Energy Benchmarking

and

Energy Performance Measurements

for

Business

Denis Cooke
Denis Cooke & Associates Pty Limited
Phone: 02 9871 6641 www.decoa.com.au

Greenhouse Challenge Plus 2005 Conference
Australian Academy of Science, Canberra
September 2005

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Abstract:

The Energy Efficiency Opportunities programme announcement by the Commonwealth Government in June 2004 as part of the energy white paper will require large energy users – those business using over 0.5 petajoules per year – to undertake energy efficiency opportunities assessments and report publicly on the outcomes.

The framework for energy reporting and energy efficiency assessments is being determined. In the event that the framework requires an assessment equal to or greater than level 3 as set out in the Australian Standard for Energy Audits AS3598:2000, then this will require affected businesses to reconsider the way in which they measure, monitor and manage their energy use.

This paper discusses a range of energy measurement techniques that would be required under this likely framework and discusses the use of the measured data in the context of:

- suitable performance indicators and energy performance indicators,
- overall plant and business efficiency,
- process efficiency, and
- process / equipment / facility benchmarking.

The paper also provides a discussion on statistical analysis of the measured data, curve fitting and trend lines, per unit energy performance and suggests ways of interpreting the results to show areas where energy savings and greenhouse gas savings are possible.

Finally the paper discusses possible useful outcomes for business in monitoring and tracking energy and greenhouse performance as an overall efficiency indicator, as a key performance indicator and as a relative performance indicator for operations that are similar. The paper includes a number of graphs that illustrate all the features discussed.

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Introduction:

The Energy Efficiency Opportunities programme announcement by the Commonwealth Government in June 2004 as part of the energy white paper will require large energy users – those business using over 0.5 petajoules per year – to undertake energy efficiency opportunities assessments and report publicly on the outcomes.

The framework for energy reporting and energy efficiency assessments is being determined. In the event that the framework requires an assessment equal to or greater than level 3 as set out in the Australian Standard for Energy Audits AS3598:2000, then this will require affected businesses to reconsider the way in which they measure, monitor and manage their energy use.

Level 3 Energy Audit to Australian Standard AS 3598:2000:

A level 3 energy audit as set out in Australian standard 3598 provides a detailed analysis of energy usage, the savings that can be made, and the costs of achieving those savings. It may cover the whole site or may focus on a particular area such as a single industrial process. Under the standard, it is suggested that the auditor may often employ a specialist to carry out specific parts of an audit or may need to install local metering and logging.

The report from a level 3 audit often forms the justification for substantial investment by the business. For this purpose, a detailed economic analysis with appropriate level of accuracy is required. AS3598 specifies an accuracy of 10% of costs and -10% of benefits.

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Energy Measurements:

In th event that the framework for Energy Reporting and Energy Use Assessments requires an assessment greater than a level 3 Energy Audit, it would be appropriate for businesses falling within this reporting requirement to consider installing some type of computerised energy management system (EMS). The precise details of an appropriate energy management system would be site-specific to the particular business. The purpose of installing such a system would be to provide comprehensive and accurate data on energy usage and costs across the site which could then be used as part of the reporting requirements.

A computerised energy management system that is appropriately designed and installed debt also be used to provide useful performance indicators of energy efficiency, energy per production unit as well as track greenhouse emissions performance. The energy types to be measured and the level of the sub of metering would depend on a specific site and the work processes on the site. Ideally, energy should be measured in sufficient detail to allow a comprehensive energy balance based on different processes to be achieved across the site.

Energy that is measured in this way can then be related to specific processes by cost and production so that meaningful comparisons may be made between similar processes both by cost and energy usage.

Energy types to be measured by the EMS naturally would include electricity and natural gas, and depending on the sophistication of the system would extend to include fuels such as diesel, LPG and others. Liquid fuels present particular challenges in measurement and data gathering in a way that us useful to measure equipment and process performance. Appropriate sub-metering systems would provide the required breakdown of energy usage across the site for evaluation and use in the energy efficiency statement. Even in the absence of a reporting requirement, it is worth evaluating the cost benefit of an energy management system.

Figure 1 below shows an approximate electricity balance which would be used as a starting point in an energy audit. From this data, energy costs by area and process would be used in the decision making process of further investigation into energy efficiency improvement projects.

