Intelligent Analytics for Factory Energy Efficiency

M. Srikanth, S. Prasanth, T. Viswanathan, and C. S. Ram Shankar

Abstract Energy Analytics for factory energy efficiency is one of the key improvement processes for machinery and equipment in the establishment of smart manufacturing. Currently, the manufacturing industries need upgrade towards the benefits that extend beyond just the production of goods into functions like planning, supply chain logistics, and even product development. Energy flexibility and efficiency are becoming more important than just automation. Energy consumption reduction and sustainability are important for companies concerning the high price for energy and the planned phasing-out of nuclear power. Strategies need to be framed to overcome these obstacles. This paper discusses real-time problems through a case study that includes descriptive, diagnostic analysis and explains further about the impacts of building predictive analytics for the energy system.

Keywords Automation · Smart manufacturing · Energy flexibility · Energy efficiency

1 Introduction

Smart manufacturing operations adopt the physical and cyber technology combination and integrate the already existing independent discrete systems to be more complex and achieve high precision than before. Evolution in manufacturing technology through the development of cloud-based enterprise, information technology, data mining, and data visualization made us move from just digital to intelligent analytics for factory energy efficiency.

Currently, intelligent manufacturing technology is the high-end technology where industrialized countries pay more attention to Europe 2020 strategy [1],

M. Srikanth (✉) · S. Prasanth · T. Viswanathan · C. S. Ram Shankar
Maxbyte Technologies, Coimbatore, India
e-mail: srikanth.m@maxbytetech.com

T. Viswanathan
URL: https://www.maxbytetech.com/

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Industry 4.0 strategy [2], and China manufacturing 2025 [3]. Reindustrialization and manufacturing reflow has been highly accelerated in the United States [4].

The future manufacturing is intrigued by the intelligent analytics and transformation worldwide. One side involves a variety of changes and challenges demanded by the Industry 4.0 and companies are on the verge of facing it. The planned phasing-out, the increasing price of energy are dealt with by companies today. These obstacles need to be handled by establishing measures to mitigate energy consumption and improve energy efficiency. Transparency needs to be achieved in terms of the energy consumption of the machines. Energy analytics, i.e., examining raw data to derive conclusions from the energy data, is a key enabler for implementing Smart Manufacturing [5]. Solutions for energy analytics need to be carved systematically through descriptive, diagnostics, predictive, and prescriptive analytics to derive insights for known and unknown problems [6].

In Smart Manufacturing, analytics need to be performed in the desired manner due to the availability of insurmountable data (volume), structure and unstructured data (variety), highly responsive toward decision-making (velocity). Accurate and timely insights need to be enabled for better decisions by utilizing big data infrastructure.

1.1 Energy Analytics

The energy analytics within companies is achieved by intelligent analytics for factory energy. The preventive measure and control are derived by intelligent analytics for factory energy to ensure the energy supply of a company while respecting the economic and ecologic aspects. To be effective, energy analytics programs should include main sections: (1) Descriptive analytics; (2) Diagnostic analytics (3) Predictive and Prescriptive analytics. We will discuss here primarily on the first two analyses made for energy analytics in Industry 4.0 with a case study.

2 Methodology

2.1 Descriptive and Diagnostic Analytics

It is the study of collected energy data to analyze the characteristics. The data contains information to be studied meticulously and insights need to be derived (Fig. 1).

The insights herein deal with the scope to bring down the cost and energy consumption to an optimized level. The steps involved are two as mentioned in the above diagram. ***Step 1***: Descriptive Analytics will interpret the historical data to give clarity over the happenings in the past of a machine to make us know *what happened.*

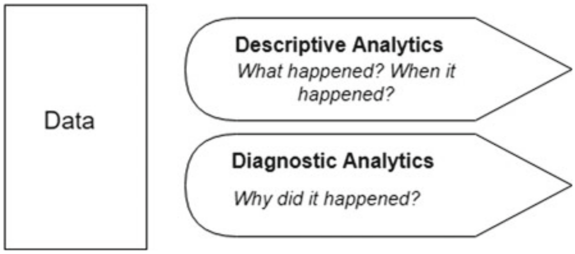

Fig. 1 Steps for analysis

Step 2: Diagnostic Analytics is an advanced analysis to derive the characteristic by techniques like data drill down, data mining, correlation within data, etc., to make us understand *why it did happened?*

2.2 Benefits of Energy Analytics

Various advantages can be accomplished through energy analysis. Some of these includes [7]:

- Reducing energy consumption and increase sustainability.
- The decrease in operating costs (approximately 20–30%) by systematic analysis.
- Overall performance of the total system and the productivity, profitability can be improved.
- Depletion rate can be decreased towards natural resources and demand-supply narrow gaps.
- Avoid unexpected equipment failure.

