Energy Accounting – Importance of Electronics and Computing

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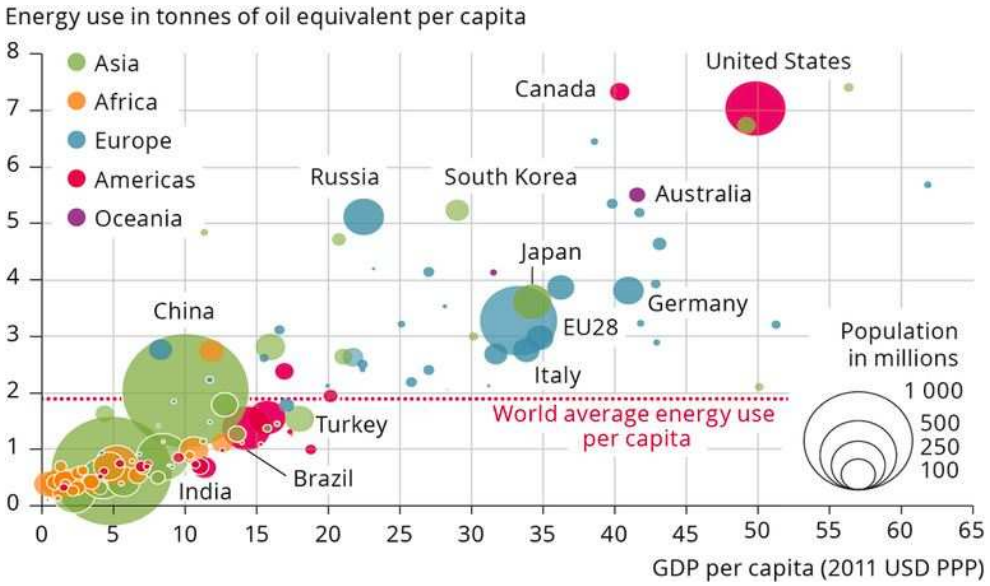
A. INTRODUCTION

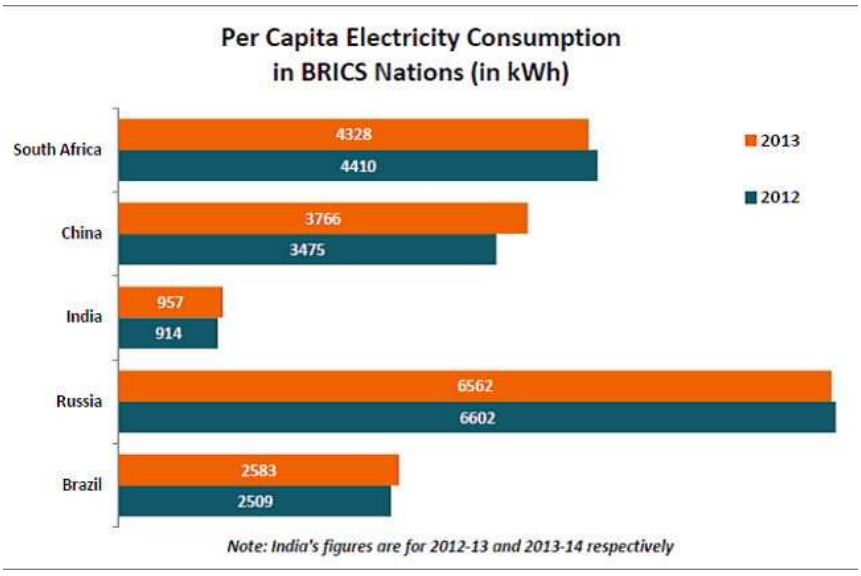
Indian Economy is now entering the second generation of reforms. The quantitative restrictions are almost non-existent. The tariff barriers are crumbling down. This situation, coupled with high finance charges; Poor international penetration, protected labour and bloated bureaucracy leave no other option than to improve productivity.

