INTERNATIONAL ASSOCIATION OF BIOLOGICALS AND COMPUTATIONAL DIGEST
International & Peer-Reviewed Journal
E-ISSN: 2583-3995

A REVIEW: ENERGY & WATER AUDIT: TYPES, SCOPE, METHODOLOGY AND GAPS.

Almas Mansuri*, Dhara bhavsar*, Archana mankad*

Department of Botany, Bioinformatics and climate change impact management, University School of Science, Gujarat University Ahmedabad.

Email: almasmansuri005@gmail.com

ABSTRACT

In most developing countries, the energy problems to be addressed are countering the high dependence on traditional sources of energy. An energy Audit is key to a systematic approach to decision-making in the area of energy management. The energy audit is a wide spectrum of energy study which ranges from identifying major energy problem areas to implications of alternative energy efficient measures. one must go for the energy audit to save electricity at a much lower cost. Water Audit comes into the picture in the late 80s to overcome drought-related problems, shortages, leakages and losses. Water audits provide a rational, scientific framework that categorizes all water use in your system. The standard water balance or methodology is the framework for categorizing and quantifying all water uses in the water audit. The utility should be estimating the amount of water used in this category as accurately as possible. For many systems, the water used in this category may vary over time, or it may be zero. Recommended by the [IWA and AWWA] Water Loss Committee. Distribution and its efficient use to reduce capital and operating cost as an added advantage over the optimized use of water resources with environmental protection.

Key words: Energy audit, Energy Consumption, Save Energy, Water Audit, Save Water

INTRODUCTION

The majority of emerging nations have energy issues that need to be solved to reduce the excessive reliance on conventional energy sources, which account for more than 90% of all energy utilised and hasten deforestation [1], reducing the soil's fertility, etc. As a result, a lot of information is needed to characterise their interactions, and a variety of tools are required to analyse various problems and produce a range of findings that are required for the planning process[2]. India is the world's fifth-largest generator of electrical energy. Despite these accomplishments, the energy supply and demand mismatch is widening daily [3]. An energy audit is a process study to find out how and where electrical energy is consumed, as well as to find ways to conserve energy. [4].The foundation of a methodical approach to decision-making in the field of energy management is an energy audit. Overall, this has led to a massive increase in the demand for energy, which can no longer be met by outdate energy technology that relies only on limited local resources. Appropriate methodologies for conducting energy surveys to estimate and project sectoral useful energy requirement are evolved [5].

A drought-related issue, scarcity, leaks, and losses are addressed by a water audit in the late 1980s. Human population growth, anthropogenic activities, usage of fertilizers, and other man-made activities, various dangerous pollutants have heavily contaminated the water. An audit's objective is to provide an assessment of a person, business, system, etc.., Water audits provide a rational, scientific framework that categorizes all water use in your system. It is a method to combat problems caused by drought, including shortages, leaks, and losses. The water audit demonstrates how much water arrives, leaves, and is provided to the client. Water audits have been surprisingly rare in the public water supply across the majority of the world, despite being as important and ubiquitous as financial audits are to the world of commerce.

ENERGY AUDIT:

The energy audit covers a broad variety of energy studies, from identifying the main sources of energy use to the effects of more creative energy-saving strategies [6]. An energy audit examines and evaluates how businesses and other organisations utilise energy.

https://iabcd.org.in/

National rules and regulations for energy usage and conservation state that,[7] inquiry and energy audit management. Actual energy use was measured during the general audit, duration, and power factor based on the quantity of light-connected loads. The illumination level was measured [8]. The rooms' sizes as well as their electrical fixtures, such as lighting, fans, and ventilation, were documented.

Audit activities in order:

- Identification of all energy systems.
- Evaluation of conditions of the systems.
- Analysis of impact of improvement to those systems.
- Preparation of energy audit report.

After the audit process is completed, all the data collected is used to conduct the analysis, which includes the economic analysis. Energy audits and conservation have been proven to save money in studies and research [9]. In the industrial sector, there is a lot of room for energy conservation. Regarding electricity, these savings are the same as installing.

