

Cost Reduction through Energy Improvement using the ENgage Method

Andrew Morrison*

KBC Process Technology Ltd, 42-50 Hersham Road, Walton-on-Thames, Surrey, UK
amorrison@kbc.com

There is a growing uncertainty surrounding the future availability of inexpensive energy supply and the possible implementation of more stringent environmental controls. Industrial companies, especially those reliant on high levels of energy consumption, must strive for optimal energy performance to ensure they remain viable. KBC has developed ENgage; a comprehensive approach to cost reduction through energy improvement. The Strategic Energy Review component of the programme is demonstrated through the use of a refining case study that resulted in significant energy savings. The Energy Management System component of the programme assists in sustaining these improvements in energy performance in the long term.

1. Introduction

Global energy prices are once again approaching record levels and look set to hinder any chance of a rapid worldwide economic recovery. At the same time emissions constraints continue to be tightened as awareness of the possible consequences of climate change spreads. Improved energy efficiency stands out as one of only a limited selection of methods for industrial companies to decouple rising energy prices from dropping profitability.

Pinch analysis is a well known and proven form of process integration with an impressive history for realizing significant energy savings throughout a multitude of industries (Smith, 2005; Kemp, 2007). The original pinch techniques were first published in 1978 (Linnhoff and Flower, 1978) and commercialized as Linnhoff March International Ltd soon after. KBC Process Technology Ltd (KBC) acquired Linnhoff March in 2002 and continues to evolve and apply the strategies as part of a comprehensive approach to cost reduction through energy improvement. While KBC has over 30 years of experience assisting a range of process industries, it is renowned as a leader at providing consultancy services to the oil and petrochemicals sector. The refining industry consumes very large quantities of energy as it converts raw crude oil to the many different hydrocarbon products used in applications such as heating, transport and power generation. According to the BP Statistical Review of World Energy (BP, 2010) a total of 3882 Mt of crude oil were globally consumed in 2009. Refining records show that on average 6.3 wt% of crude oil feed is consumed as energy, therefore over 260 Mt of oil equivalent per year are used during the refining process. The case study included in this paper demonstrates how the implementation of KBC's Strategic Energy Review can result in a significant improvement in energy efficiency.

2. ENgage Programme

KBC has developed the ENgage Programme (KBC, 2010) as a means of delivering best practice energy performance by addressing all areas that influence energy use. Figure 1 shows how the programme combines technical improvements with human performance improvements to ensure clients improve current performance and sustain the benefits long term.

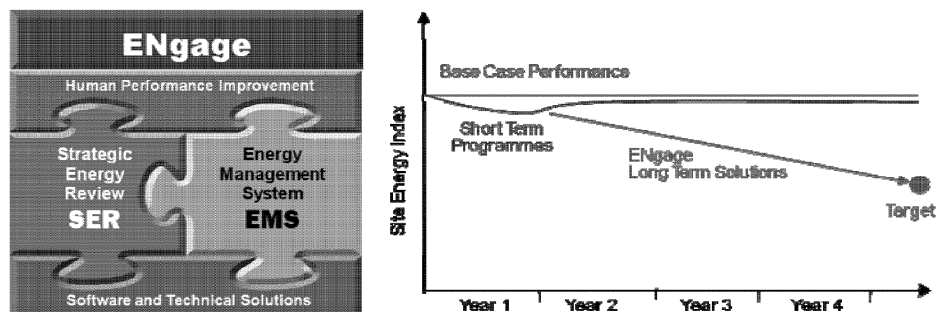


Figure 1: ENgage addresses both the technical and human performance, and ensures that the solutions provide sustainable improvement in energy performance.

2.1 Strategic Energy Review

The Strategic Energy Review (SER) is the first stage of the ENgage programme to be carried out. It begins with a site visit where a list of potential opportunities is generated during a thorough review of the key process units. Additional process data is also collected to assist with further analysis. The SER cumulates in a Roadmap of all cost effective energy related investment and non-investment opportunities for the site.

2.1.1. Benchmarking

Energy benchmarking involves quantifying and comparing the energy consumption of a process to a pre-selected standard. Various methods and standards can be used, and a well established energy benchmark in the refining industry is Solomon's Energy Intensity Index. It uses a statistical model to determine the energy efficiency of a given unit or plant.

