps to analyze utility cost per product to determine wastage of energy, which is a key element of energy optimization.

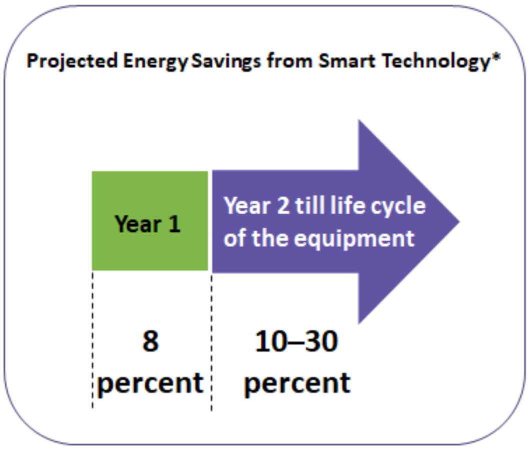
The following chart indicates the correlation of energy consumption vs. production output by which the user will be able to understand the effectiveness of energy consumption in a particular hour, e.g., if the energy consumption is high and the produced quantity is less, then that indicates that there is an issue in the machine or line or the machine was running idle for a longer time. A study conducted in a beverage manufacturing plant showed that the use of IIoT based smart meters resulted in $172,281 of annual energy savings and saved 807,081 kWh/annum of electricity [5].



Air (HVAC system)

A typical HVAC maintenance is reactive in nature, where technicians have a list of service requests to complete for a day. A technician must identify what has led to the failure and carry out the maintenance accordingly. Reactive maintenance wastes valuable labor time and effort unlike predictive maintenance provided by IIoT solutions where all the HVAC equipment are linked to the IIoT gateway. In such an environment, the data can be easily accessed and analyzed through big data, and the predictions are made available on desktops or easily accessible via mobile applications to facility managers to act immediately. The anomaly detection functionality compares the present data with previous data and picks up even the slightest variation, predicting the potential problem and helps avoid system failure.





https://www.beroeinc.com/article/iot-predictive-maintenance-hvac-systems/

For example, during regular operation, when a chiller is loaded, it operates stable but continuous running of chiller when there is no load may lead to wastage of energy, wear and tear for the machine, reduce asset lifetime, all of which in turn increases the maintenance cost. It is essential to analyze the running /loading capacity of the chillers for better performance and improve the asset lifetime.

With the help of descriptive-analytics functions of IIoT, real-time running capacity data of chiller can be captured, analyzed, and compared with cooling demand from factory floors and facility. The actual load requirement can be determined or measured from the sensors and based upon the chiller operation, the system recommends the user to act on reducing the chiller running capacity, which in turn reduces the wastage of energy and also increases the efficiency of chillers.

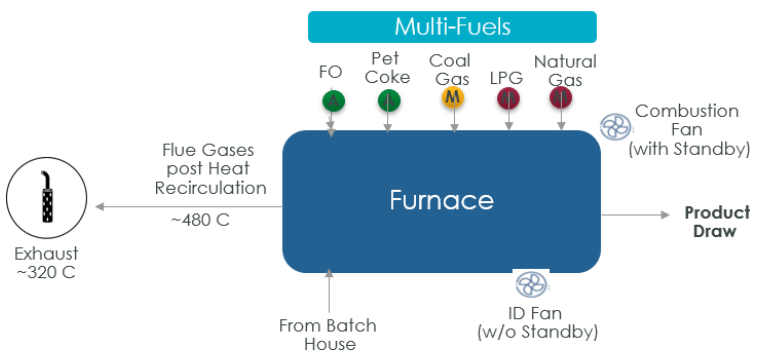
Water

Water is one of the major commodities used and acts as a raw material to manufacture many products, especially in pharmaceuticals. A water treatment system consists of a pre-treatment unit, treatment unit, water storage & distribution structure, process monitoring, control devices, and chemical cleaning and sanitation systems. Pumps and heat exchanger are critical units of this system. Failure of these assets can make the system come to a standstill and cause productivity loss or increase the contamination in the output of the system. In this sense, water quality control plays an important role, as it is an essential tool that ensures the production of medicines meeting required specifications, which is achieved by a dedicated PLC-based water purification system installed in the plant.

IIoT based Asset Monitoring and Predictive Maintenance solution reduces unplanned downtime, improving productivity, and reducing the maintenance cost of operations. In addition, a flow meter or a water meter is a common solution for water management. When it gets integrated into an IIoT solution, it not only helps to measure the flow but also the monitoring and control of water consumption, offering an efficient water management system. An IIoT water management solution can also monitor and provide insights into the water purification system by connecting to the PLC control system for additional visibility to conductivity, purity, water leakage, quality of water, treatment plants, etc. The solution also provides metrics to analyze the real-time usage data captured by the IIoT system. It can help to make better decisions about the service and additional requirements of the water treatment systems. The user can remotely monitor the operation and performance.