Three options available are labour productivity, raw materials and energy. The first is time consuming and requires cultural change, though many industries are showing signs of success. The second one is technology and equipment intensive, requiring large investment, and with low return on investment. The energy conservation option in many cases have very high returns, (direct pay back in weeks or months), relatively low investments and proven technology. It is ironic that most of the Indian industries accept partially proven technology for production with very high investments, while insisting on many similar practice for energy conservation before implementation.

One primary indication for nation's growth is GDP. It is obvious that energy use has a close correlation with GDP growth

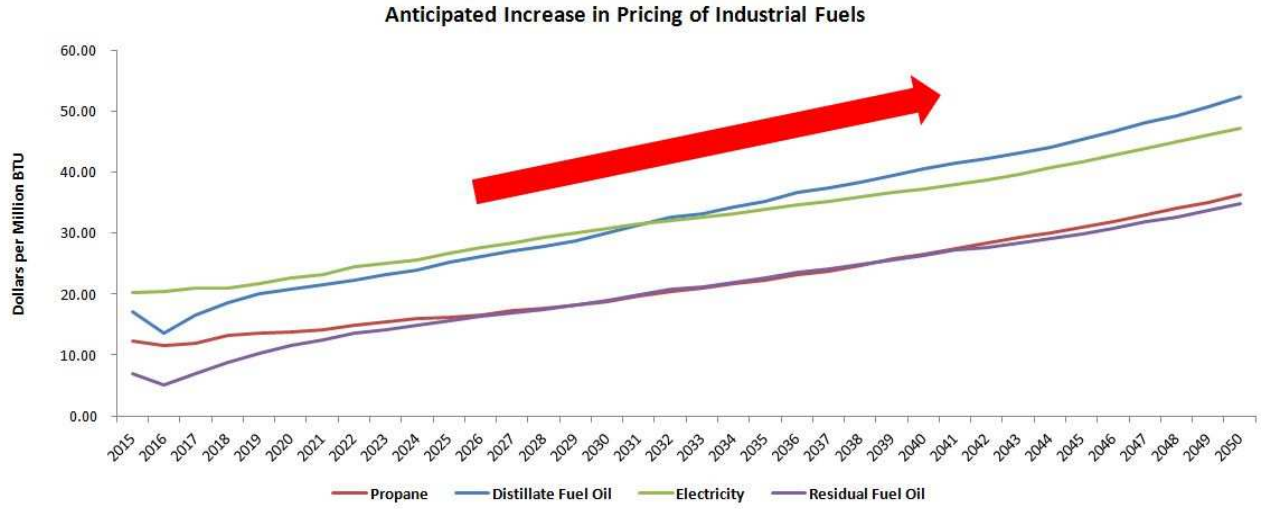


The possible increase in India's energy use is also reflected in the BRICs comparison



Energy being both scarce and expensive, and the fact that energy saving is independent of any other productivity measures, is being realised by many industries.

This information from US department of energy is a good indicator of how industrial energy costs are set to rise – and any investment on energy conservation would be cumulative.



The past few years are changing the outlook of many industries, as they have realised that the energy saving option is not only attractive, but requires low lead time compared to other areas. Thus, there is a higher interest in energy conservation than before. The passing of the energy conservation bill has unfortunately dampened the individual industries energy conservation program by directing the focus to benchmarking than self improvement along with designated industries concept.

When the industries start looking at Energy as a proportion of Value addition, instead of looking at Energy as a percentage of turnover, paradigm is likely to change (Value addition, for simplicity is taken as Sales Turn Over – (Raw Materials + Consumables)

