The International Journal of Engineering and Science (IJES)
|| Volume || 13 || Issue || 2 || Pages || PP 12-19 || 2024 ||
ISSN (e): 2319 – 1813 ISSN (p): 2319 – 1805

Energy Audit in True Perspective

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ABSTRACT
Energy Audit in many third-world countries is the most misinterpreted and misunderstood operational activity. In reality, it is very vital when the business operation is stretched to limits due to financial crunch and energy shortage. Energy audit and implementation of the recommended Energy Conservation Measures (ECM) are generally expensive. The standard mindset of the procurement head is to place the order with the lowest quoted price which is impossible to practice in energy conservation projects. The management considers it as an expenditure due to a lack of correct and complete information resulting in delayed priority. If a detailed energy audit is done properly and implemented correctly, it will be an investment with lucrative returns as long the facility is in operation without any further money being spent. Therefore, the energy auditor needs to understand the process properly which will help the business owners to consider the much-needed fund to be an investment and not an expenditure that can be delayed. This article highlights a birds-eye view of an ideal energy audit and a typical energy audit report that can be easy to understand and implement.

Keywords: *Energy Audit, Energy Management, Energy Balance, Energy Efficiency, Energy Conservation*

Date of Submission: 03-02-2024 Date of acceptance: 14-02-2024

I. Introduction

Coal was still the main source of energy when the third-world countries were slowly getting into industrialization. It was the early 1970s when the FirstWorld Energy Crisis was experienced and Demand Side Management (DSM) was coined as the apt solution to overcome the gap between demand and supply[1]. Energy Audit (EA) made its way into the industrial practices as part of DSM to account for the justifiable use of energy in the manufacturing processes so that energy conservation can be achieved. Energy Conservation (EC) came into prominence against the backdrop of gradually diminishing world fossil fuel reserves as highlighted in Figure 1. Gradually EA became the standard practice in many countries as part of EC [4]. However, there were lapses and deterioration in the energy audit process due to a lack of proper understanding and perhaps due to the non-availability of proper training facilities on the energy audit and its nitty-gritty[3]. That is why it is essential to understand the energy audit process.

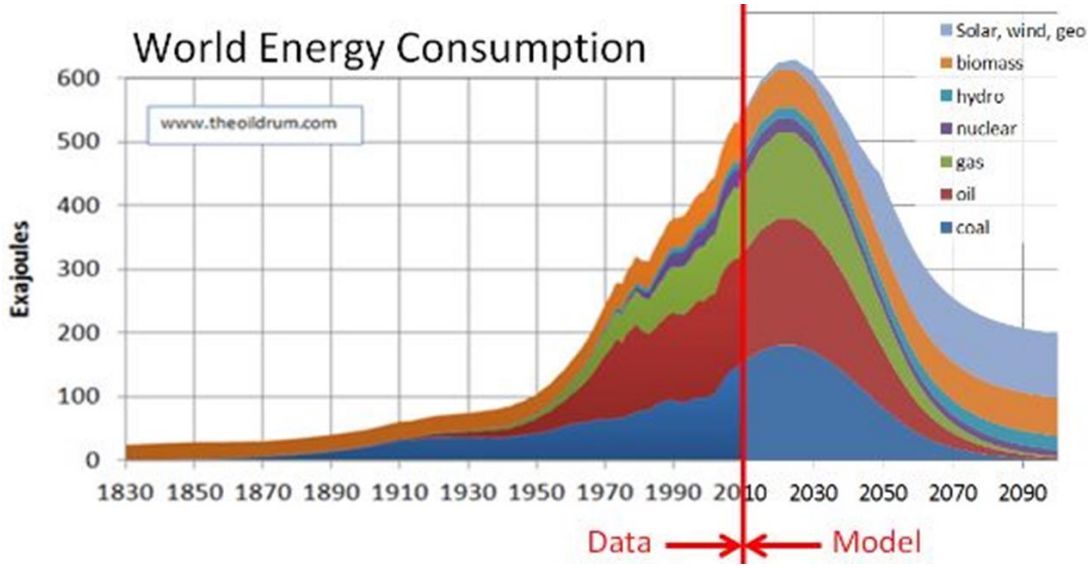

Figure 1: World Energy Scenario
Source: https://www.linkedin.com/pulse/looking-back-10-years-after-peak-oil-abd-el-hakim-mohamed-izran

II. Theoretical Premise

The literature review suggests the need for proper planning for a systematic energy audit that will be target-oriented and implementable. Based on the "Antecedents-Behaviour-Consequences Theory" and its understanding, Wai et al., [7] developed an Energy Awareness Process framework for energy conservation application as shown in Figure 2. It is a step-by-step process with proper planning so that the antecedents can influence the behaviour for energy conservation.