TYPES OF ENERGY AUDITS:

- Preliminary energy audit.
- General energy audit.
- Detailed energy audit.

Preliminary Energy Audit

Alternatively known as a basic audit screening audit, the preliminary energy audit or walk-through audit, is the simplest and quickest type of audit. It is conducted during a constrained period and concentrates on the main energy suppliers and needs [10]. It tries to implement the required procedures for an establishment's energy-saving programme. It entails tasks connected to data gathering, categorization, presentation, and analysis to determine the best course of action for creating energy conservation. It entails gathering the essential data and conducting only brief interviews with site operation staff, a quick examination of the facility's power bills and other operational information reveals the most egregious instances of energy waste or inefficiency.

Typically, only significant issues will be found during this kind of assessment, Corrective actions are quickly discussed, and short implementation cost estimates are provided, There are straightforward payback times and possible operational cost reductions presented [11]. While not sufficient for making a final judgement on whether to implement suggested actions, this level of information is sufficient to set the order of energy efficiency initiatives and evaluate whether a more thorough audit is required.

General Energy Audit:

A mini audit is another name for the general energy audit or site energy audit or complete site energy audit. By gathering more specific data regarding facility operations and conducting a more thorough examination of identified energy conservation solutions, it builds on the preliminary audit [12].

To enhance utility data, additional metering of certain energy-consuming equipment is frequently carried out. To gain a deeper understanding of the main energy-consuming systems as well as insight into fluctuations in daily and yearly energy consumption and demand, in-depth interviews with facility operational staff are done. Given the institution's operational characteristics, this kind of audit will be able to pinpoint any energy-saving methods that are suitable for the facility.

Each measure is given a thorough financial analysis based on accurate implementation cost estimates, both the customer's investment requirements and site-specific operational cost benefits. The level of information is sufficient to support project implementation.

Detailed Energy Audit:

A comprehensive audit is another name for a detailed energy audit or investment grade audit. It expands on the general energy audit. The estimate of energy input for various processes is covered. Gathering historical information on prior levels of output and individual energy usage. It is an extensive energy audit action plan that the sector should properly implement.

It offers a dynamic model of the energy usage characteristics of the facility as it now is and of all identified energy-saving strategies [13].
A great deal of focus is placed on comprehending not just how all energy-consuming systems operate [14], Sub metering of significant energy-consuming systems and monitoring of system operating parameters are used to enhance the utility data already available.
A thorough audit study must be finished within three weeks from the start date, with savings of 8 to 10% being the minimum. After that, it will take three weeks to finish preparing the energy audit results.
In industries where an energy audit is to be conducted, the following key systems are encountered: refrigeration or cold rooms, boilers, furnaces, air conditioning systems, etc., systems for the production and distribution of electricity, compressed air, pumps, and electric motor-driven systems [15].

1. Importance of Water Audit:

The source of life for humans is water. Water is necessary for drinking, home usage, irrigation, and agricultural purposes [16]. Leakage accounts for some of the overall water usage, and faulty metering also contributes to some of it. Part of it may be sent to clients' homes as water, and some of it might be used illicitly. A water audit identifies the final destination of the water and the quantity that made it there. The water audit's degree of detail will change depending on the information the system has at its disposal [17]. For several causes, all water systems experience some water loss. The amount of water lost is not accurately measured by statistics. Customers and the system both have financial responsibility for water loss Utilities are unable to eliminate water loss. Unavoidable water loss exists, thus trying to stop every drop from exiting your system would be expensive. However, a water audit may help manage the majority of loss that happens in water systems.

Methodology of Water Audit:

The standard water balance or the framework for categorising and measuring all water consumption in the water audit is called methodology. It is known as a balance because, when finished, Water input from the sources is equal to all water consumption in the system [18].In Figure 1. This is the most popular approach to understanding the often-used water balance, which was created by American Water Works Association (AWWA) and International Water Association (IWA) in 2000. It can also be shown as individual equations or as a spreadsheet. It's critical to realise that each category's vertical height corresponds to a certain volume of water. Thus, The volume of water pumped by the system over a specific period is represented by the height of the System Input category. Authorized Use and Water Losses are two other categories that apply to this amount of water. Therefore, Authorized Use + Water Losses = System Input. The whole standard water balance uses this vertical height water measurement.