A Cement Manufacturing Unit			
Parameter	**2015-2016**	**2015-2014**	**2014-2013**
Turnover	75362.5	61947.19	65684.96
Raw Material	20751.84	13677.43	13264.88
Energy	11907.11	14373.93	16514.05
Energy Expense as a % of TurnOver	16%	23%	25%
Energy as a % of Value Addition	**21.8%**	**29.8%**	**31.5%**
A Sugar Manufacturing Division			
Parameter	**2015-2016**	**2015-2014**	**2014-2013**
Turnover	239541	226504	194548
Raw Material	132708	139482	124560
Energy	7672	6640	5045
Energy Expense as a % of TurnOver	3%	3%	3%
Energy as a % of Value Addition	**7.2%**	**7.6%**	**7.2%**
A Pigment Manufacturing Firm			
Parameter	**2015-2016**	**2015-2014**	**2014-2013**
Turnover	22522.16	17388.67	15327.82
Raw Material	10353.91	7539.6	6268.79
Energy	1085.61	1289.42	1329.5
Energy Expense as a % of TurnOver	5%	7%	9%
Energy as a % of Value Addition	**8.9%**	**13.1%**	**14.7%**
*All values are in Lakh Ruppes			

Summing up, the need for using energy carefully is

- **Energy is scarce**
- **Energy is expensive**
- **Energy saving does not affect any other productivity measure**
- **Energy saving helps environment**
- **Hence,**

Energy has to be used carefully

B. MANAGEMENT TOOLS

For managing anything, the tools are the same, be it finance, project, inventory, sales, or **ENERGY.**
The tools of management are listed below in their sequence.

1	**Measure**	**One Can Manage Only What Is Measured**
2	**Account**	Without Accounting, Measured Values Are Just Figures.
3	**Analyse**	Change Can Occur Only With Analysis
4	**Formulate Action Plan**	An Action Without Plan Is Inco-ordinated.
5	**Implement**	The Final Action, Without Which There Is No Profit.

Energy management too, has to follow the same steps. In case of energy, two intermediate steps are used after analysis. They are:
1). Identify Savings Potential.
2). Estimate Commercial Feasibility.
The above approach, would lead to proper management of energy, and anything else would be less scientific.

C. CURRENT APPROACH

Presently all energy conservation starts with energy audit. An energy "auditor" is sought, and a study of the existing operations is conducted over a week or a fortnight. They see the operation on those few days, and come out with some standard recommendations. Some of them get implemented, and some energy is saved. Even the implemented standard solutions - the results are far lower than expected. The industry compares itself with the bench marked energy consumption. If they are near the top, they get convinced that the best has been done. Otherwise, the size and age of the plant, or investment constraints are the reasons for higher energy usage.

Thus, the momentum is lost, and precious energy gets wasted.
To sum up

Energy management should be

- **Measurement**
- **Accounting**
- **Analysis**
- **Identify energy saving potential**
- **Ensure commercial feasibility**
- **Formulate action plan**
- **Implementation.**
- **Back to Step Measurement for a Dynamic and Continuous Process - A Pursuit Towards excellence**

But the current approach is

- **Call energy auditor - get recommendations**
- **Implement some - Save some energy**
- **Implement others - Face difficulty or no savings**
- **Compare performance with Similar industries - (Bench Marking)**
- **Be complacent if closer to the best**

Which Misses The First Three Steps. This Situation Leads To Some Question, Which, When Probed Becomes Disturbing.

D. DISTURBING QUESTIONS

Let us start with each question which arises after an energy audit - implementation cycle.

1. Have we achieved the lowest possible energy conservation?

Most industries, immediately after an energy conservation exercise, say that they have done the "**best they could**". Does that mean that there is some more to be done or that the constraints are larger? Does it mean that the industry knows exactly, the amount of energy which can be saved, but found them commercially non-viable? It is but a fact that most of them may not have the thermodynamic base, to know the theoretical minimum, and the present efficiency levels. It is but unfortunate, that most leading energy consultants feel that thermodynamics based analysis would lead to nothing - Forgetting for a while that thermodynamics at the minimum tells how close one is to the **"ultimate"** in energy conservation.

2. Have we chosen the best method?

Each company knows that it has chosen the proven method of energy conservation. But many of them are not sure if they have chosen the best method and that there is no further scope of improvement. For example,

- *While thinking of a variable speed drive to a pump or blower, theoretical requirement by understanding the process better,(or improving their efficiency) could get missed*
- *While looking at installing a recuperater in the exhaust, the possibility of reducing the exhaust loss by process optimisation might not have been studied thoroughly.*

With energy accounting, the exact quantification ensures that the one method is chosen before analysing all the possibilities.

