

# ACHIEVING ENERGY EFFICIENCY

Eva Heyman and Livio Accattatis, Shell Global Solutions International BV, discuss the implementation of an energy efficiency programme at a highly complex refinery.

The Shell Global Solutions energy efficiency programme, Energise™, identifies, develops and helps clients to implement small projects designed to reduce energy use and increase energy efficiency at refineries and petrochemical facilities. Improved energy efficiency can deliver real bottom line value and help improve a facility's environmental performance by lowering greenhouse gas emissions. The project portfolio primarily comprises operational excellence and minor capital expenditure projects. The client approves and implements these projects within the site's own safety, environmental and technical integrity processes. The savings realised are sustained using technical tools and monitoring systems that help achieve savings that are visible and controllable at all levels of the site organisation.

By late 2005, the energy efficiency methodology had been initiated at 29 refineries and petrochemical facilities worldwide. At refineries there was typically an achievement of 5 - 7% reduction in annual energy, with no or low capital investment.

## THE REFINERY SITE

The Energise energy efficiency programme has been successfully completed at a highly complex refinery in North America. The site's high Solomon refinery complexity factor, the high level of overall unit interaction and its capability to produce gasoline and middle distillates to stringent specifications, indicate its operational complexity. The site's process and utility units are divided into several operating areas. The main operating areas are:

- Crude distillation.
- Catalytic and thermal conversion.
- Hydroprocessing, catalytic reforming and alkylation.
- Gas processing and hydrogen system.
- Amine treatment and sulfur recovery.
- Utilities and logistics.

The projects implemented under the Energise energy efficiency programme covered most parts of the refinery and were not localised to any specific operating area.

Figure 1 shows the refinery system boundary and indicates energy and non energy streams that cross that boundary.

An Energise energy efficiency programme cannot be done in a vacuum; the changes to be implemented must be vetted for their total impact on site operations and

performance. Typically, there are several energy related improvements that can have significant margin benefits, for example, allowing a higher feed rate to a processing unit and/or increasing the overall product volume at the same specifications.

Contribution and support from refinery staff during all the phases of a programme are crucial to its success. There must be input from the refinery personnel directly responsible for implementing and completing projects and from the personnel involved in preliminary data collection, generating ideas during unit review sessions and providing advice on specific operational issues.

## THE REFINERY ENERGY SCENE

Due to the North American refinery's size and complexity, it has very large annual power and fuel operating costs. The power demand is met by combining onsite power generation with import from the grid. The refinery can export power to the grid, but owing to the current pricing structure for selling and buying power, it tries to minimise power export, which typically represents less than 10% of the power generated and consumed.

The fuel demand is met entirely by gaseous fuels, which are a combination of site produced off gases and imported natural gas. All the refinery provided streams are treated to meet stack gas emission levels for sulfur and nitrogen oxides.

## THE PROGRAMME ACHIEVEMENTS

The Energise programme was executed over 12 months in the period 2004/2005 and achieved substantial energy

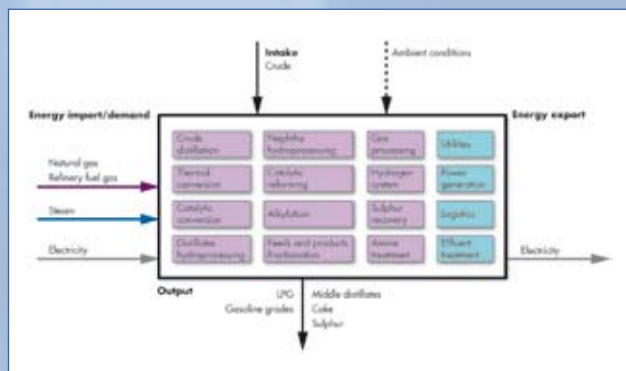


Figure 1. The refinery system boundary showing energy and non energy streams.

savings for the refinery. The programme had an excellent payback, with an annualised added value well over the total costs incurred. All the target deliverables for the programme were met. These included:

- Energy savings of approximately 5% on energy consumption. In addition, several of the projects realised benefits such as increased yield. A total value of some US\$ 20 million/yr in energy savings and improved margins.
- Documented evidence of the savings realised. The project specific key performance indicators (KPI) and other tools and procedures needed to monitor and sustain the savings in the longer term.
- A list of other energy saving project ideas that could not be addressed within the programme's constraints on time, capital budget and manpower.

## SUSTAINING REALISED SAVINGS

The key to the success of an Energise energy efficiency programme is the sustainability of the implemented projects after the Shell Global Solutions team has left the site. To facilitate this sustainability, a local refinery energy coordinator was appointed and given the task of maintaining the sustainability of the realised savings, and monitoring and further improving the refinery's energy use and management. Sustainability tools and methods were put in place to help minimise any possible erosion of the realised energy savings.

## OPERATIONAL KPI TARGETS

KPIs that focused on the set points of the relevant systems were established for each project. The set point KPIs were included in either the refinery's distributed control system (DCS) or the operators' field awareness tools, which exchange data with other refinery information management systems. The approach of fully integrating the sustainability tools within the existing site systems for operations monitoring and optimisation was requested and fully endorsed by refinery management. The operators have the operational target information they need where they are used to finding it, and can act upon it in the usual way. An additional benefit of the KPIs is that support from Shell Global Solutions in tracking the performance of completed projects is made easier and remedial action can be proposed if erosion of savings occurs.

