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General Aspects of Energy Management and Energy Audit— from a POET perspective

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Abstract—This paper presents the general aspects of energy management and audit, from a Performance, Operation, Equipment and Technology (POET) perspective. Each of these components are discussed along with their relationships to other factors such as technical, time and human factors. Each of these components is also compared with one another to clearly identify their meanings and differences, as well as how they can be used from an auditing perspective to provide insight into what should be considered when energy efficiencies across various components need to be improved.

Keywords— energy management, audit, efficiency, POET

I. INTRODUCTION

Energy management is an organised, systematic and proactive approach to manage energy and is an important factor that needs consideration in almost every industry, be it a power, mechanical, chemical or labour system. Energy management is, therefore, considered as a key strategic area for cost reduction, both in development of new systems as well as in upgrades of existing ones [1].

Energy efficiency can be divided into four parts. The first part represents basic measures, which includes activities such as powering off unused devices, fixing leaks, and so on. This is one of the most cost-effective methods for reducing waste and increasing efficiencies. The second part includes improving operation and control of energy-systems. This part also has a significant improvement, however, not as much as the first part. The third part introduces more efficient equipment, which is not always possible. The fourth section is dedicated to research and development. Although the least of a priority, this part covers the first three and is thus essential for development of more efficient systems.

In the literature, various perspectives on energy efficiency are discussed, including management, operation, control, billing, performance and fuel efficiencies. Due to the large variety of efficiencies and their different departure points, a unifying framework or classification system is needed to simplify the approach to dealing with the potential energy efficiencies. The POET framework presents energy efficiency as a unified classification, in terms of performance (P), operation (O), equipment (E), and technology (T).

The POET energy efficiency components and their relationships with each other are summarised in Fig. 1, and can be used in the planning and prioritising of energy management projects, with the first goal being to achieve the non-technical goals, which are considered as the low-hanging fruits.

II. PERFORMANCE EFFICIENCY

Performance efficiency is defined as the efficiency measurement that is determined by external deterministic efficiency indicators. This can be broken into two groups, namely Engineering Indices (EI) and Social and Environmental Indices (SEI). These include production costs (SEI), the environmental impact (SEI), technical indicators (EI), amongst others. For cost performance, financial accounting systems can provide plant-level information. For plant-level performance, meter reading can be used and compared to data from similar facilities. For system-level performance (e.g. boiler plant, Heat Pumps), data can be obtained from sources such as sub-meters. As for equipment-level information, these can be obtained from equipment nameplate data, as well as other sources including run-time and schedule information, together with sub-metered data [3].

After obtaining the relevant information, it can be summarised using various graphs, pie charts, and bar charts. [4]. Typical indicators used include pie-chart for indicating the distribution of energy consumption amongst different fuel-types, bar-charts for energy consumption and production analysis, whereas XY graphs can be used to gain an understanding on the relationships between energy and production, which are good for fitting and making predictions based on trend-data. It can also be used for Cumulative Sum (CUSUM) graphs to represent the difference between predicted and actual consumption points, giving a clear picture of patterns, savings and losses, as well as performance changes over time.

It should be noted that there are certain trade-offs that have to be made when focusing on performance efficiencies, which includes engineering-indicators competing with socio-
economic indicators. Apart from these indicators, other factors such as time-of-day (TOD) tariffs [5] must be considered, along with other decisions that must be taken to balance all indicators to achieve a sustainable solution [2].

III. OPERATION EFFICIENCY

Operational efficiency considers proper coordination of system components in a system-wide measurement. It is achieved when technical, human and time factors are coordinated correctly.

Technical factors take into account the system’s physical parts, which must fit together optimally in terms of sizing and compatibility. This implies that the equipment sizing and loading, for example, must be chosen to maximise operational efficiency for the available resources. If a system is too powerful for the required task, it would possibly waste too much energy, and if a system is too small, it would either waste too much power by overheating, or it will not be able to perform the required tasks at all.

Human factors that are considered in the operational efficiency has to do with using adequately skilled persons to operate systems, machinery or processes in the most efficient manner.

