What Gets Measured, Gets Done

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ABSTRACT
Energy remains a controllable cost and energy users can make significant savings through a systematic approach to the management of energy. A diverse "multi-path" approach is required for energy management to reduce energy, greenhouse gas emissions and operating costs. Two of the paths suggested include measuring energy efficiency between diverse customer premises (benchmarking) and the five-steps to energy management.

The suggested energy efficiency performance indicators are: energy index, off-peak ratio, power factor, load factor, demand index and load duration plot.

The 5-steps to energy management are:
1. Public commitment by the CEO (Management commitment)
2. Make someone responsible for the project (Senior staff responsibility)
3. Implement an energy audit (Find technical solutions and implement)
4. Staff education and awareness (Staff motivation)
5. Report and measure progress.

SUGGESTED BENCHMARK INDICATORS

Measuring energy efficiency between diverse premises is not simple. Suggested energy efficiency performance indicators are:
- Energy index (EI)
- Off-peak ratio
- Power Factor
- Load Factor
- Demand index (DI)
- Load duration plot or building signature.

Energy index (EI)

Tracking changes in the overall energy consumption of a premise without accounting for the underlying activity levels of that premise gives no indication of the relative efficiency of energy use. The EI indicator provides a measure of how annual energy consumption (kWh or MJ) is related to activity levels, such as gross building area, nett lettable area, equivalent full-time employee or production variable. The lower the EI, the better.

Off-peak ratio

Off-peak ratio is a measure of how much electricity is consumed out-of-hours i.e. the lower the better, down to 0%. Large industrial premises consume around 40% electricity during off-peak times. Typical off-peak hours are between 10pm to 7am (overnight) each weekday and all weekends.

Power Factor

Power factor (PF) is a measure of how effectively premises are using their electricity. A poor PF will add to a premise's energy costs and waste energy i.e. preferably above 0.95 and closer to 1, the better. Premises on kVA tariffs are especially vulnerable to kVA demand charges and it is imperative whenever cost-effective, to improve the premise's PF at time of maximum demand.

Losses in electricity networks
The National Electricity Market (NEM) comprises:

- Generators – equipment that generates electricity
- Customer loads – equipment or infrastructure that uses electricity
- Networks – transmission and distribution elements comprising such equipment as overhead transmission lines, cables and transformers that transport electricity from generators to customer loads.

No network is a perfect conductor of electricity. Because of resistance within the network element, a small amount of electricity is "lost" when being transported from one point to another. The proportion of power generated that is lost depends on the location of generator and customer load connection points.

It is important to minimise the losses in the transmission and distribution networks (to the extent that it is cost effective to do so). Commercial & industrial customers pay for transmission losses and distribution losses. Generally, network losses from customer loads can be minimised by reducing electricity consumption or by reducing reactive power losses at the customer's premises.

What is reactive power?
The electrical power used by motors and fluorescent tubes, has two components: active power and reactive power. The active power is converted into useful work - turning motors or producing light - but the reactive component is only used to "energize" the magnetic or electrostatic properties of the equipment. Reactive power still has to be produced by the generator and transmitted to the customer over the electricity network. Supplying large amounts of reactive power through the networks increases current flow and network losses. Producing and transmitting the reactive power creates costs for the generators and networks, which are passed on to commercial & industrial customers as PF penalties.

Commercial and industrial customers with low PF are placing an undue demand on the electricity network and causing excess greenhouse gas emissions. Improving PF will reduce the need to spend additional funds on increasing the capacity of the network, thereby minimising electricity price increases.

Compensating for reactive power improves the efficiency of the NEM by reducing the amount of current flowing in the network, thereby reducing the network losses and consequently reducing greenhouse gas emissions.

Example: A customer's PF drops, the NEM becomes less efficient. A PF drop from 1.0 to 0.9 requires approximately 10% more current for the same load. A PF of 0.7 requires approximately 40% more current and a PF of 0.5 requires 100% (twice as much) to handle the same load. The answer to these efficiencies is to reduce the reactive power drawn from the network by improving or increasing the customer's PF.

Power Factor Correction
If the customer's electricity bill contains a PF penalty or if the customer is charged for peak load measured in kVA, power factor correction (PFC) can help to reduce such costs. PFC will also compensate for reactive power.

Depending on the original PF, the investment in PFC equipment can be recovered in two years, as cost savings can be up to 25%. The subsequent PFC saving can then be invested in other energy conservation measures and greenhouse gas emissions abatement initiatives. The greenhouse gas emissions reduction is generally between 1% and 2%, estimated from the power loss (Dugan 1996) α $(PF_{original} / PF_{corrected})^2$.

