# Energy Monitoring, Targeting and Waste Avoidance

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*Abstract* — **Energy monitoring is a technical and management function which provides a capability to monitor, record, analyze, examine, and control energy flow through systems. Energy used in industrial process is expected to depend on the quantity of products, while energy in residential building is expected to depend on weather conditions, there are several approaches and methods can be taken for each particular case of study.**
**Monitoring is deployed to compare internal variations in energy consumption with external trends, and monitor the performance over a period of time. Regular trending such as weekly or monthly analysis of energy consumption patterns provides improved information; therefore the accuracy of data becomes important factor at this level of monitoring.**
**Targeting is a realistic dynamic procedure in which energy performance goals are set for various conditions, energy consumption levels should be periodically monitored and justified in order to achieve acceptable energy usage. To achieve these goals, a necessary information and data have to be collected and be correctly interpreted. The techniques to do this come under "monitoring and target setting".**
**This study examines a precise description of monitoring and targeting concept and the technique of collecting and analyzing energy data, also the subject of waste avoidance and the methods of diagnosing and eliminating wasteful energy will be covered.**

*INDEX TERMS* **— Accuracy, Analyze, Energy Consumption, Monitoring, Targeting, Waste Avoidance.**

## I. INTRODUCTION

The ability of any nation to survive economically depends upon its ability to produce and manage sufficient supplies of low-cost safe energy raw materials [2]. Any attempt to reduce the rates of energy consumption even by one percentage per annum; ensure an effectively unchanging future supply as the world moves towards renewable energy economics.
It is important that the energy management program has an objectives and means of monitoring progress towards them [5]. The actions that have been taken should achieve the expected results and suitable correction action has to be apply, in order to achieve this we must collect the correct and accurate information of the amount of energy related to the activity of the business and able to interpret it correctly.

Governments, industrialists, commercial organizations, public sector departments, and the general public have now become aware of the urgent requirement of the efficient management of resources and energy consumption activities [2]. Most organizations, manufacturing, retail sectors, and industries have created energy departments or have employed consultants to monitor energy consumption and to reduce wastage. The energy manager must also be responsible for day-to-day management of the flow of energy, resources, production and distribution, services, process equipment, polluting exhaust, effluents and wastage.
It is possible to establish the existing energy consumption of a facility or organization through an energy audit, However this only produce a 'picture' of past energy consumption. In order to control the subsequent energy consumption, it is necessary to initiate monitoring program, although by itself it is only of limited values, as it simply records energy consumption. To achieve improvements in energy performance, a targeting program in which targets are set must accompany the monitoring process and planned improvements made. Key elements of monitoring and targeting (M&T) program are as follows [1].

- Establish an Energy Account Centres (EACs) within an organization (these may be cost centre or departments); operational managers should account and calculate the energy flow and consumption of EACs for which they are responsible.
- Establish a standard energy performance benchmark for each EAC. Standard energy performance relates the energy consumption to a variable such as degree days or production output, it provides a base line for the assessment of future energy performance.
- Monitor the energy consumption for each EAC within an organization and setup procedures to ensure the regular collection of reliable energy data.
- Establish an energy data targets for each EAC. Energy cost saving can be achieved if improvements are applied on standards performance; therefore achievable targets have to be set in which improved on standard performance.

- Energy management reports have to be produced for each EAC on a regular basis; these reports provide an active improvement energy performance and should also determine the quantity of improvements that are achieved.

It is important that the (M&T) program has to be designed to suit the needs of the organization. Organizations can be classified in different ways; one useful classification method is by the number of covered sites and the level of metering as follows: (the four points are quoted from reference [1]).

- Single site with central utility metering.
- Single site with sub-metering.
- Multi site with central utility metering.
- Multi site with sub-metering.

Single sites with central utility metering is best treated as single EAC, while sub-metering enables such sites to be broken up into number of separate EACs. If the organization have a number of separate properties each with central utility meters, the sites have to be treated as separate EACs, and if the organization have multiple properties each containing sub-metering; then each site has to be probably divided into number of separate EACs.