3. Are the achieved savings being maintained?

To quote an experienced senior person

> "When an investment proposal is taken to the management, the proposals for saving on raw materials are always given the first priority. It is because, the management can not only visualise the savings, but have a system in place for continuous monitoring. The energy conservation proposals, on the other hand, are always treated on the merit of the person proposing it. It is finally granted on the personal commitment by the proposer. The management knows that after the initial monitoring, no one knows if the energy savings are sustained"

The exceptions are where energy is used almost like raw material.

4. Can We State With Confidence That None Can Better Than Us?

Most industries believe that they have done the "*best they can*". If an industry does better, "*their operating conditions are different*" - else "*we are presently on top and we would keep it up*". Thus, while the industries achieve considerable energy savings, none is sure if others can be better. Being number one in energy management thus becomes a guessing game. Energy accounting changes this, as everyone knows the exact quantum wasted, and in most cases, what is not done is known.

5. Do we have plan for the next 5 / 10 years?

The energy saving proposals are part of the annual budget. Thus, some proposals can get carried over for number of years, and some of them get approved almost immediately. With a long term master plan, it would be easy to have achievable targets and also reach them. With energy accounting as the base, it is possible to even work out more than one alternate method of energy saving, and choose the more attractive one at the time of implementation

The present practice

- The energy auditor looks at energy conservation potential
- Looks for areas for saving of energy than auditing energy usage.
- Recommends "PROVEN" measures which match observations, based on "Check List"
- Savings are great in early stages - then the savings and interests tapers off
- Large hidden potential for savings never get exposed.

Imagine financial management, without accounting, Energy management without Energy accounting would be similar. It is possible to achieve large savings without systematic approach, but it would never be complete.

The energy accounting ensures 100% coverage of all energy usage, and ensures that the audit and expert functions are separated from the basic accounting.

The following would be the roles of the industry, auditor and the expert.

Company	Maintain energy accounting
Auditor	Check for the correctness of account and apply conventional solutions
Expert	Find ways for saving energy beyond conventional methods and ensure result

Thus, for effective energy management, energy accounting becomes the proper base.

E. BASICS OF ENERGY ACCOUNTING

It is to be acknowledged that the concept of energy accounting is in its evolution stages, and lot more refinement is possible as the time goes by. The basic framework has to be consistent, if a useful system has to be the final result. The guidelines are as follows.

✶ Avoid Sampling Situations - Not only data is collected over a long period, action is based on continuous data collection.
✶ Account for Energy as we account for Money - Group the energy as expenses are grouped, go into detail where required, ensure input and output (like income - expenditure) are balanced.
✶ Energy Accounting to be a regular feature - It is continuous like financial accounting
✶ Verify - Each data is verified by at least one other method (Theoretical estimation, alternate form of measurement etc.,)

This results in
- Correct and accurate information
- Improved awareness

Both the above, result in better base for Energy Management.

F. ENERGY ACCOUNTING METHODOLOGY

The energy accounting is divided into two major divisions

1	Macro accounting	Accounting for the same form of energy
2	Micro Accounting	Accounting of energy in a single equipment - where change of energy form is involved

G. MACRO ACCOUNTING

The macro accounting, is basically balancing the input and the usage of the same form of energy
- in different departments
- in different sections
- And in different equipment.

If we can have accurate metering for each of the equipment, the accounting would simply be a question of arithmetic. In reality, it is too expensive to have meters, and also to ensure that each meter is recorded.

Even if one can install and record all the meters, the accuracy of the meters would always leave a gap in the balancing.

Hence, prudential energy accounting has to have a method for validating the meter, and also be able to have a method for estimating the energy consumption independently for cross verification with meter readings. Thus, judicious use of meters, and estimation methodology would provide the base for macro accounting.

It is due to this reason, initial accounting starts with about 80 % accuracy, and slowly increases the accuracy over a year or two. The final accuracy of balancing would be between 95 and 99%, due to the limitation of accuracy of the meters, and small losses. Of course, there are smaller areas, where the accounting would yield better accuracy where it matters.