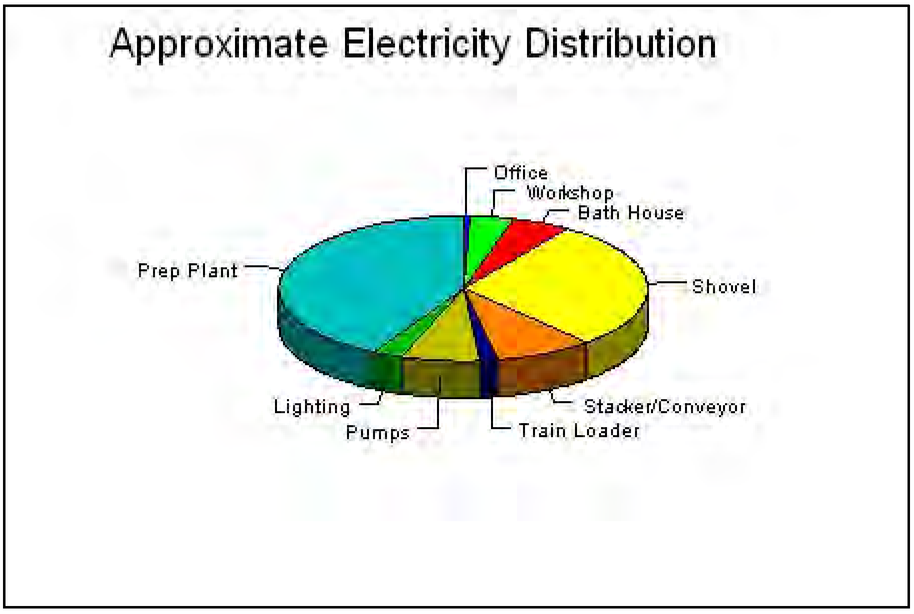

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Figure 1: Electricity Balance

Business and Plant Energy Performance:

In any industrial process, energy is used to perform work. It can be expected that the energy used in an industrial process would be related to production plus some base load constant, i.e. some type of linear relationship of the form $y = mx + c$ would apply, as shown below where y = the total energy use, m = the energy per unit of production (the gradient of the line), x = the units of production, and c = a constant or the base load (standing load) when there is no production activity.

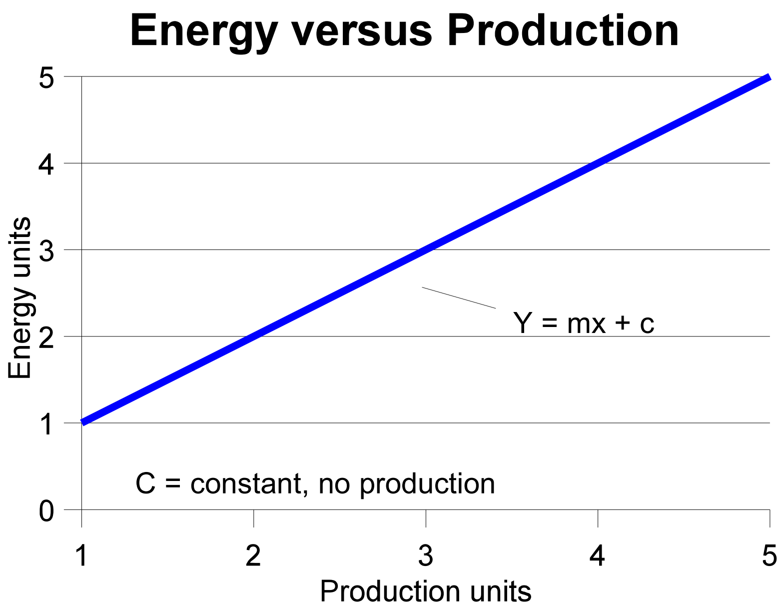

Figure 2

Indeed this type of relationship often appears when analysing the energy usage for a single process. And it may be observed that the energy used across a given site is the sum of many discrete processes.

Some field results that show this type of relationship are shown below. The curve is a line of best fit using a least squares regression analysis (available in most spreadsheets).