Typical components of PFC equipment include a cubicle (near the main switchboard and billing meter) containing capacitors, controller, contactors, protection and harmonic reactors. Other methods of PFC may also include the use of synchronous motors via control of the field excitation or procuring plant & equipment with high PF.
Other benefits for correcting low PF include:

- Increases the capacity of a customer's electrical infrastructure
- Reduction of heating losses in transformers and distribution equipment
- Longer equipment life
- Stabilised voltage levels
- Improved profitability
- Lowered electricity bills
- Defers the need for costly electricity upgrades by networks (community benefit).

Load Factor
Load Factor (LF) is a measure or indication of the extent to which the electricity supply is fully utilised i.e. the higher the better, up to 100%. It is a measure of the volatility in the premise's electrical load, with regards to its electrical peaks and valleys. LF is a ratio of the average and peak consumption in the period. Typical monthly load factors in Queensland:

- Office buildings: 30% to 40%
- University: 50% to 60%
- Large hospital: 60% to 75%

Demand index (DI)
Is a measure similar to EI but includes only the electrical maximum demand in kilowatts (kW). The lower the DI, the better.

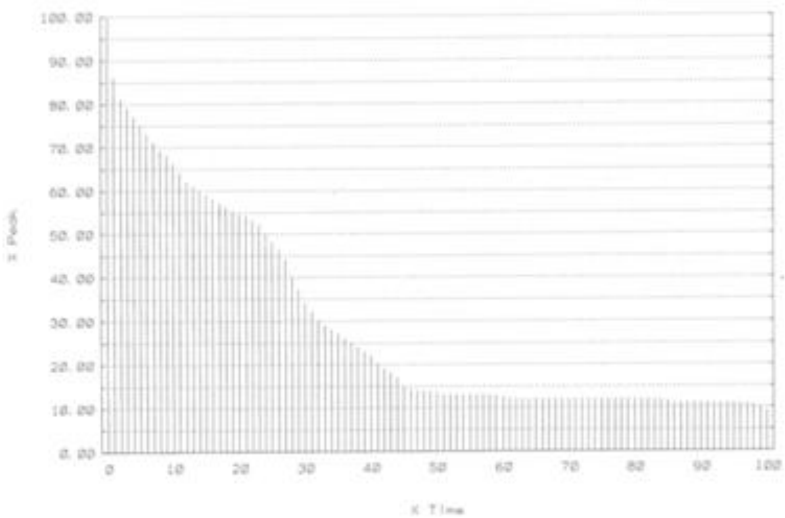
Load Duration Plot or Building Signature
Electricity annual consumption patterns or 'signatures' for premises and buildings may also be useful in comparing performance between energy users.

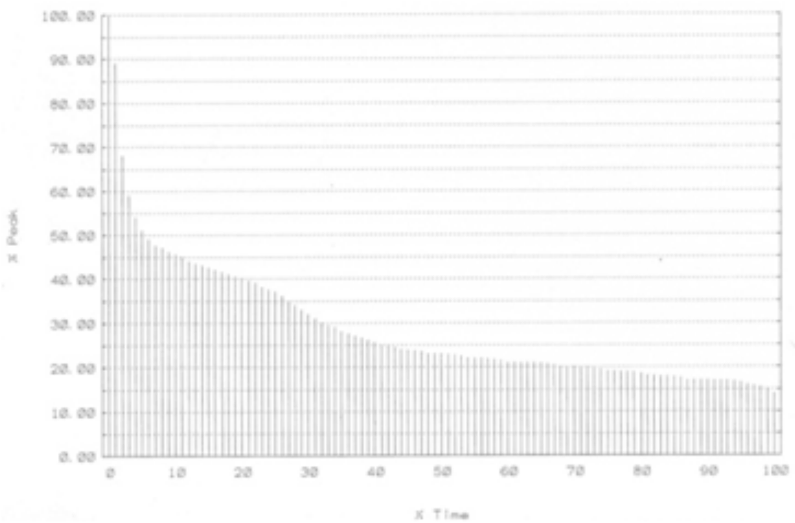
The following two building signatures indicate usage over 12 months. Building 1 (peak or maximum demand 290 kW) is a typical commercial gas-heated office building, operating 10 hours each business day. Building 2 (peak or maximum demand 350 kW) is an electrically–heated building with substantial 24-hour data processing activities all year round.

The vertical axis comprises the percentage peak or maximum demand reached in the year. The horizontal axis comprises the percentage time over the 12-months that the demand has occurred.