***Definition: Degree days*** are a measure of variation of weather temperature which helps the designer of building and users to determine the relation between the energy consumption in the building and the weather variations effect, they determine how long, and how far the external temperature has fallen below the set base temperature. The daily data can then be accumulated for any required period (week, month, and year…etc) and compared directly with the energy data.

## II. MONITORING AND DATA COLLECTION

The main element of any (M&T) program is the data collection. The accuracy of an energy audit for the (M&T) program depends on the collection and input of good quality data. To ensure accuracy; a firm data collection procedures must be established, but problems occur for many reasons. In case of use a very few data, the analysis will be meaningless, therefore most systems require at least 12 sets of data in order to carry out a logical and meaningful analysis. But in case of excessive data are used, these date will slow down the collection and analysis process and leads to over complex (M&T) system. In some case if the data are collected from various sources and this data may be incompatible, making the comparison very difficult. If meters are read incorrectly and also when readings are incorrectly logged; errors may occur.

## III. COMPUTER-BASED MONITORING AND TARGETING

The used of computer designed software as main potential tool with the (M&T) program, computers enable a large amount of data to be stored, processed, and analyzed in a very short period of time. A software packages for many energy management are commercially available with different level of complexity, they all share the following features:

- Capability of storing and organizing large amount of collected data over long period of time.
- Ability to record energy data for all types of utilities, including data collected from invoices or meters.
- Ability to carry out complex utility tariffs, which are vary form company to company and as a reason of introduced competition into the utilities sector the tariffs become more complex.
- Ability to handle other variables such as degree days and production data [1].
- The ability to incorporate statistical data analysis software into the energy management system.
- Facility of reporting, to produce an integrated energy management reports.

The main advantage of computer-based system is their database facility, the historical data and data from many resources could be compared instantaneously. The collection process of data can be categorized into two types of data source:

1) Data form invoices: invoices are the main source of energy data. Problems occur as a result of misplaced invoices, because these invoices cover different types of utilities; therefore it is necessary to establish a good collection procedure to ensure a good quality of data has entered to the computer system.
2) Data from meters: it provides another useful source of energy data. Theoretically these readings should be relatively simple task, but in practice a number of faults occur, some of these common faults can be listed:
   a) The data digits may be recorded in the wrong order, or too many digits may be inserted in the recorded readings.
   b) The recorded readings may be mistaken by factor 10 or even 100.
   c) Possibility of loosing readings after recording process.
   d) Inaccessible to read data form faulty meter, or read data from wrong meter.
   e) Apply poor trend information when recording data, poorly recorded meter readings can lead to waste of time and efforts; therefore meter readings have to be validated all the time.

f) Operator or human error as a reason of wrong meter installation set up which leads to create a source of reading differences.

Therefore a robust data validation system has to be established in order to alert the operator or user in case of potential error is detected. Validation check activity can take place either when data are input or at the initial levels of data analysis.

Using hand to write down digits of data, and manual reading of meters are time consuming process and it subjects to mistakes. there are a variety of alternatives to the manual approach, for example a portable data reader capture unit can be used to collect the data from the meter and once the data stored in the memory of the reader unit, it will be easy to download all these data in suitable software form to the (M&T) computer for storage and analysis purposes.

If the exist metering devices are unable to give enough detailed information, additional sub-metering devices may be necessary to be installed to enhance the overall metering performance, but additional metering can increase the cost of the system and moreover it will increase the quantity of processed data, therefore the option of installing an additional meters has to be studied and justified carefully to ensure that potential energy cost savings are not exceeded by installation cost.

## **IV.** ENERGY TEARGETS

At the outset of any (M&T) program, it is important to set energy targets. Initially, these should be the standard energy performances which have been established for the respective EACs [3].

Standard performance can be determined through the analysis of past energy consumption data, if these data are not exist, then it will be necessary to undertake an auditing process to establish a credible standard energy performances for the respective EACs. Standard energy performance is generally used as an initial target; subsequent energy targets should represent improvements on standard performance [1].

One way of establishing an improved target is by plotting both the standard consumption and the target consumption and compare between them as shown in Fig.1. Energy targets should be assessed on regular basis and this can be done by defining the best historical performance as a target or by basing the target on an agreed action plan that is designed to achieve energy saving. Both these methods have an advantage of being based on real data, and therefore it should be achievable. Amore random and possibly method giving lower quality approach is to set targets based on a percentage improvement on the current energy performance, all targets should be realistic and achievable in order not to loose credibility. Targets and actual data should also be reviewed regularly in order to control and reduce energy losses.