Time factors that are considered includes the correct planning for switching equipment on and off, scheduling certain events of work to prevent tasks from waiting on one another, as well as the control of energy time-of-day usage [6]. Time of day usage could consider not only varying tariffs, but also the fact that some systems work less hard at certain times of the day, for example.

Control systems play a crucial role and has a strong relationship with energy efficiencies. There are four components utilised by these systems to achieve optimal control, the first of which is identification of what needs to be controlled. The second component is modelling the system’s dynamic, which involves modelling the different interactions and constraints between the various systems. The third component deals with either trajectory planning or determining the operating point, which is normally defined by the interactions with internal system components; this part can be achieved in both an open- and closed-loop systems. The final component deals with how such controllers are implemented, with actuators controlling various devices based on inputs and outputs. Fig. 2 represents a general closed-loop control system, in which the measurement system senses system outputs, and the controlling feeds the measurement to the system. An open-loop controller will schedule time-sequenced trajectories for the next system [2].

![Energy management and control system for POET](image)

Fig. 2: Energy management and control system for POET [2]

IV. EQUIPMENT EFFICIENCY

Equipment efficiency of a system is defined through the measurement of isolated energy-equipment with respect to design specifications [7]. Measurements are made under ideal conditions, separated from any potentially interacting equipment. It is expected from manufacturers to design and develop equipment in accordance with technical standards that have been developed to ensure the optimum functioning. Replacing a piece of technology, such as incandescent lights with compact fluorescent lights (CFLs) is considered an equipment-efficiency improvement. However, to make a clear distinction between equipment efficiency and technology-efficiency improvements, it is worth noting that technology efficiency is rather defined as improving CFLs (or other technologies), instead of replacing them [8].

In order to evaluate the efficiency improvements, it is necessary to include factors such as specifications, constraints, standards, capacity, and maintenance indicators. To ensure optimum performance, it is deemed most important for equipment specifications to adhere to the technical design specifications. Operating at optimal capacities is also considered important; it is often found that equipment operating at the same energy-consumption levels may still differ in capacity. Another important factor to consider is equipment constraints, because this limits the durability and ability of equipment to support heavy loads. Equipment maintenance is also essential, as it would cause efficiencies to decrease over time, if it is not properly maintained.

V. TECHNOLOGY EFFICIENCY

Energy-conversion, transmission, processing and consumption efficiencies are all considered as technology efficiency. In order to evaluate technology efficiency, it is required to take into account its feasibility, life-cycle cost, various coefficients in its operations, and other technical factors for evaluation. Despite technological advancements, it is often subjected to and restricted by laws of energy conservation, which states that it is impossible to output more energy from a system than what is input. This always needs to be taken into account when evaluating technological efficiencies. Another crucial consideration that has to be made when looking for the most optimal solution is that there is a constant drive to improve technology in ways that might not be thought to be possible, and also no definite boundary (other than output energy that would always be less the input power).

Whenever new technology is considered, the life-cycle costs and the return on investment (ROI) must be taken into consideration. The deciding factors for proceeding with new equipment should be to take project profitability and running costs into consideration [9]. Examples of technology improvements include for example the improvement of solar and wave energy conversion ratios, improving the transmission and distribution efficiencies in power systems, and finally making the right decisions at different levels of a project, ranging from financial decisions right through to stakeholder and technical decisions. Decisions are necessary from start to finish because various aspects through the lifecycle of a project necessitate such decisions to be made.

VI. CONCLUSION

With a the scarcity of available energy resources, the prices, and a global shift toward more energy-efficient ways of
using available energy resources, identifying available sources, identifying their indicators, recognizing how they can be enhanced, and deciding the changes should be prioritized is critical.

This paper provides a summary of the four components of efficiencies, which is identified by the POET framework. Each of these components was addressed, as well as their relationships to other factors such as technical, time and human factors. This covers performance, operation, equipment and technology efficiencies, while comparing and describing each of these efficiencies so that a clear definition of what each component entails can be provided with its priorities and some basic examples that provide a better context of what they mean in real-world situations.

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REFERENCES