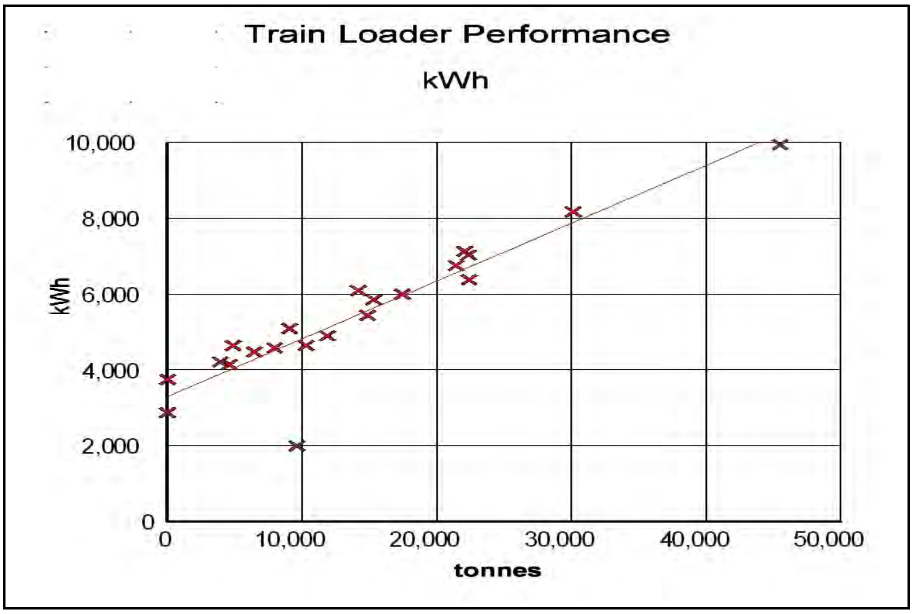

Figure 3 Energy Performance for a Train Loader

The particular features that should be considered with this type of relationship are:

1. The consistency of the data - how good is the linear relationship?
2. Is there a high correlation coefficient with the data fit?
3. What happened where there are inconsistencies in the data?
4. Is the base load reasonable?

The other type of curve that is of particular interest in analysing energy performance is the relationship between the energy per unit of production and the production. For the data in figure 3, this relationship is shown in figure 4 below:

Figure 4 Per Unit Energy Performance - Train Loader

For this data, the curve of best fit was found to be an exponential, which is to be expected from the previous linear relationship.

The particular features that should be evaluated with this type of relationship are:

1. The consistency of the data - how good is the curvilinear relationship?
2. Is there good is the overall data fit?
3. What happened where there are inconsistencies in the data?
4. Is the per unit energy consumption reasonable?

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Relative Performance and Benchmarking:

The previous energy performance analysis takes on added significance when more than one similar and preferably identical process are compared. Shown below are similar graphs showing the energy and per unit energy performance of two modules of an industrial process plant:

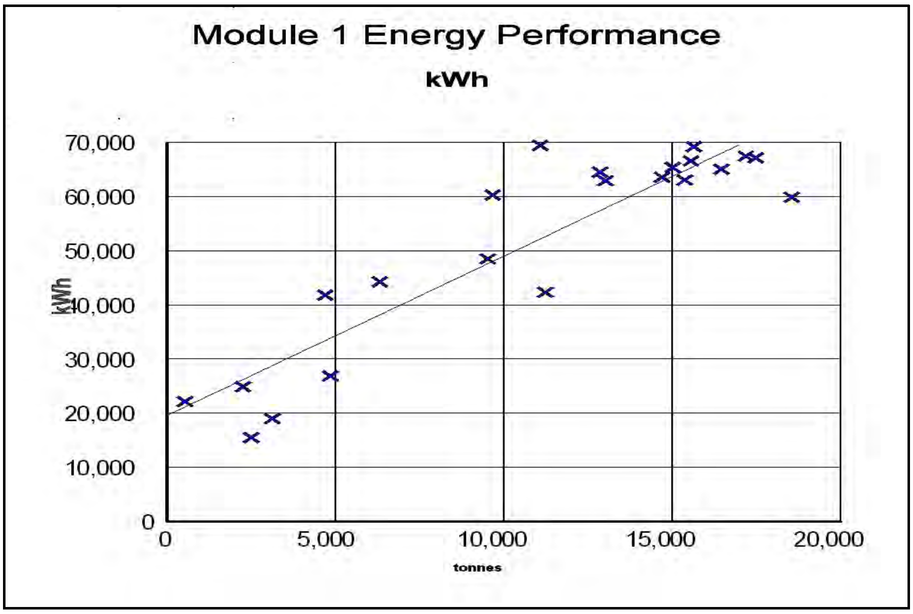

Figure 5 Module 1 Energy Performance

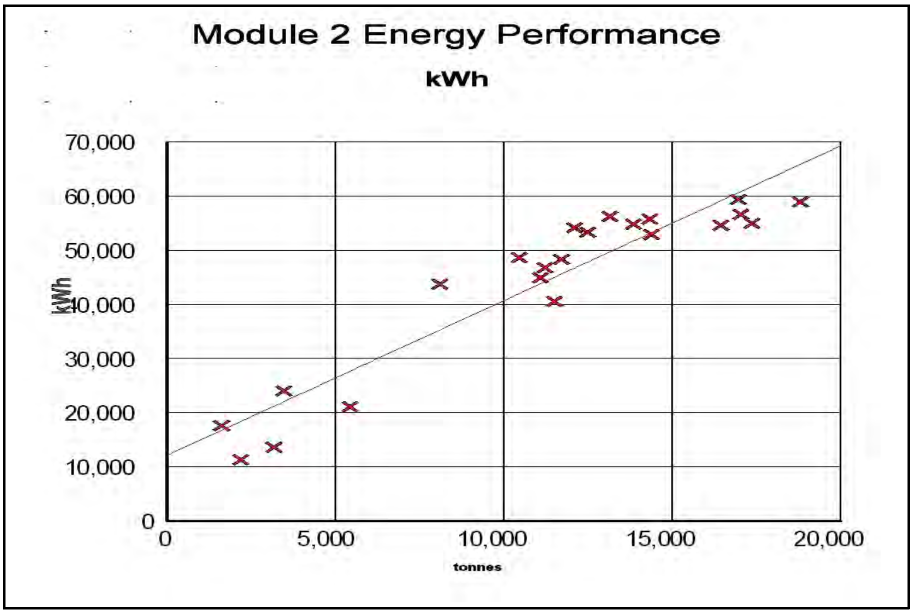

Figure 6 Module 2 Energy Performance

From the graphs, it can be seen that module 2 uses less energy for the same production throughput which is confirmed by combing the two graphs in figure 7 below:

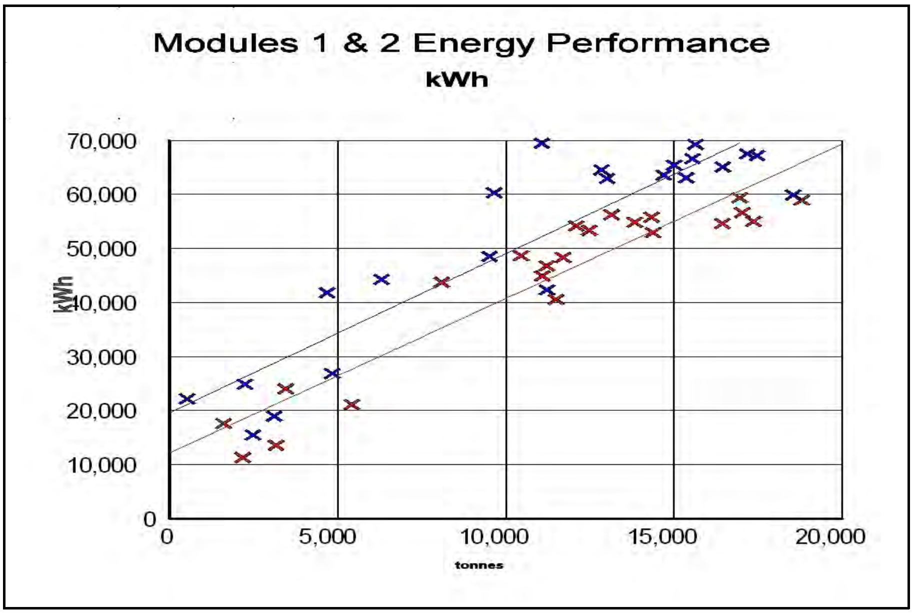

Figure 7 Modules 1 and 2 Energy Performance

Figures 8 and 9 below show the per unit performance of the two modules.