- Water Losses = Apparent Losses + Real Losses.
- Nonrevenue Water = Water Losses + Unbilled Authorized Use.
- Apparent Losses = Metering Inaccuracies + Unauthorized Use

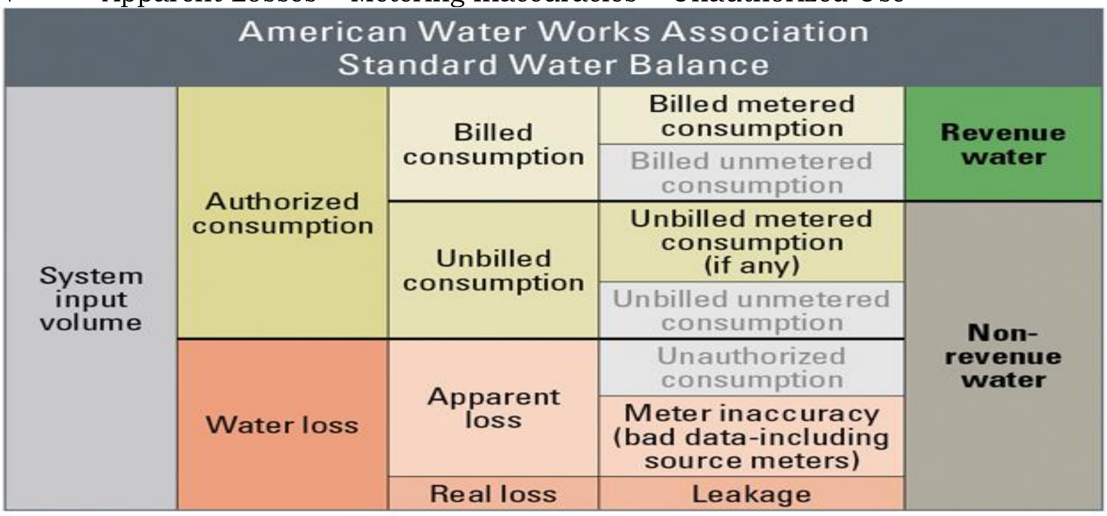

Figure .1 AWWA /IWA WATER BALANCE [21].

https://iabcd.org.in/

Thus, solving these equations requires following the five-step procedure listed below.

- Source Evaluation.
- Calculation of Authorized Consumption.
- Evaluation of Apparent Losses.
- Evaluation of Real Losses.
- Performance Measurement.

Source Evaluation:

Determining System Input is the first stage in finishing the standard water balance. Numerous sources can be included in the System Input group. Multiple wells, springs, or surface water intakes may be owned by a system. Even though there is only one category, this is a crucial step; A proportionate quantity of water should be added [19]. All water systems place a great deal of importance on master metre readings. The only reliable method for calculating the system's total water usage is accurate master metre readings; this could be warranties, records of maintenance or verbal conversations with system staff, as well as the dates of installation. Other crucial elements of the system are impacted by these measurements, such as paying fees and abiding by water rights (i.e., the Water Conservation Fee), together with fees for any water acquired from other networks. Other accessories, such as valves, must be in good working order to properly maintain these metres [9].

Calculation of Authorized Consumption:

If the system has been maintaining accurate billing records, this step should be fairly simple. The category Revenue Water must be calculated in the first step comprising Billed Metered Consumption and Billed Unmetered Consumption. Since the mechanism bills for both of these groups, you should be able to find the information you require by reviewing the documents. Residential, business, and industrial users are included in billed metered consumption. The system might use various techniques to charge these various customer groups. A deal to supply water from a fire hydrant to a building site to irrigate roads serves as an illustration. The utility should make its best effort to determine the precise amount of water used in this category. The amount of water used in this group by many devices may fluctuate over time or may even be zero.