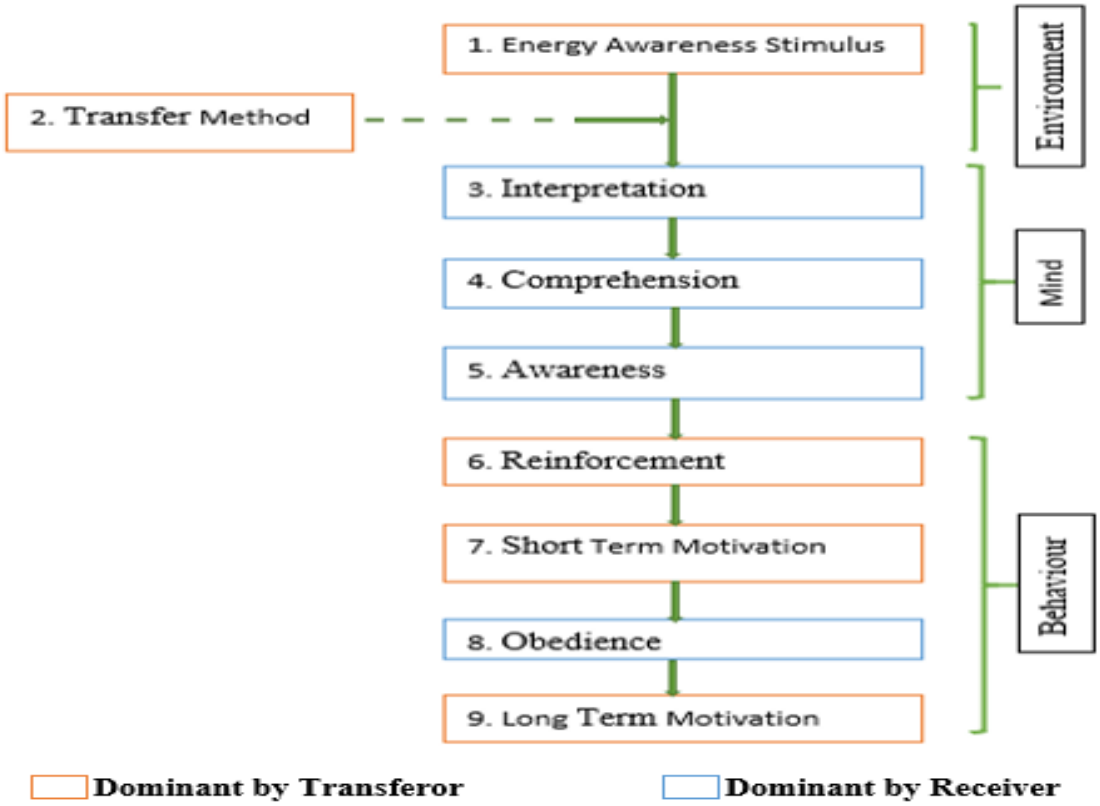

Figure2:Energy Awareness Process Framework
Source: Wai et al., (2006)

Energy conservation in a true sense should encompass awareness about the need for it, and technological excellence to improve the efficiency and implementation of the Energy Conservation Measures (ECM) in a planned manner[10]. Technological excellence alone cannot achieve optimal usage of energy and will not be sustainable in the long run. Energy Management (EM) will have the biggest impact when human behavior becomes part of that EM initiative as shown in Figure 3. The behavioral impact is equally important as technical and organizational impacts when we talk about sustainable energy conservation[16].