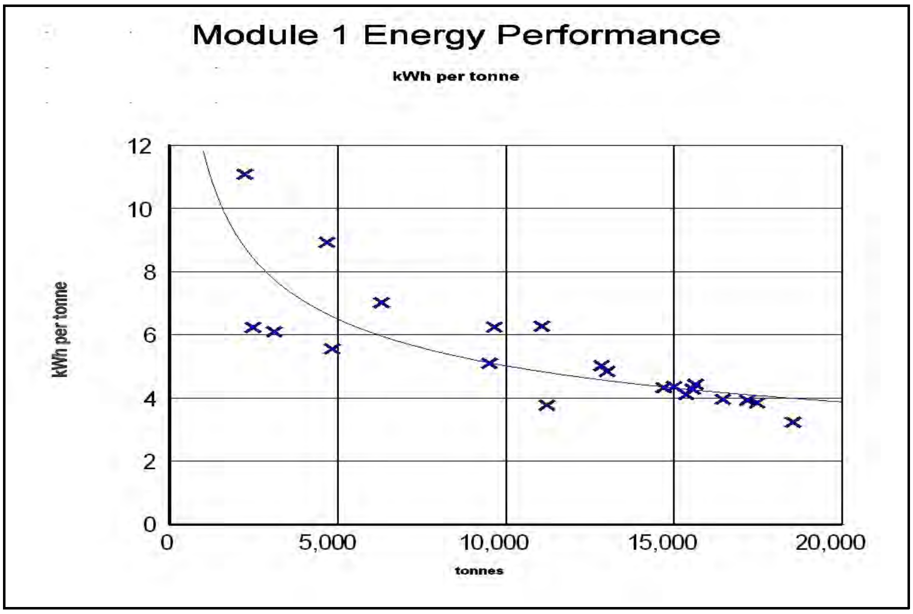

Figure 8 Module 1 per unit Energy Performance

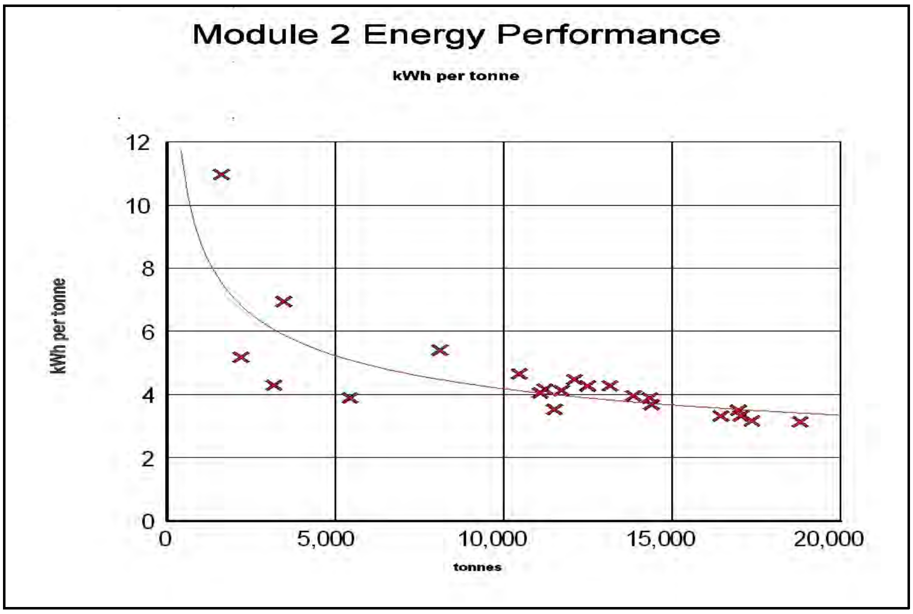

Figure 9 Module 2 per unit Energy Performance

Figure 10 below shows figures 8 and 9 combined:

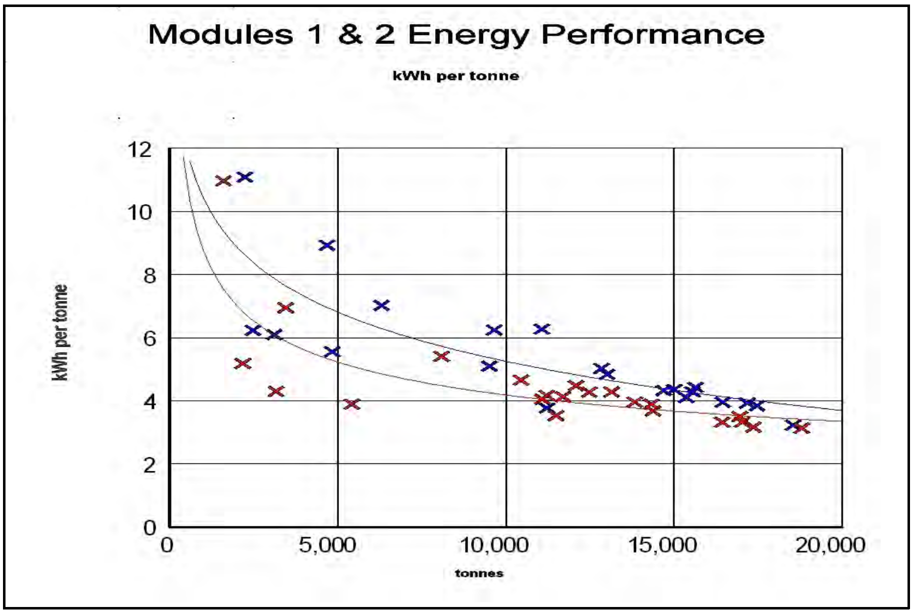

Figure 10 Modules 1 and 2 per unit Energy Performance

An analysis of figure 10 shows that module 2 is about twenty percent more efficient than module 1. This is turn raises a number of questions to be answered including:

1. Is there an obvious explanation for the difference in energy use between the modules?
2. Can the difference be explained by process operations?
3. Can the difference be explained from technical differences?
4. Are there opportunities to improve the efficiency of module 1?
5. Can the efficiency of module 2 be improved further? And so on

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Performance Tracking:

The previous energy performance graphs are not suitable for tracking performance. One simple measure to track performance is shown in the figures below for the two modules used in the previous section.

Figure 11 below shows the per unit energy performance for module 1 on a shift by shift basis. Comparison with figure 12 for module 2 could provide a useful benchmarking and relative performance monitoring once the other issues mentioned previously in the initial comparison had been addressed.