3 Case Study

One of the leading discrete manufacturing industries in India wants to convert each of its manufacturing facilities to Smart Manufacturing.

The block diagram (Fig. 2) is the abstract representation for the establishment of smart connected and operation replacing the traditional manual interventions to manage the manufacturing industry. Descriptive analytics performed towards increasing the efficiency of energy through intelligent analysis using the approach namely *Pareto analysis.*

It is a statistical approach in decision-making utilized for the selection of a fewer number of tasks that will make a significant overall effect. Utilization of Pareto Principle (otherwise, called 80/20 rule) is to generate 80% of the benefit from the entire job by working on 20% of the work. This method is also called the vital few and the trivial many. This method identifies the top causes that when addressed to resolve the primary portion of problems.

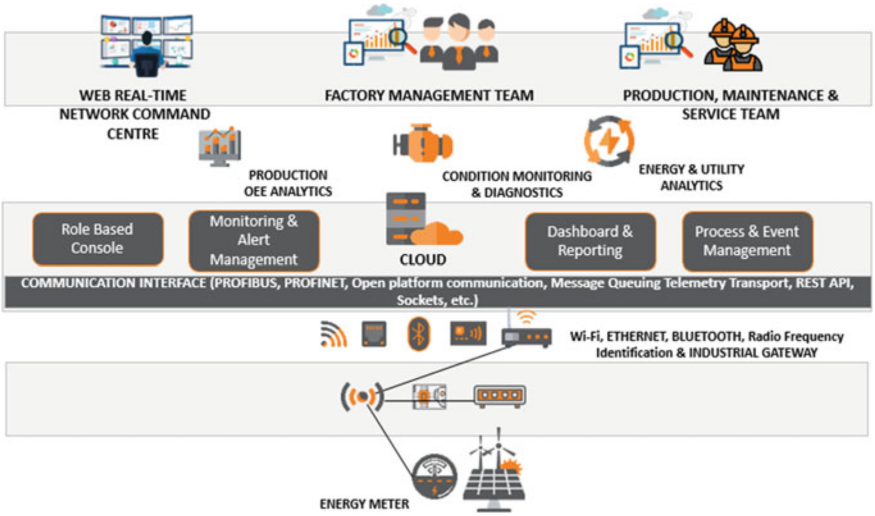

Fig. 2 Schematics architecture

4 Energy Analytics Audit

The current system is digitally enabled to display machine running/idle status, production status, energy status, and many other aspects of the production system. There are about 40 energy meters installed on the premise to monitor the amount of energy consumption.

The Pareto analysis will help us to identify the major energy-consuming machines.

The energy data were acquired from all energy meter for October, November, December months of 2018. The top energy-consuming department was identified using—**Pareto Principle** in Fig. 3.