KBC utilises its own proprietary method (KBC, 2007) known as Best Technology (BT). This method is not based on a statistical model but instead calculates a unit's BT energy allowance using process simulation of a "best design" unit. Variations in key parameters such as feed rate are taken in to account. By summing the allowances for individual units a refinery allowance is reached. The ratio of actual energy consumption and the refinery allowance gives the refinery BT index. This is an accurate indicator of current energy performance, and hence the scope for potential improvement.

For new plants a refinery BT index of 100 % is achievable, however it is unlikely to be cost effective to retrofit an existing site to a level of 100 % BT.

2.1.2. Gap Analysis

The Gap Analysis stage takes the results of the BT benchmarking and provides a more detailed breakdown of where the current energy inefficiencies exist. The difference in energy use between the current process and a BT process is contributed and quantified to each of four critical refinery areas:

1. Fired Heaters
2. Power Generation
3. Heat Integration
4. Utility Systems

The results of the Gap Analysis give an indication of where the most promising opportunities to improve energy performance are likely to be discovered.

2.1.3. Opportunity Identification

Once the BT benchmarking and the Gap Analysis results are known the Opportunity Identification stage can commence. Each potential opportunity that was generated during the site visit discussions is investigated in detail using a combination of process simulation, process experience and calculations including pinch analysis and costing. Software applications such as PetroSIM, SuperTarget, Prosteam and HTRI are essential tools for this analysis. After this investigation stage only a limited number of opportunities will be considered suitable for implementation.

2.1.4. Metrics

Key energy metrics that have a significant influence on energy consumption are identified for each process unit. This task is often carried out in tandem with the Opportunity Identification stage due to the intertwined relationship between the two stages. The key role of the metrics is to ensure that improvements in energy performance are sustained over the long term without having a detrimental effect on yield.

The energy metrics are developed on a range of levels from Energy Influencing Indicators (EIV) for individual units through to Key Performance Indicators (KPI) for site wide energy consumption. EIV's will be of most value to operators and process engineers, while engineers and site management will find greater value in the KPI's. While it is possible to generate a very large set of metrics, instead the quantity is limited to avoid confusion and to emphasise the most important parameters that have an impact on energy performance.

2.1.5. Roadmap

The final stage of the SER involves developing a Roadmap out of the non-investment and investment opportunities that have been accepted during the Opportunity Identification stage. These selected opportunities will be those that meet the site economic criteria and are consistent with the energy strategy. In this way the Roadmap provides a clear outline of which projects should be carried out by the client to improve the site energy performance. It ensures that investment in short term goals does not have a negative impact on long term energy targets, and that investment is directed towards the most productive areas. It is also possible to display projects that do not

currently meet the site's economic criteria but may become viable if energy costs rise in the future. Table 1 displays the improvements in energy performance that are generally achieved by an SER.

Table 1: Typical savings achieved by standalone implementation of a SER

	Reduction in Site Energy Costs
Non-investment Opportunities	3 – 4 %
Investment Opportunities	2 - 4 %
Utility Systems	3 – 4 %
TOTAL	8 – 12 %

The key benefit of the Roadmap is that it is a concise way of presenting the site's energy strategy that brings together the results of the SER programme. An up-to-date Roadmap is also a key requirement before the construction of an Energy Management System can begin.

2.2 Energy Management System

The Energy Management System (EMS) is a unique framework for each site that aims to assist in achieving and sustaining optimum energy use targets (Knight, 2007). A key component is an energy strategy containing measurable and up-to-date targets, which are usually in the form of metrics. The EMS will also involve an organisational review to ensure the structure and personnel are capable of achieving energy best practices. If necessary, energy management workshops and training courses are held and job profiles are redefined to ensure the relevance of energy goals.

Documentation such as operating procedures are reviewed as often they become out of date or lost over time, while new guidelines for best practice operation and checklists are created if required. The best combination of software and monitoring tools for the specific site is also highlighted. This can include recommendations to install energy or metric tracker software or online optimizers. Lastly, the EMS will include a means of reporting so that all relevant personnel are aware of changes in the energy performance.

3. Case Study

This section of the paper describes an SER that was recently undertaken by KBC. The client is a European refiner and information considered sensitive has been withheld from the results when deemed appropriate.