## **V. I**NITIAL STEPS TO BUILD MONITORING AND TARGETING SYSTEM:

To build a monitoring and targeting system, a real energy data has to be employed, in practical environment the data has to be chosen from a single site or multi site of energy metering, but to assist us in our study we are going to use a data of an industrial district cooling plant located in United Arab Emirates – Dubai, EMICOOL, supply chilled water to the residential and commercial areas.

Every organization should have access to this data, as they need to keep 6-7 years of invoices to satisfy Inland Revenue requirements. The tradition approach to (M&T) is based on defining energy accountable areas [7].

The starting point is by:

- Collect and systematically arrange 12-24 months of energy invoices or (meter readings).
- Arrange the production energy data for the same period of time.
- Energy data has to be entered into spread sheet.
- Produce a chart of energy production per month as shown in Fig.2.
- If we add the consumption energy data to the production data under the same period of time, we will gat the production-consumption details as shown in Fig.3 which provide us the behaviour of the consumption energy flow and according to these we can calculate the losses in energy and we can estimate and construct the target plan. More clear comparison which shows the margin level between production and consumption energy can be concluded from scattered curve as in Fig.4, and it can be used to drive the standard consumption for the next years.
- A formula relate the energy production and consumption has to be defined and generated according to the available parameters, generally this formula is in (1):

$$E = (M \times P) + C. \qquad (1)$$

Where,

E: is the energy consumed in period.

M: is the energy consumption directly related to the production (variable).

P: is the production for the same period of time.

C: is the (fixed) energy consumption (i.e. energy consumed such as lighting, heating or cooling, and general auxiliary services that is not effected by the production levels). Using this we can calculate the expected or “standard” energy consumption for any level of production within the range of the data set [7].

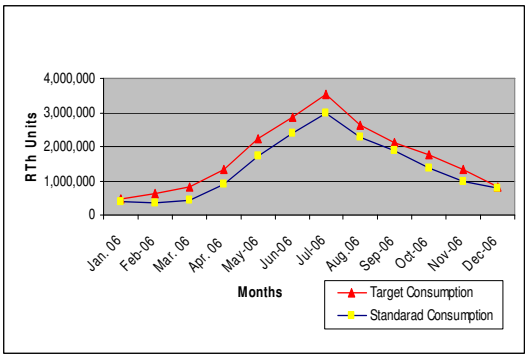


Fig. 1. Target curve based on best historical performance for year 2006.

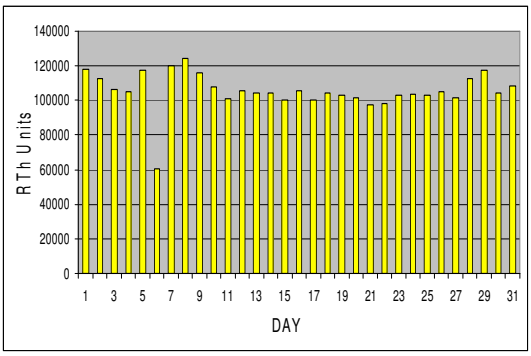


Fig. 2. Daily plant energy production (RTh) for month of July 2006.

## VI. WASTE AVOIDANCE

The basic concept of waste avoidance principle is to enable a large energy cost savings to be gained without significant capital investment, therefore waste avoidance aims to reduce avoidable wasted energy as large quantities of energy can be lost over long or short period of time. The program of waste avoidance should be quick and not so expensive to be implemented.

It is easy to detect the rate of waste in the field of materials wastage, but energy wastage is not as easy to be detected and identified and it is usually require more inspection and concern. A very simple example of waste energy avoidance can be given from a practical life, consider the case of heater switch in the switchgears compartments or in the electrical panels, the benefit of the heater is to keep the compartment's internal atmosphere within a certain temperature in order to prevent frost in winter season, but in summer there is no necessity to keep the heater switched ON unless for special purposes, keeping the heater ON all year round without any concern leads to waste in energy. If the case is detected early enough, a large savings can be achieved.