Since water use in this group is permitted by the system, one might anticipate that quantification will be easy. Public usage within the community makes up the majority of unbilled authorised consumption. Unbilled Metered Consumption and Unbilled Unmetered Consumption are two subcategories of this group As long as these metres are being read and documented; metered uses should be simpler to measure. Since no one is being charged for these uses, reading these metres is occasionally not a system concern. Once both parts of Unbilled Authorized Consumption have been quantified, add this category to Billed Authorized Consumption and Revenue Water, to establish Authorized Consumption. Calculate the water losses by deducting this amount from the system input.

Evaluate Apparent Losses:

Two categories i.e. Apparent Losses and Real Losses comprise the elements of Water Losses. These two words' initial definitions, which are as follows, can be perplexing, Apparent Losses of water appear as inaccurate measurements of water movement, Incorrect water consumption and mistakes in water accounting. Real Losses water's actual bodily egress from the distribution infrastructure, and consist of leaks and spills before the moment of final use. Another way to think about Apparent Losses is that water delivered to an end user, including unauthorised use, but not correctly measured or documented, falls under this category. Sometimes apparent losses are called “paper losses" because they contain water that hasn't been accurately documented on paper. Apparent losses are more costly to the system than real losses. Apparent Losses are composed of Customer Metering Inaccuracies and Unauthorized Use. Theft or other types of unlawful water intake are examples of unauthorised use. Unauthorized use can be found and determined using a variety of techniques. You can get the information you need by following the flow readings on distribution lines; especially if only a small number of clients are used for the assessment Valve-based line isolation may also be effective.

Evaluate Real Losses:

Real Losses are water's actual bodily egress from the distribution infrastructure, and incorporate spills that occur before the site of use, such as leaks. Real losses companies usually lose more water due to these factors compared to apparent losses. Real water loss has a marginal cost that is based on the cost of production, which includes the costs of extraction, treatment, transportation, operations, and upkeep. Leakage on Mains is the first category of Real Losses. Any actual loss of water in the distribution system—as opposed to storages or utility connections—is referred to as leakage on mains. Those who are not acquainted with the standard water balance frequently confuse this group with "water loss" or "unaccounted-for water." On-main leakage will change over time. Make sure the data you purchase will satisfy the requirements of the water assessment [20]. The most recent and sophisticated actual loss sign (recommended by the IWA and AWWA Water Loss Committee) is the ILI, the Infrastructure leakage index. The ILI is a measure of the management of a transportation network (maintained, repaired and rehabilitated) for the control of real losses, and pressure at the moment of action. I The percentage of the most recent annual output to Real Losses (CARL) to Unavoidable Annual Real Losses (UARL). ILI = CARL/UARL

Being a ratio, the ILI has no units. But what are unavoidable losses and how are they calculated? Practitioners of leakage control all over the globe are well aware that Real Losses will always be there, even in a brand-new, well-run institution. The following algorithm can be used to determine the UARL. UARL (litres/day) = (18xLm = 0.8 x NC + 25 x Lp) x P

Where;

Lm = Length of mains (km);

Np = Number of service connections;

Lp = Total length of private pipe, curb-stop to customer meter (km);

P = average pressure (m).

Calculated components of Unavoidable Annual Real Losses are shown in table 1.

Sr. No.	Infrastructure Components	Background Losses	Reported Bursts	Unreported Bursts	UARL Total	Units
1	Mains	9.6	5.8	2.6	18	Liters/ km mains/Day /meter of pressure
2	Service Connection, meters at edge of street	0.6	0.04	0.16	0.8	Liters/Connection / day / meter of pressure
3	Underground pipes between edge of street and customer meters	16.0	1.9	7.1	25	Liters/km / Day / meter of pressure

Table No 1: Component of UARL

Performance Measurement:

The water audit procedure still has one more stage left: analysing the data that was gathered. A performance metric that is expressed as a straight number does not take into consideration changes in usage or system input. Consider the next straightforward illustration:

	System Input	Total Gallons Consumed	Total Customers	Use per Capita	Total Real Losses	Percentage of Water Loss
System 1	1,000	800	10	80	200	20%
System 2	1,800	1,500	10	150	300	17%
System 3	1,300	1,000	10	100	300	23%

The quantity of clients served by Systems 1 and 2 is the same. System 2 uses more resources overall, more resources are used per person, and more resources are placed into the system of real losses. However, due to the ratio involved between real losses and system input, Water leakage is less frequent in System 2. Additionally, System 2 and System 3 both serve the same number of clients and have the same real losses. System 2 uses more water per person and loses less water overall. These fictitious cases should demonstrate that a straight proportion of water loss should not be used to assess the water efficiency effectiveness of a system without taking into consideration several other variables. There are other success metrics available to assess the water use effectiveness of your company.