Since energy accounting goes into detail even in smaller areas, the actual un-accounted loss would be far less than the 1% imbalance of the overall accounting.

The broad steps are listed below:

1. Separate each energy form.
2. Measure/estimate the consumption by each section/ department/ equipment - for each individual energy form
3. Compare with the total input of the respective energy form.
4. Validate the measurement by comparing the measurement with estimation / vice-versa.
5. Ensure that the incoming and the consumption of each energy form is balanced.

H. MICRO ACCOUNTING

Micro accounting is estimating the useful energy in any individual equipment, using thermodynamics, and estimating the losses by measurement of various parameters. This helps us to know both the quantum of losses, and their nature. It then becomes possible to analyse and reduce these losses to the extent possible.

The thermodynamic useful energy is the absolute theoretical minimum energy consumption required. The losses which can be minimised by closer maintenance of the parameters can be saved by better operation or control.

The modification in the design of the equipment, or the way energy is used is the saving by technology modification.

By monitoring the parameters, working out the energy balance and comparing with the theoretical minimum, we can exactly estimate the possible savings by improved control.

The quantification of the losses separately, the cost benefit of using different technologies for containing the losses can be estimated very precisely. When these data are available on regular basis through energy accounting, it becomes possible to monitor the savings achieved by implementing the energy conservation projects, and do it on a continual basis.

The basic methodology is as follows:

Take a single equipment.

1. Use thermodynamics to find the useful energy (that which is required by the product/ process).
2. Measure and estimate the loss of energy as radiation, sensible /latent heat in exhaust, leakage etc.,
3. Total all losses and the useful energy.
4. This should balance with the input energy to the equipment, once the loss estimate is done accurately.
5. Ensure that this is done on a continuous basis for each batch/ shift/ day , based on the process.

I. PERIODICITY OF ACCOUNTING

The data can be split into two types.

1. Those which vary depending on production
2. those that remain constant due to the basic design.

The data which varies, such as production, energy consumption, hours of operation etc or accounted depending on the logging frequency. For convenience, if there is no data logging, this can be once a shift or once a day.

The constant data are, those which could vary only over a longer duration, due to deterioration or changes in the ambient. Some of the examples are surface temperatures of the walls of the heating equipment, compressor / pump efficiencies, loading of constant loaded machinery etc.,. These data could be taken / checked once a month or once in three months, based on the expected variation, as reflected in energy accounting. These data are also checked, if the macro energy accounting shows gross imbalance, after it was established for consistency.

By properly documenting all the constant data, it also gives one, an idea of the loss of energy due to deterioration, say of insulation, or worn vanes in pumps etc.,.

J. ENERGY ACCOUNTING RESPONSIBILITY

The Energy accounting requires *team* effort, and involvement of personnel from various departments. The members of the team have to work in co-ordination, preferably under a single leader / champion.

The members from the following department are recommended
1. Production
2. Utility
3. Maintenance
4. Technology
5. Accounting

It is estimated, that only about four to five hours per week would be required for energy accounting by each member after the system is set up, while longer involvement would be required during the setting up of such a system.

K. INSTRUMENTATION

It is but obvious that accounting cannot be done without measurement. It is also a fact that the measurement has to justify the investment on the instrument. Since such precise justification could be difficult, and uncontrolled investment cannot be justified, basic maximum investment budget can be taken as 1% of the energy usage in that particular area / equipment in any year. Even this investment is to be judged on the basis that either
(a) The existing instrumentation do not give sufficient data for estimation
or
(b) The accounting variation on estimation is large enough, that we scope for saving energy by actual measurement.

One expects that all the investment requirements in instruments for energy accounting in a typical plant, would be covered over two year's budget of 1% of the cost of energy in each year. The point to remember is

What you cannot measure - cannot be controlled

L. ROLE OF ELECTRONICS IN INSTRUMENTATION

The cost of the instruments are further controlled, by stressing the repeatability and reliability of the instrument rather than the accuracy. The cost of instrument increases drastically with specification calling for higher accuracy, while the energy accounting can be managed with lesser accuracy, if the inaccuracy is consistent.