## SUSTAINING SAVINGS

A tool has been developed to help monitor the plant's energy performance and for preparing monthly energy reports. The tool builds up an overall picture of the plant's actual savings from real time calculations of the savings captured from those parts of the refinery where an energy efficiency project has been completed. The requisite plant data (tag number values of the daily average type) are automatically downloaded for the necessary calculations. The tool includes calculation of the historical energy consumption and the actual energy consumption. The difference between the two is then used to calculate the realised energy savings.

Using this tool to monitor how well savings are being sustained assists timely identification of any erosion. Any reduction in the savings is a signal for a detailed check of how each implemented change is being managed on a day to day basis. Manufacturing sites are subject to many changes in crude, operating conditions, product slate and staff, and any or all of these could have an impact on the optimal energy management. The refinery can also call on technical support from Shell Global Solutions in evaluating and proposing correlative actions for any operational problems.

## ASSESSING THE VALUE OF ENERGY SAVINGS

A further tool has been developed that enables the refinery energy coordinator and the Shell Global Solutions refinery contact point to derive the current unit prices for all classes of energy. This information is used for monetisation of the monthly energy savings data. First, the monthly average power and fuel unit costs are obtained from defined sources and inserted into a table calculator; this then estimates the unit costs of the related steam qualities, fuel gases and power using consistent conversion calculations valid for the refinery's circumstances. This tool helps make sure that the unit value attached to any specific energy saving is completely transparent and current.

## EXAMPLES OF COMPLETED PROJECTS

### Naphtha feed fractionation steam usage

One project concerned improving the steam usage of a naphtha feed fractionation column reboiler and optimising its steam consumption. The reduced reboiler heat input proposed would not adversely affect the overhead and bottom stream qualities (simulation work was performed to evaluate this), but would result in an operational shift in terms of a small compositional change that would give processing credits in the downstream processing units such as the catalytic reformer units. The reboiler steam rate is controlled by an advanced process control (APC) system.

The reboiler steam rate reduction was targeted at 30% for the prevailing column charge rate. The processing credits for the downstream units would be lower fuel use and a consequent reduction in steam production as well as a reduced steam usage. The total realised savings on an annualised basis were approximately US\$ 4 million/yr.

### Routing of vent gases

Treated vent gases were being split between being used as refinery fuel gas (RFG) and as feed for hydrogen manufacturing. However, the amount of vent gases that can be utilised is limited by feed pretreatment capacity restrictions. The project rerouted some of the vent gases, using an existing header, to hydrogen manufacturing instead of to RFG. The original design premise for the header included a case for its use during operational upsets; this case is not compromised by the change in normal operations.

The scope of work comprised adding piping with isolation valves and essential flow meters and control valves to facilitate the new routing option while safeguarding the functionalities of both the original and the new routing options. Implementation was performed in a single step and process tests were unnecessary. The impact of the changed feed diet on the entire hydrogen system was evaluated using simulation tools.

To sustain the savings, KPIs were added that target the minimum use of natural gas as hydrogen manufacturing feed and, at the same time, sending the minimum volume of vent gases to RFG. The value of using vent gases as feed for hydrogen manufacturing is greater than that of using natural gas as feed.

The project improved the molecular management of the gases sent to the hydrogen system and the gases sent to the RFG system. The overall savings on an annualised basis were US\$ 1.9 million/yr and were based on the differential value of rerouting approximately 4.5 million ft<sup>3</sup>/d of vent gases from RFG to the hydrogen system, taking into account both the fuel value and the resulting processing credits.

## Hydrogen manufacturing feed optimisation

To further optimise the hydrogen manufacturing operation, a software tool was developed to guide operations in routing the gaseous streams. The project proposed had three phases, the first two of which were completed during the Energise programme.

### Phase one

The volume of refinery dry gases sent to fuel was minimised and the gases were preferentially used to produce hydrogen at a lower cost. The dry gases concerned were cracked and saturated gases, vent gases, propane and natural gas. To achieve this, a Microsoft™ Excel based tool was developed for determining the routing of each dry gas source at a rate determined by the hydrogen demand from the hydrogen consuming units.

### Phase two

The feed selection to hydrogen manufacturing was optimised. This required additional development of the software tool developed for phase one. The enhanced tool accounts for the differences in processing efficiency for each dry gas type and for their compositional variations. The feed selection is constrained within the tool to prevent multiple operational limitations being exceeded. Several process control initiatives support the new method for plant feed selection so that the total feed diet is optimised for any given set of refinery gases within the operational plant limitations.

### Phase three

The development of an APC system that will automatically select the dry gas feeds given the plant

operating constraints and processing demands was proposed. This project is being pursued as part of the overall refinery optimisation programme. The actual operation of the hydrogen system, in addition to the existing operational KPIs, has been used to demonstrate the benefits of providing the operators with more detailed information on plant feed selection, via the software tool. The savings were found to be coming from a reduced demand for natural gas, both as feedstock and for fuel. This demand was adjusted to meet a change in the system steam demand caused by the alteration in the total feed diet. Overall, the equivalent net fuel savings on an annualised basis were US\$ 6 million/yr.

## CONCLUSION

By focusing on operational excellence and minor capital expenditure projects, the Energise energy efficiency programme can help deliver real bottom line value and improve a facility's environmental performance. Tools and methods can be put in place to help make savings visible, and therefore more likely to be actively managed, enabling the facility to sustain the benefits of the implemented projects.

## NOTES

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