CONCLUSION

Opportunities for energy savings will be found through an energy assessment. It will assist you in better understanding how much energy you use and how to use it. An energy assessment can find electrical, wiring, and ventilation safety issues, making your house or place of work safer. The worth of a house when it is sold will rise.

As an added advantage to the efficient use of water resources, transportation and its use can reduce construction and operating costs with the protection of the environment, it shall be handled in the water audit study. A water assessment can help us locate leaks and calculate costs. Set a performance objective to improve the area's service level standard and implement the necessary systemic safeguards for the foreseeable future.

Gaps and future challenges for:

Water audit:

One drawback of water auditing is that it can be time-consuming and expensive to implement. Conducting a comprehensive water audit requires a significant amount of data collection and analysis [25], which can be labour-intensive and costly. In addition, water audits may require specialized equipment and expertise, such as flow meters and leak detection tools, which can further increase costs. Another potential drawback is that water audits may not capture all sources of water use within a system. For example, water audits may focus on buildings and infrastructure but may not capture water use associated with landscaping or other outdoor uses. This can lead to an incomplete understanding of a system's overall water use and potential opportunities for conservation [26].

One future challenge for water audit is the increasing complexity of water systems due to factors such as population growth, urbanization, and climate change. As water systems become more complex, it becomes more challenging to accurately measure and monitor water use, identify inefficiencies, and develop effective strategies for water conservation. Another challenge is the availability and reliability of data [27]. Water audits rely on accurate and comprehensive data to identify water use patterns, detect leaks and other inefficiencies, and develop effective conservation strategies.

Energy audit:

One limitation of water audits is that they may not account for all sources of water use, particularly outdoor uses such as landscaping and irrigation. This can lead to an incomplete understanding of a system's overall water use and potential opportunities for conservation [22]. Additionally, water audits can be time-consuming and expensive to implement, and their success ultimately depends on the willingness of stakeholders to implement recommended changes. Finally, the availability and reliability of data can also be a challenge, as water systems become more complex and data quality can vary significantly depending on the source and method of collection [23].

One future challenge for energy audit is the increasing complexity of energy systems due to factors such as renewable energy integration, distributed generation, and energy storage. As energy systems become more complex, it becomes more challenging to accurately measure and monitor energy use, identify inefficiencies, and develop effective strategies for energy efficiency and conservation. Another challenge is the availability and quality of data, as energy systems become more diverse and decentralized, making it harder to collect and analyse data from various sources [24]. Additionally, keeping up with evolving technologies and regulations, as well as maintaining the necessary expertise and resources, can also pose challenges for energy auditors.

REFERENCES:

1) Ashok, S., & Banerjee, R. (2001). An optimization mode for industrial load management. IEEE Transactions on Power Systems, 16(4), 879-884.
2) Wong, H. K., & Lee, C. (1993, December). Application of energy audit in buildings and a case study. In 1993 2nd International Conference on Advances in Power System Control, Operation and Management, APSCOM-93. (pp. 977-981). IET..
3) Mendis, N. N. R., & Perera, N. (2006, December). Energy audit: a case study. In 2006 International Conference on Information and Automation (pp. 45-50). IEEE.
4) Zhang, J., Zhang, Y., Chen, S., & Gong, S. (2011, July). How to reduce energy consumption by energy audits and energy management: The case of province Jilin in China. In 2011 Proceedings of PICMET'11: Technology Management in the Energy Smart World (PICMET) (pp. 1-5). IEEE.
5) Singh, M., Singh, G., & Singh, H. (2012). Energy audit: A case study to reduce lighting cost. Asian Journal of Computer Science and Information Technology, 2(5), 119-122.
6) Baskar, R. H., Mittal, H., Narkhede, M. S., & Chatterji, S. (2014). Energy audit—A case study. International Journal of Emerging Technology and Advanced Engineering, 4(3), 73-78.
7) Khalid, M. U., Gul, M., Aman, M. M., & Hashmi, A. (2012, December). Energy conservation through lighting audit. In 2012 IEEE International Conference on Power and Energy (PECon) (pp. 840-845). IEEE.
8) CO_GEN, N. G. B. (2007). Bureau of energy efficiency.
9) McCullough, J. S., Casey, M., Moscovice, I., & Prasad, S. (2010). The effect of health information technology on quality in US hospitals. Health affairs, 29(4), 647-654.
10) Sultana, G., & Harsha, H. U. (2015). Electrical energy audit a case study. IOSR Journal of Electrical and Electronics Engineering, 10(3), 01-06.
11) Gomes, J., Coelho, D., & Valdez, M. (2011, July). Energy audit in a school building technology, professional and Artistic School of Pombal. In Proceedings of the 2011 3rd International Youth Conference on Energetics (IYCE) (pp. 1-6). IEEE.
12) Bhawarkar, S. R., & Kamdi, S. Y. (2011, December). Electrical energy audit of a electroplating unit—A case study. In 2011 International Conference on Recent Advancements in Electrical, Electronics and Control Engineering (pp. 25-29). IEEE.
13) Ali, S. B. M., Hasanuzzaman, M., Rahim, N. A., Mamun, M. A. A., & Obaidellah, U. H. (2021). Analysis of energy consumption and potential energy savings of an institutional building in Malaysia. Alexandria Engineering Journal, 60(1), 805-820.
14) Gopinath, K. Optimizing The Energy In An Educational Institution Using Energy Audit.
15) Bhatia, R. (1987). Energy demand analysis in developing countries: a review. The Energy Journal, 8(Special Issue).
16) Dinesh, R. (2005). Water audit in National scenario. In National conference on water management conservation and sustainable development,. Abstract (Vol. 1, pp. 26-27).
17) Rivett, M. O., Halcrow, A. W., Schmalfuss, J., Stark, J. A., Truslove, J. P., Kumwenda, S., ... & Kalin, R. M. (2018). Local scale water-food nexus: Use of borehole-garden permaculture to realise the full potential of rural water supplies in Malawi. Journal of environmental management, 209, 354-370.
18) Lambert, A. O., Brown, T. G., Takizawa, M., & Weimer, D. (1999). A review of performance indicators for real losses from water supply systems. Journal of Water Supply: Research and Technology—AQUA, 48(6), 227-237.
19) Fanner, P. (2007). Evaluating water loss and planning loss reduction strategies. AWWA Research Foundation.
20) Lee, J. Y., & Yim, T. (2021). Energy and flow demand analysis of domestic hot water in an apartment complex using a smart meter. Energy, 229, 120678.
21) Water Loss Control | American Water Works Association. (n.d.). Water Loss Control | American Water Works Association. https://www.awwa.org/Resources-Tools/Resource-Topics/Water-Loss-Control

22) Al-Yasiria, A. J., Alib, M. A., Alic, R. S., & Bekheetd, H. N. (2020). Renewable energy sources in international energy markets: reality and prospects. Renewable Energy, 11(3).
23) Bhat, A., & Hegde, R. Comprehensive Study of Renewable Energy Resources and Present Scenario in India.
24) Jahangir, M. H., Zavvari, S., & Parvin, M. (2022). Optimizing the size of the hybrid power and heat generation system during COVID-19 crisis (case study: Italy). Electric Power Systems Research, 211, 108610.
25) Anand, N. (2015). Leaky states: Water audits, ignorance, and the politics of infrastructure. Public Culture, 27(2), 305-330.
26) Richardson-Prager, L., Sturby, D., Shaffer, C., & McMaster, E. (2004). Dalplex Water Audit.
27) Mathis, M., Kunkel, G. A., & Howley, A. C. (2008). Water loss audit manual for Texas utilities. Austin, Tex: Texas Water Development Board.