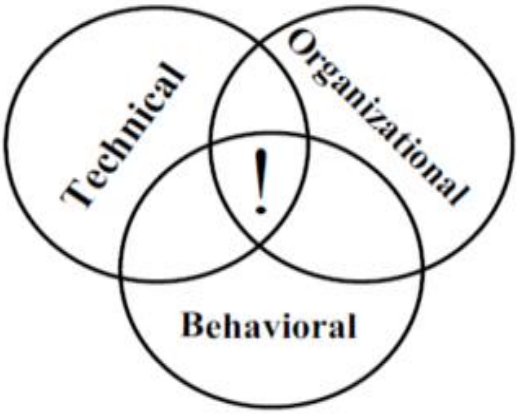

Figure 3: Energy Management Dimensions
Source: www.energy.gov.za/EEE/Projects/IndustrialEnergyManagement

III. Energy Audit Approach

Energy Audit of any premise should be considered in totality and with the right perspective. To do that it is very important to have the right energy audit approach. Afive-phaseenergy audit approach on the principle of Total Quality Management (TQM) for energy conservation projects in the Jordanian industrial sector was suggested to be the apt approach [22]. The model is termed "Kablan's 5 Steps Close Loop TQM Model" as shown in Figure 4. The approach starts with preparation and goes through various steps to the evaluation phase with a feedback loop for course corrections, if any.

Figure 4: Five Phases Close Loop TQM Model by Kablan
Source: M.M. Kablan, (2003)

The energy audit approach should also have due considerations for governing policy, audit planning, ECM implementation, Measurement and Verification (M&V), and feedback mechanism to make it a closed loop system with continuous improvement arrangement as shown in Figure 5[4].

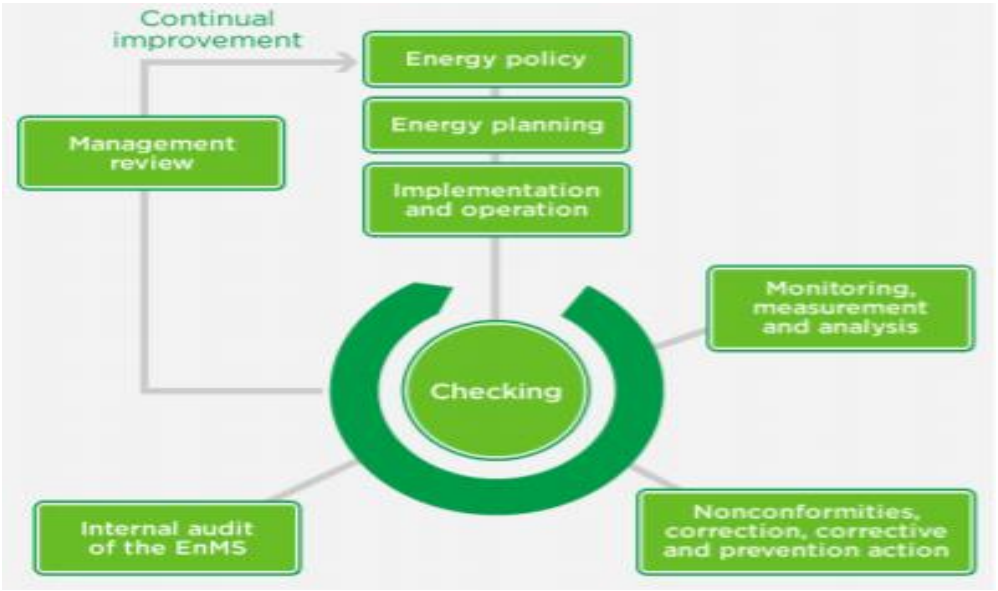

Figure 5: Energy Management System Structure
Source: Joshi et al., (2016)

IV. Energy Audit Plan

An energy audit is a systematic planned activity as discussed in the earlier section.A typical Energy Audit plan, as proposed by Sapar et al. [30] is shown in Figure 6.