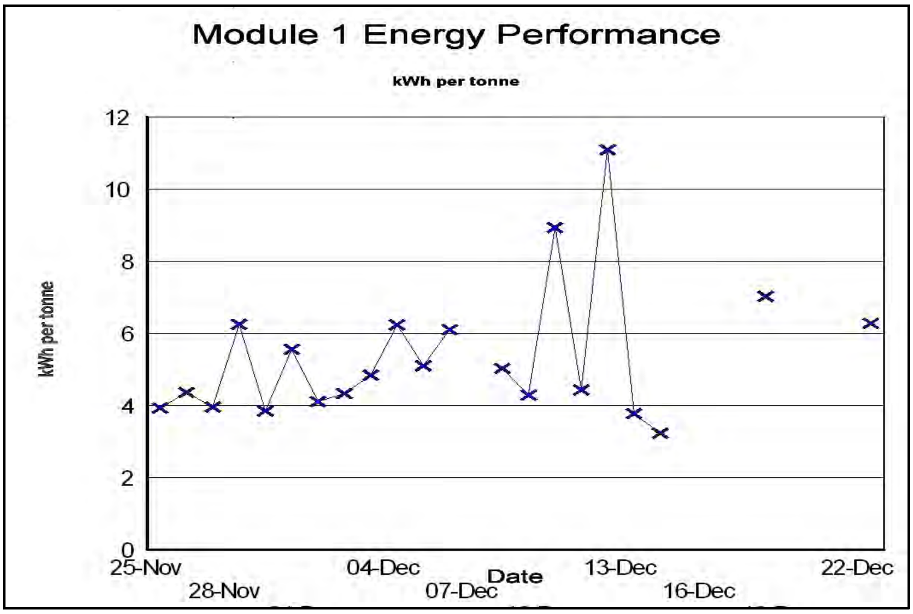

Figure 11 Module 1 per unit Energy Performance by Shift

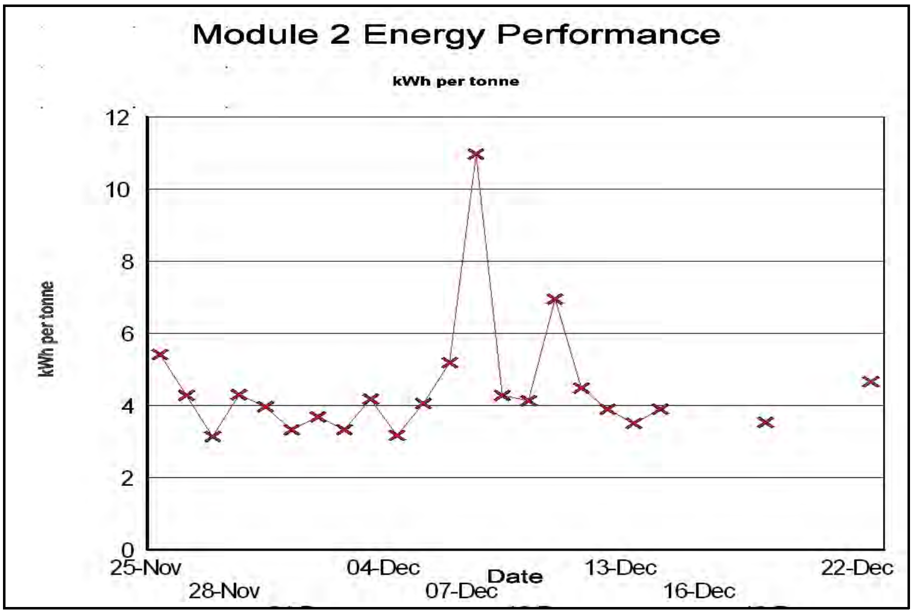

Figure 12 Module 2 per unit Energy Performance by Shift

The consistently better performance from module 2 can be seen.

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Maximum Demand Profiles:

Maximum demand profiles can provide useful information about the nature of the operation of particular piece of equipment or process.

One example of a maximum demand profile is provided in figure 13 below:

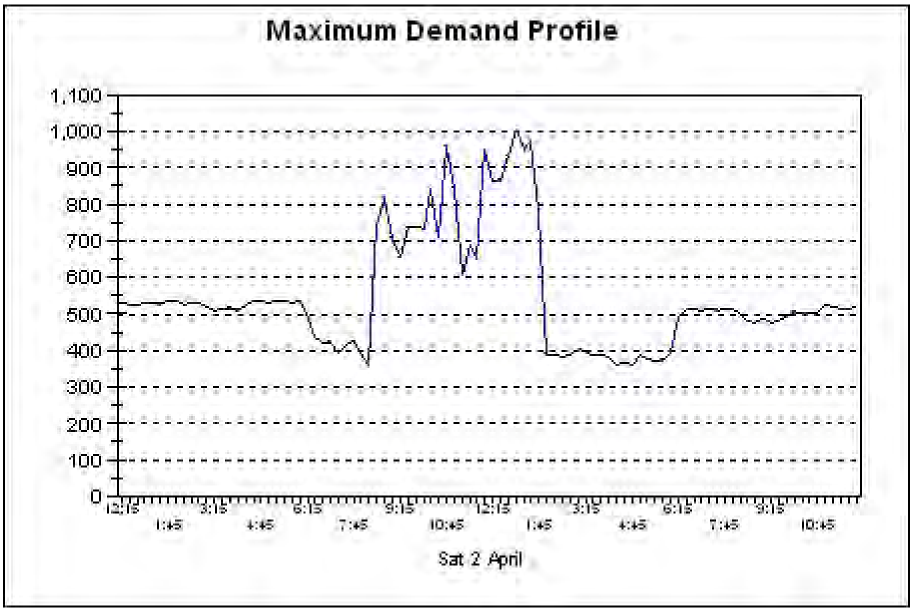

Figure 13 Maximum Demand Profile

The maximum demand profile can provide information on how plant and equipment is operated and will show down times, process interruptions, and meal breaks which will allow a greater understanding of process operations.

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Energy and Greenhouse Performance Indicators:

Some companies have used this type of information to monitor and track overall efficiency for the business. The two graphs shown below are for two businesses that tracked performance over ten years using greenhouse gas kg CO_2 per tonne of production. The result was a significant improvement over the time period and illustrated the end result from a focussed effort on continuous improvement coupled with staff awareness programmes and specific energy and greenhouse efficiency projects.