Gas

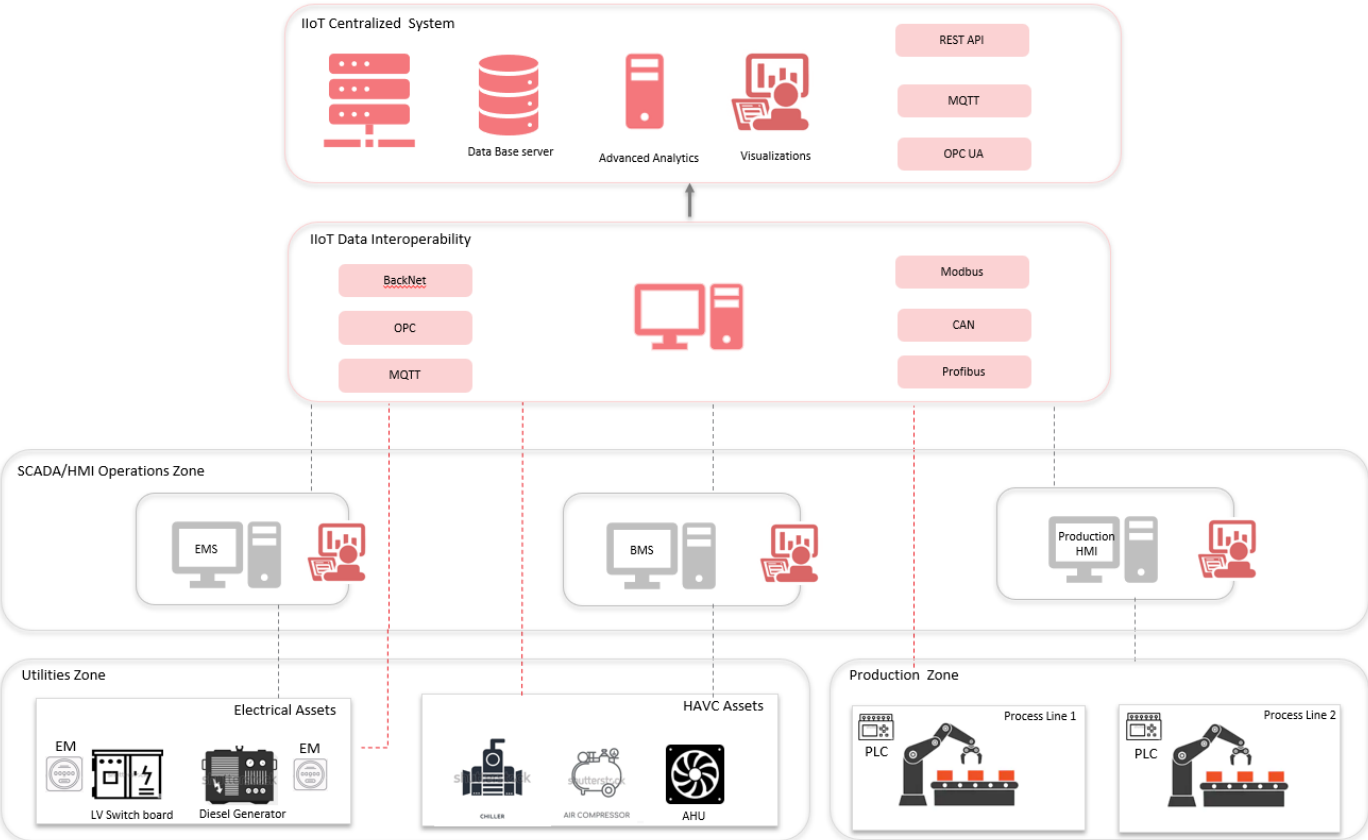
Gas is widely used in the firing systems of furnace and kilns in many industries like glass manufacturing, refractories. In these gas firing systems, energy utilization and CO_2 emission monitoring are critical factors for energy optimization and also to control CO_2 emission to provide a sustainable environment. IIoT based solutions and sensors help to correlate the production data along with energy/gas consumption in the firing system. The OT/IT system integration helps to gather and analyzes production planning data from the ERP system and can provide a recommendation to reduce the firing flow to the operator by alerts, which allows to achieve better energy optimization.



For example, multiple fuel furnaces use different types of fuels, including gases, as the source of firing. The typical furnace system consists of numerous assets, including ID Fans, Combustion Fans, and Exhaust Fans, which are critical and need to be maintained well in order to achieve an efficient temperature requirement for the operation and better productivity of the furnace. A Predictive Maintenance solution helps predict the failures related to this equipment in advance, reducing unplanned downtime, improving resource planning and also helping to save energy and cost indirectly.

Reference Architecture

The graphic here presents the IIoT architecture across all critical elements of IIoT solution for utilities. The architecture has been segmented into four layers



1. **Utilities and Production Zone**
   This zone falls under a plant layer wherein all types of utilities and production assets are connected with gateway or PLC or any control device.

2. **Control system Operations Zone**
   This zone falls under the plant layer, and wherein all assets can be monitored and controlled wherever applicable using various systems like EMS, BMS, SCADA, etc.

3. **Data Interoperability Zone**
   This zone falls under the IIoT layer, wherein all plant utility assets and production assets can be interfaced with one standard data interoperability application directly. This solution supports and gathers data from numerous driver protocols such as Modbus, CAN, OPC, Profinet, MQTT, BacNet, etc., and transfer the data to the IIoT server layer.

4. **Server and Visualization Zone**

This zone falls under the IIoT layer where all functional servers for IIoT reside and are used to collect, store, and analyze the data and provide insights to the end-user to take necessary actions.

With the increasing expansion of manufacturing industries and with the constant need for the utilities, which form the backbone of these industries, the use of IIoT for the effective maintenance, monitoring, and management of the utilities is the next big opportunity. IIoT as a Utility will be the beginning of more pervasive IIoT systems that the world will benefit from.

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