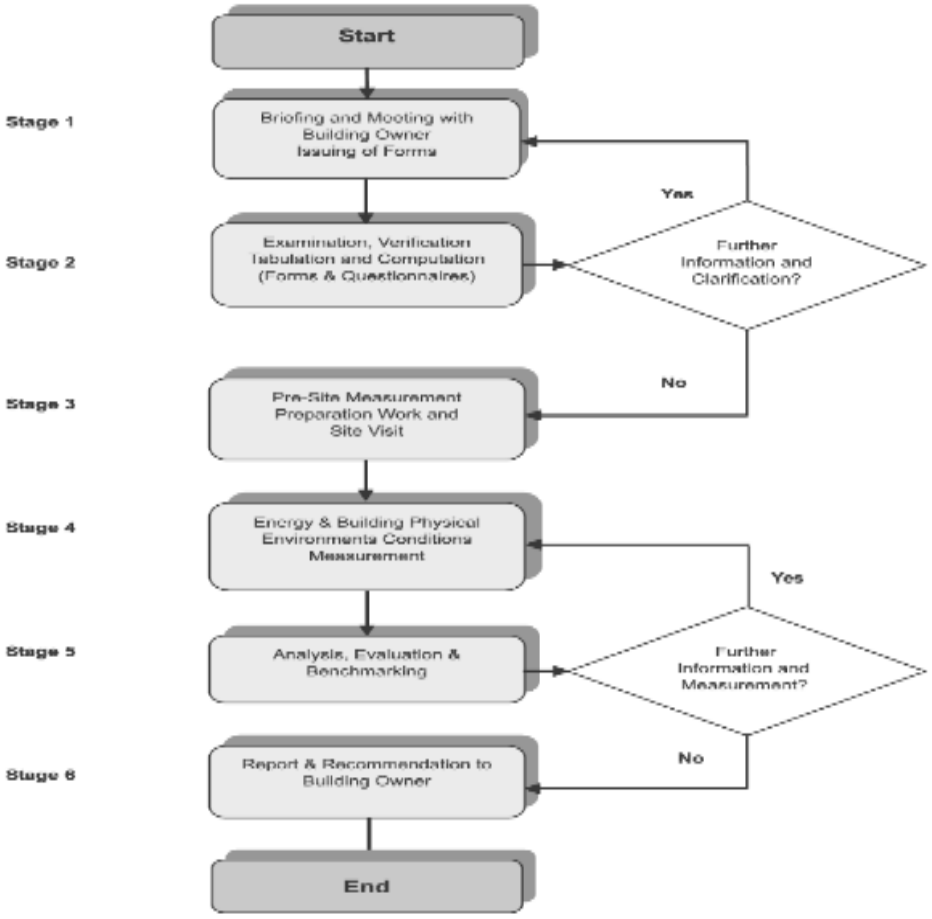

Figure6: Energy Audit Flow Chart
Source: Sapar et al. (2005)

The above flow chart is an indicative approach and it should be unique for each facility based on their work/process, operational requirements, and practices. The most followed approach by any Energy Servicing Company (ESCO) will start with walk thorough audit, followed by data collection and then data analysis as discussed further in the subsequent sections.

4.1 Walk Through Audit:

It is the very first steptoward an energy audit of any premise. The purpose of this audit is to familiarize with the facility, its operations, activities, and work culture, understand the existing perennial problems, if any, and the customers' expectations from the energy audit[28]. An experienced energy auditor should be able to identify the No-Cost ECMs during this audit and take advantage of implementing the same at the same time to reap the energy-saving benefits from day one. A list of historical details that will be needed for data analysis should be given to the customer at this time so that the customer has enough time to keep these documents ready to hand over at the time of operational field data measurement and recording. Operational field data measurement and recording can be scheduled based on the walk-through audit findings. It will help in measurementwithout disturbing the regular business operations and readings are taken when the machines are working either on full load or near full load condition[24].

4.2 Data Collection:

Data collection for energy audits are two types. Historical data is neededto understand the past energy consumption pattern and history of the facility so that a baseline can be drawn for comparison purposes. These documents like electricitybills, fuel bills, etc. are to be provided by the customer. Actual conclusions from the energy audit can be erroneous in the absence of these documents[23].

The second type of data collection is the actual measurement of energy consumed when the machines are in running condition either at full load or near full load condition. Various test equipment is used for various machines and this test equipment should be duly calibrated by the competent authorities. It is always a good

practice to take some extra readings to identify the root cause of perennial problems if any[14]. It is very important to take these readings when the facility is in normal working condition.