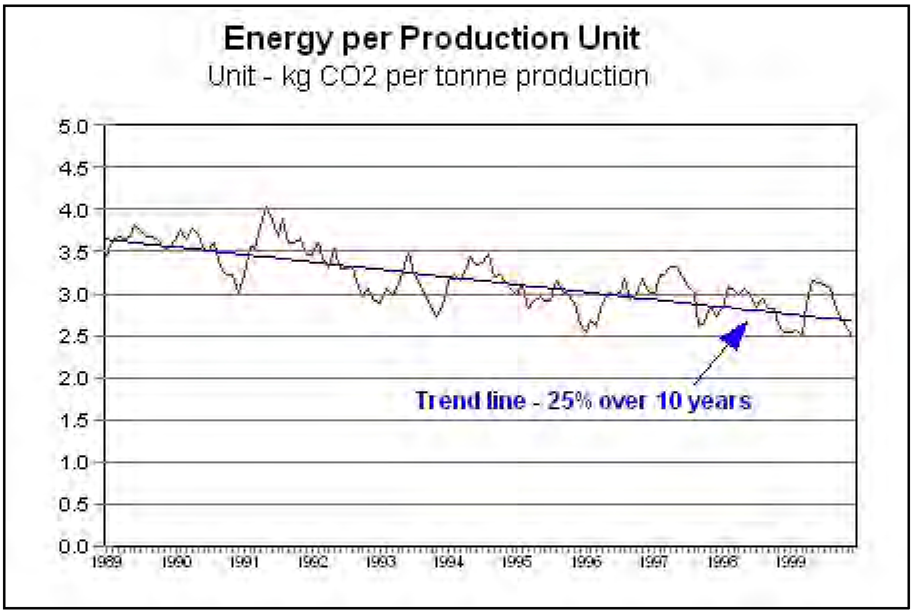

Figure 14 kg CO_2 per Production Unit - 10 years

Business #1 - 25% improvement in efficiency over ten years.

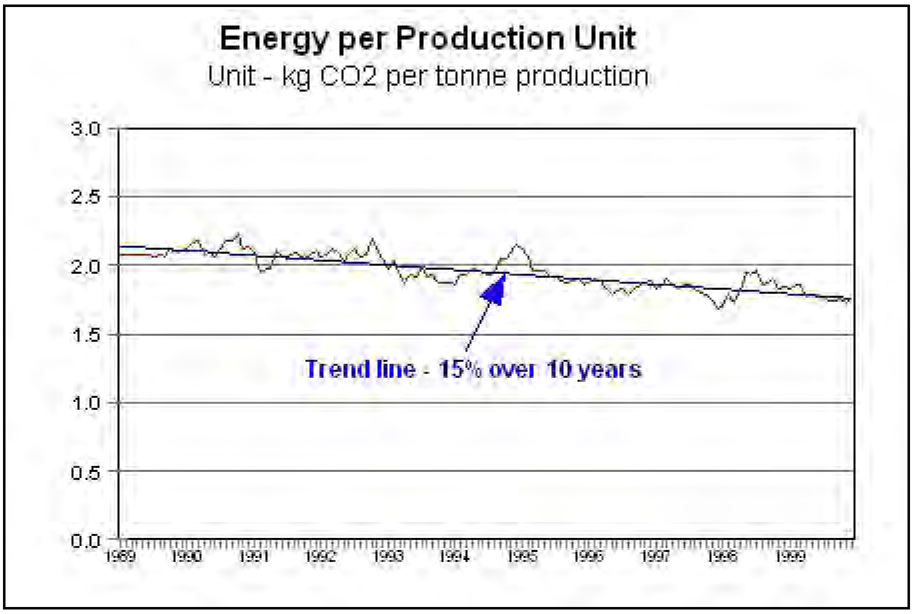

Figure 15 kg CO_2 per Production Unit - 10 years

Business #2 - 15% improvement in efficiency over ten years.

As can be seen, greenhouse and energy indicators can provide a useful indicator of overall business performance.

For the businesses above the per unit reductions achieved over ten years shown by the data represented millions of dollars.

This particular indicator has been an excellent performance indicator that in the one measure showed exceptional overall energy and greenhouse performance. It was able to bring together the results from a range of internal company programmes including continuous improvement, employee awareness, environmental response, innovation and specific projects.

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Do You Require Further Assistance?

Please call if you would like any assistance in:

- ♦ setting up energy performance monitoring systems,
- ♦ analysing the data and energy performance trends,
- ♦ setting up key perfornance indicators, or
- ♦ establishing energy targets and energy benchmarks.

Denis Cooke

Denis Cooke & Associates Pty Limited
Phone (02) 9871 6641
Fax (02) 9614 1723
Mob 0411 030 936

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