## VII. CAUSES OF AVOIDABLE WASTE

Organization and facilities may vary widely; many of the causes of the avoidable waste are generic and common to most application. These generic causes include the following [3]:

- Frost protection devices remain switched ON over a long periods of time when there is no danger of frost damage, similarly the pre-heating coils in air handling units (AHU) usually operate all year round without aware of the problem.
- Major energy wastage can be caused as a failure of switches, the switches are used to turn equipments ON and OFF automatically, but if for any reason the switch failed or stacked in (ON) position then this leads to keep the equipment running continuously for a considerable period of time till the system operators notice and take serious action.
- Excessive energy consumption can be caused by time controller, time controllers are designed to turn OFF equipments after pre-set time of operation, if controller failed or if they simply pre-set incorrectly this will leads to extend equipments running operation and much extra energy being consumed and wasted. also the lack or missing of controller from some equipments such as lighting devices and ventilation fans often have no time controller, such of these devices are tend to be left working ON continuously and the operation staff usually forget to switch OFF these items.
- The leakage of water or steam from pipes are often go undetected for long period of time because they usually occurs underground or out of the site of operation, the wastage in water or steam energy are costing the organization and increase the charges of maintenance.
- Excessive energy wastage can be caused by control valves and dampers if they are not correctly monitored and controlled. In the heating system if the damper remains in open mode position for long period of time during winter season, much energy will be wasted in order to heat up quantities of cold air. In air handling systems, the quantities of fresh air and re-circulated air can be controlled by employing modulating dampers devices.
- The poorly set controls in air conditioning systems causes much wasted energy. In case of cooling set point is set below the heating set point, both of cooling and heating coil units operate at the same time and fight each other. In practice this incident usually occurs without aware of the building occupants or the system operator and it leads to waste excessive energy consumption.

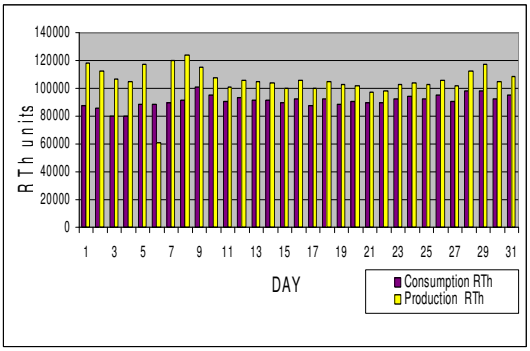


Fig. 3. Daily plant production-consumption - July 2006.

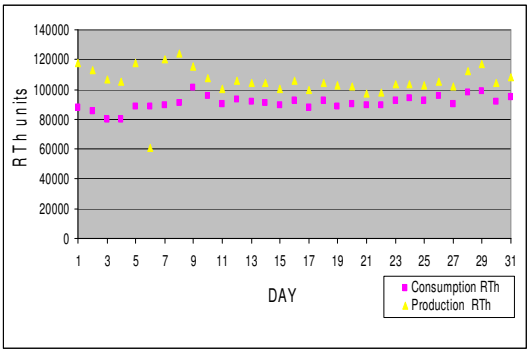


Fig.4. Daily plant production VS daily plant consumption - July 2006.

## VIII. CONCULSION

"The secret to effective management in any fields is the effective use of time and resources" [6]. The main purpose of the (M&T) program is to improve the efficiency. Without a constant input of all variables associated with the energy consumption, target and monitoring program can not realise the savings of energy. An immediate action has to be taken by the responsible manager against any changes in target gain or losses to ensure effective targets are maintained.

During monitoring and targeting period it becomes clear that two main factors limiting the accuracy of monitoring process:

- Human errors in reading meters and the actual timing of meter readings [6].
- The reliability of operation meters.

To ensure reliability, the installed meter should have a digital readout and must include an automatic recorder indicating time and consumption.

Most of the causes of the energy wastage are due to incorrect control setting, control failure, and the use of insufficient controllers, these failures can be rectified with relatively little cost. The energy wastage problems can be solved by creating a checklist which identifies common problem areas. This list can assist the prioritization of energy conversion measure by commencing from simple and obvious energy saving cases and progress towards hard and hidden cases.

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