4.3 Data Analysis:

Data analysis is an important step in any energy audit and many times the energy auditor tends to overlook certain important aspects due to various reasons. The basis of all calculations should be clearly stated and the formulae used should be unambiguous. All data should be tabulated correctly and operational data should be in line with the historical data[12]. One should be able to do an energy balance after the data analysis is done.

V. Energy Audit

The main purpose of the energy audit is to account for all the energies that go into a process for doing certain activities. It is briefly explained in Figure 7. Every facility will have energy losses due to system inefficiencies, wastage, and pilferages and these are normal in any facility. If the energy consumption readings are taken correctly, machine efficiencies are evaluated properly, and wastage and pilferages are identified correctly then it is easy to identify the energy conservation opportunities in the facility[2].

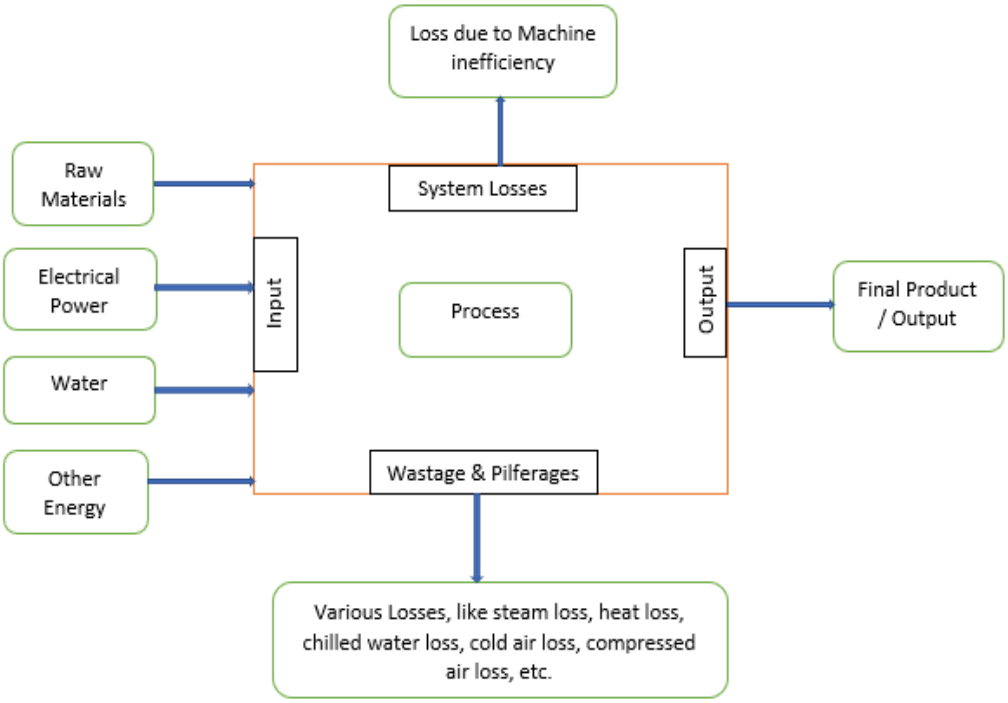

Figure 7: Energy Distribution
Source: Author

VI. Energy Audit Outcome

A detailed energy audit will be able to paint the correct picture of the energy usage of any facility. It will help the facility owner to see many unseens which will help understand the myths[5]. Various essential elements of a detailed energy audit report are discussed further.

6.1 Energy Balance

The first thing a detailed analysis of the historical and measured data can do is an energy balance report as shown in Figure 8. It will give a very clear picture of the utilization of energy and the purpose of its usage. One will be able to identify the inefficient machine, pilferage, and wastages in the system which will help to identify energy conservation opportunities[6].