An initial site visit was held, which allowed KBC consultants the chance to review all process units with the refinery engineers. These discussions resulted in a draft list of over 100 potential opportunities that required further screening and investigation. Relevant process data from the site was collected and requests for additional process and design data were made.

3.1 Results

Benchmarking of the refinery energy performance was carried out using KBC's proprietary Best Technology method. The refinery BT index was 149 %, which indicated that the site was consuming close to 50 % more energy when compared to a best performance configuration.

To provide a better indication of where these energy inefficiencies were located a Gap Analysis was completed. A breakdown of the results is displayed in Table 2. As expected the majority of the gap can be attributed to power generation, heat integration and utility systems. By comparison the fired heaters were operating relatively efficiently and only accounted for 3 % of the gap. A 15 % portion of the gap was not attributed to any of the four categories and will include process design and operational inefficiencies such as non-optimal blow-down rates and operating pressures.

Table 2: *Distribution of energy performance gap*

	Portion of Gap Attributed
Fired Heaters	3 %
Power Generation	21 %
Heat Integration	31 %
Utility Systems	30 %
TOTAL	85 %
Unaccounted	15 %

Each potential opportunity from the initial list that was generated during the site visit was investigated in detail. Where a full set of process data was not available PetroSIM was used to generate a model of the operating conditions. Pinch analysis software (SuperTarget), utility modeling software (Prosteam) and heat exchanger modeling software (HTRI) were all utilised during this investigation phase. Opportunities that displayed promising energy saving results were financially evaluated to check whether they met the refinery economic criteria.

A Roadmap was produced containing the selected opportunities that improved the site energy performance and also met the site payback requirements. Table 3 displays the savings that were identified in the Roadmap. From a starting point of in excess of 100 potential opportunities only 16 opportunities were included in the Roadmap. However, the full implementation of this energy strategy would result in energy savings of 14 %.

Table 3: *Savings identified in the Roadmap*

	Reduction in Site Energy Costs
8 Non-investment Opportunities	7 %
8 Investment Opportunities	4 %
Utility Systems	3 %
TOTAL	14 %

This was an excellent result, as a standalone SER typically provides 8-12 % energy savings and including an EMS typically extends these savings to 10-15 % of the site energy consumption. As well as the 16 non-investment and investment opportunities the Roadmap also included a utilities system strategy that would save 3 % of site energy use with a payback of less than three years. Yield improvements were also identified but not included in the Roadmap.

A set of metrics were compiled to assist the refinery in retaining improved energy performance. Each major process unit at the site was assigned 2 - 9 individual metrics dependent on complexity and energy consumption.

KBC also provided the client with initial ideas towards an Energy Management System. The implementation of such a system would be expected to lead to further energy savings, and may be an opportunity for future collaboration. Overall the SER was very successful in forming a clear strategy to assist the client in improving and sustaining energy performance.

4. Conclusion

Energy efficiency is a major factor in the profitability and long term viability of many industrial processes and sites. KBC has developed the ENGage programme as a means of delivering best practice energy performance by addressing all areas that influence energy consumption. The initial stages of the SER such as BT benchmarking, Gap Analysis, Opportunity Identification and formation of Metrics are explained and demonstrated through the use of a refining case study. The final stage of the SER is the Roadmap that concisely presents the site energy strategy. The opportunity for significant improvement in energy performance shown in the case study clearly demonstrates the effectiveness of this approach. Further improvements and sustained achievements would be expected through the adoption of an Energy Management System.

5. References

- BP, 2010. BP Statistical Review of World Energy <www.bp.com/statisticalreview> accessed 8.1.2011
- KBC Process Technology Ltd, 2007. KBC Best Technology Manual, unpublished.
- KBC Process Technology Ltd, 2010. KBC ENGage – Continuous energy improvement, unpublished.
- Kemp, I.C., 2007. Pinch analysis and process integration: A users guide on process integration for the efficient use of energy. Butterworth-Heinemann, Oxford, UK
- Knight, N. 2007. Implementing a progressive strategic plan for energy optimisation. *Hydrocarbon Engineering* 12(9), 75 – 80.
- Linnhoff, B. and Flower, J. R., 1978. Synthesis of heat exchanger networks: I. Systematic generation of energy optimal networks. *AIChE Journal* 24, 633 – 642.
- Smith, R., 2005. *Chemical process – Design and integration*. McGraw-Hill, New York, UK