You may notice the difference between the buildings and their impact on electricity consumption (EI), electricity demand (DI), load factor and off-peak electricity. Different shapes or signatures reflect building operations and their energy-efficiency.

Building 1





Building 2

FIVE STEPS TO SUCCESSFUL ENERGY MANAGEMENT

Energy remains a controllable cost and energy users can make significant savings through a systematic approach to the management of energy. A diverse "multi-path" approach is required for energy management to reduce energy, greenhouse gas emissions and operating costs.

The 5-step approach below encapsulates a suggested energy management process:

1. Public commitment by the CEO (Management commitment)
2. Make someone responsible for the project (Senior staff responsibility)
3. Implement an energy audit (Find technical solutions and implement)
4. Staff education and awareness (Staff motivation)
5. Report and measure progress.

1. Public commitment by the CEO (Management commitment)

Experience has shown to achieve effective behavioural change in the use of energy, a specific and public policy position on energy and greenhouse emissions needs to be established and committed to by the CEO and the Board.

A corporate executive 'dictated energy management program', would suit a large private sector corporation. Alternatively sometimes a subtler, strategic approach is needed which recognises the special culture in some organisations. Given the predominance of analysts and high achievers in some organisations, the power of 'Social Norms' should be exploited i.e. reluctance to be shown up by peers. This can be progressively achieved by publicly reporting the results of energy efficiency.

2. Make someone responsible for the project (Senior staff responsibility)
"Where there are champions, there are savings".
A senior staff member such as Senior Managers, Environmental Managers, Senior Administration Officers or Facility Managers, need to be made responsible for an energy efficiency program. Management should drive the program, which should examine greenhouse abatement strategies leading to a reduction in operating costs. The overall approach is viewed not in terms of energy cuts but in terms of energy savings and action in response to climate-change.

3. Implement an energy audit (Find technical solutions and implement)
Improving maintenance and operational practices usually provides the greatest opportunity to reduce energy consumption. Modifying systems and plant which consume energy, can also improve efficiency and reduce energy and water usage.
Solutions are also drawn from previous environmental audit surveys, energy audits, work done by energy reduction teams and other technical specialists. Through experience with energy users, the most cost-beneficial energy-efficiency investments in building services are generally:

- Heating, Ventilation and Air-Conditioning (HVAC) plant
- Lighting
- Hot Water Services
- Refrigeration.

NABERS ACCREDITED ASSESSOR

4.Staff education and training (Staff motivation)
Staff education and participation is paramount as it is people who waste energy and it is people who can use it more effectively when they have the right information. I am aware that staff tend to respond better to an environmental issue (which affects them all), rather than a cost saving exercise, which only directly impacts on personnel responsible for the budget.
Making management and staff aware of the need for wise use of energy, encourages them to actively support the energy management program. Energy-efficiency is also an important part of purchasing, managing and maintaining plant and office equipment.

5. Report and measure progress.
"What gets measured, gets done"
One of the critical success factors in an energy management program is an energy and greenhouse performance and reporting system. Environmental audit reports, previous environmental improvement surveys and past energy audit reports all provide a baseline year for comparison purposes on energy consumption and greenhouse emissions.

A progress report using Cumulative Sum (CUSUM) control charting and analysis is helpful in detecting small, sustained shifts in energy consumption.

REFERENCES

Electrical Power Systems Quality / Roger C. Dugan, Mark F. McGranaghan, H. Wayne Beaty / 1996. Chapter 6.5 End-User Capacitor Application.

BIOGRAPHY

Michael Terry: Lectel Consulting Pty Ltd, Energy Solutions Manager
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Michael has over 30 years in sustainability and electrical engineering, covering energy management advice, energy procurement in national electricity and natural gas markets including green power and carbon purchases, Level 1 & 2 energy auditing to Australian Standards, MDA metering & sub-metering, power quality, power factor correction, tariffs and tenant bill-splitting. It includes commercial & industrial customer energy advisory work, developing greenhouse mitigation strategies and action plans for energy users. Michael has also worked in electricity generation and transmission in Western Australia and Queensland.

Lectel is a specialist electrical and telecommunications design consultancy based in south east Queensland. Our core activities are design and project management in the Utility and Development industries, including sustainable energy solutions, energy auditing and power factor correction. Lectel is an accredited service provider for design of electrical reticulation and distribution works in Queensland and NSW receiving a number of industry awards. Lectel is also rated as an industry specialist by Telstra for asset protection projects, new estates and network upgrades.

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