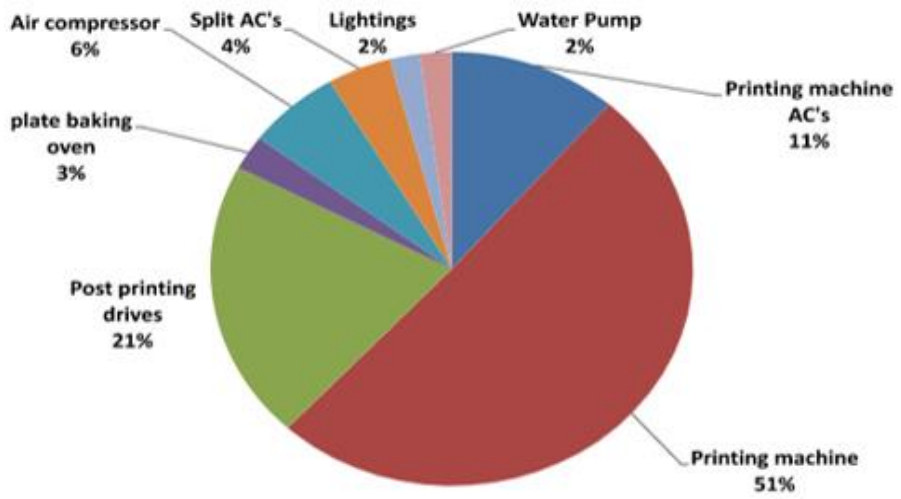

Figure 8: Energy Balance Report
Source: Author

6.2 Energy Saving Opportunities

An experienced energy auditor will be able to compare the operating data against the industry best practices/baseline data derived from the historical data and list out the areas where energy conservation opportunities exist. Important to note that every opportunity may not be an apt opportunity for energy conservation through an ECM because of economic considerations and management decisions based on business requirements[2].

6.3 Energy Conservation Measures (ECMs)

ECMs are derived from the energy conservation opportunities and are categorized as (1) No-Cost ECMs which are either implemented at the time of walk-through audit or during the field data collection and will not cost any money to the facility owner. (2) Low-costECMs are very cost-effective options where the cost of implementation of these ECMs can be recovered from the monthly energy savings in less than one year time. (3) Mid-Cost ECM which requires financial planning to implement as the recovery cost of implementation can be up to 5 years depending upon the kind of business operation of the facility [2]. (4) High-cost ECM are mainly technology changesthat cost a substantial amount of money and should be left with the management of the organization as most of the time these opportunities are known to them[9].

6.4 ECMs Implementation Plan

ECM implementation plan is an important outcome of any energy audit but gets neglected in many energy audit reports for the reasons best known to the energy auditors. A properly planned and correctly sequenced ECM implementation will have a positive impact on fund requirements and cash flow[11]. Even the cash-strapped organization can have an extended plan to fund the implementation by the savings in energy bills from previously implemented ECMs[8].

6.5 Measurement & Verification (M&V) Plan

The most misunderstood element in any energy conservation project is the M&V protocol particularly in third-world countries[13]. Many energy auditors fail to recognize the need for additional fundsto implement the proposed M&V protocol. It becomes more difficult for the facility owner to accept the need for M&V in the absence of its mention in the energy audit report. Experience shows many potentially fit energy conservation projects got shelved due to non-existence or flawed M&V protocol[17]. It is the rule of the game if the energy conservation project is implemented on the principle of "Performance Contracting".

6.6 Tentative Cash Flow Scenario

A properly sequenced and planned ECM implementation can be indicative of a tentative cash flow for the entire implementation period and can also be projected for another 5 – 10 years to paint the correct picture of the energy conservation and money saved there [15]. That is why it is strongly propagated that the cost of ECM implementation should not be seen as an expenditure but an investment with a very high ROI [2].

VII. Conclusion

A detailed energy audit report should not be the compilation of machine list and nameplate details along with the tabulation of energy bills for the past one or two years as it is seen to be the practice followed by many. It should also not be a voluminous document with unnecessary information as some energy auditors may think it to be impressive. A detailed energy audit report should be crisp and only with necessary information along with an executive summary containing some economic details for a glimpse of the whole report. The decision-making authority should be able to take the final call after reading the executive summary. The technical person should be able to understand the calculations, analysis, patterns, graphs, and findings without much difficulty after reading the report[32]. The report should list the suggested ECMs, implementation plan, and M&V protocol with a tentative payback time.

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