With phenomenal development in micro controllers, one can drastically reduce the cost of instrumentation by two means.

- Look for lower cost sensors – whose characteristics can be programmed into micro-controller or ability to calibrate on field by feeding values to the controller.
- Sensors need to be only as accurate as the economy desires – rather than specifying 0.1 % accuracy for all sensors. For example, water level monitoring can work very well with 5% accuracy.

Another aspect of retrofitting the instrumentation is wiring. Thus, any improvement of affordable RF (or any wire free) communication for limited distance to integrate with available Ethernet connection in industry can make a huge difference in speed of implementation.

M. REPORT GENERATION

The information, when not formatted, looks and feels like junk, as it unusable.

The reporting format has to take into account the following- while maintaining the core requirement of energy accounting – which is comparison of estimation Vs actual and bring out the Gaps between the two.

1. The purpose of the information – chronological trend or relationship etc.
2. The required value and the value of the “cause” or primary parameter
3. The variation in primary and resultant parameter – (eg: steam fuel ratio, unit per component (weighted basis), energy per kg etc.)

The report would have to be different at operator's level, floor/operational manager's and general management.

- The operational report would be predominantly in engineering units.
- The operational manager's report would be a judicious mixture of engineering and monetary values.
- The top management report would be predominantly in monetary value.

This would enable correct actionable pointers at each level.

Since these data and trends would have to be properly organised, stored for long duration and displayed in different combinations, use of databases and programming in selected database management languages would be essential.

By viewing the same data in different formats, the dominant causes gets highlighted for prompt and correct actions

N. AI AND ML IN ANALYSIS

Variations in energy consumption are always due to many parameters. Some of these parameters are under operational control, some are under management control and some are not under any internal control.

Thus, it is essential to filter out those influences which are not under one's control and also isolate to the extent possible the influence of parameters under control while analysing the data.

Since this become complicated, usually an expert's service who is able to "instinctively" zero in the dominant factor is sought after. With modern advances in technology, AI (artificial intelligence) and ML (machine learning) where required – can not only analyse the gaps, but help in converting them into opportunities.

O. POSSIBLE BUSINESS OPPORTUNITIES

Thus, the energy accounting throws open many areas of business opportunities. An attempt is being made to list them out, but it is not exhaustive but only illustrative.

- Low cost sensor development
- Wireless sensor electronics
- Battery / battery-less RF transmission packages for sensors
- Embedded simple communication protocols
- IOT sensors
- Data base management
- Reporting software / services
- Analytical software / services
- Specific energy conservation services/ product/ control systems
- General data analytical – covering large equipment/ processes of single equipment of single vertical to multiple equipment of multiple verticals.

Just a generalised building energy management itself is likely to offer large business opportunity.

About the Author:

An IIT madras 1974 graduate - T. Jayaraman - often referred to as Teejay is the Founder and Managing Director of SECO Controls Pvt. Ltd an energy based engineering company - which is the sole Indian manufacturer of oxygen analyzers.

"Teejay" is an Industry veteran in the engineering and energy field and is a consultant in energy auditing for over 40 years. He has been the National President of Indian Association of Energy Management Professionals and also accredited as the best energy auditor for the year (2009) by the State Government.

He is also the founder director of Indian Council for professionals in energy efficiency business.
The firm regularly trains on Electrical Safety, Operational Excellence , Energy and Electrical Utility Management.
Some of the clients include Accenture, Idea Cellular, Dubai Airport, Saudi Cements , Midas Safe Srilanka, SPIC, DCW, Enfeild, L&T Infotech, TAJ Hotels, Sundaram Motors, EICHER

Jayaraman's passion in teaching and mentoring led him to interact with a lot of youngsters only to realize that they had just the theoretical knowledge and minimal practical knowledge thus leading to the birth of the idea for E-Quad Engineering Services Pvt. Ltd. His commitment on environment is reflected in design of his office building and home - with 0% discharge ! in both buildings.