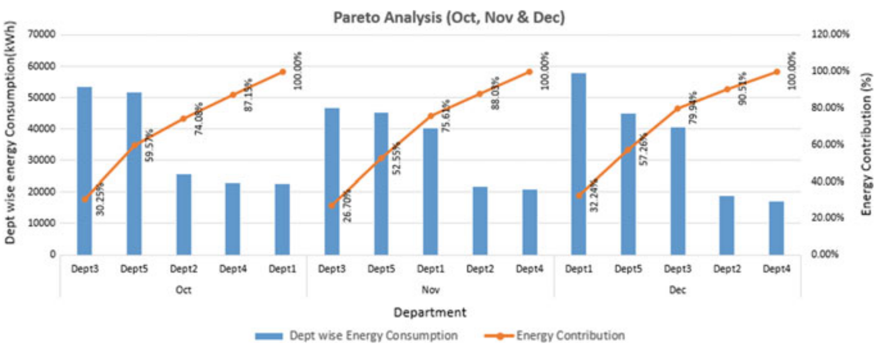

Fig. 3 Pareto chart analysis

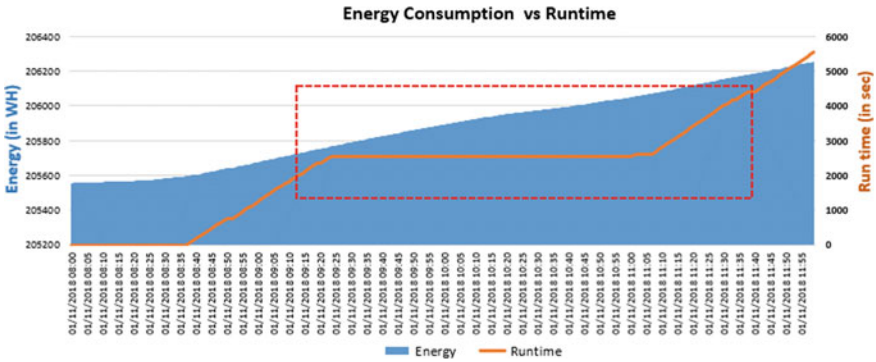

Fig. 4 Energy consumption versus runtime

From Pareto chart analysis, **Dept 3** was identified as one of the significant energy-consuming departments as per Fig. 3 and energy analysis was performed.

The instantaneous data for Dept 3 was taken and energy analysis was performed. The energy data was correlated with runtime and energy loss areas were identified.

From further analysis, certain Energy reduction scope areas were listed below,

- To identify areas where production is not happening in relation to downtime reasons, but still, energy is utilized.
- To optimize usage of energy in the machine, when it is in idle state.
- To calculate energy consumption ratio with respect to the production and to reduce energy level.

From Fig. 4, it is inferred that energy is being consumed when the machine is not running.

5 Impacts of Energy Loss

The energy consumption analysis (Fig. 5) chart is plotted using minute-wise data. The graph depicts the amount of energy consumed when, Part Production, machine running with no production, machine was Idle for October, November, December 2018.

The energy consumption when (1) Machine running with no production and (2) Machine Idle were classified as energy waste areas. Thus, the energy waste for three months accounts for loss of **₹5, 31,769**. (*Assuming ₹.7/kWH, the below cost analysis is performed*)

Table 1 is the detailed cost analysis made with respect to Fig. 5.

The total cost analysis audit for the three months was found to be **₹10, 67,052** from the table. This observation makes us identify that **49.83% of energy loss** occurs

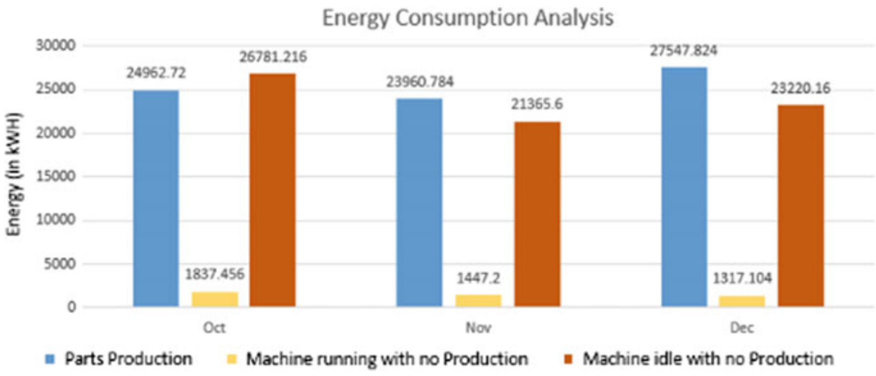

Fig. 5 Energy consumption analysis

Table 1 Energy cost analysis (minute-wise data)

Month	Parts production	Cost (Rs.)	Machine running with no production (kWh)	Cost (Rs.)	Machine idle	Cost (Rs.)	Total cost (Rs.)
OCT	24,962	1,74,734	1837	12,859	26,781	1,87,467	375,060
NOV	23,960	1,67,720	1447	10,129	21,365	1,49,555	327,404
DEC	27,547	1,92,829	1317	9219	23,220	1,62,540	364,588
Total	76,469	5,35,283	4601	32,207	71,366	4,99,562	1,067,052

considering the machine idle and machine running with no production. This could be a significant start for building an intelligent analytics system for this factory.

6 Summary and Conclusion

Energy analytics is an intelligent production system wherein [8], we could concentrate on energy data through the statistical approach involves intelligent analytics for factory energy.

This paper discusses the energy analytics audit towards the different levels of impacts made by energy data. It was understood through a case study about the real-time energy audit using the Pareto analysis. This approach we discussed will help us to address the major portion of the energy impact in descriptive analytics. In near future, to mitigate the cost, energy and to build sustainability in the system, an intelligent analytics for factory energy can be initiated in the primary portion of waste energy consumption areas through the findings made.

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