How Cogeneration Saves Energy Costs

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ENERGY IN THE INDUSTRY

Energy is one of the basic components of any production or manufacturing activity. It is a basic aspect of industry that cannot escape the scrutiny of cost and efficiency.

The cost of energy has always been an area of research for the industrialist and with today's reality of ever increasing energy costs, conservation of energy has become an area of wide concern and interest. Industries with the twin needs of power and thermal loads, such as the pulp and paper, chemicals, refining and plastic industries are constantly searching for ways to lower energy costs, increase energy efficiency and make socially and environmentally responsible decisions by identifying environment-friendly energy sources.

The most basic and important form of energy used in the industry today is electricity. Technology to convert electricity into alternate forms of energy has been developed through the years into a highly advanced form. Just take for example the simple electric motor, first invented in the 19th century to convert electrical energy into mechanical energy. This piece of equipment has since evolved into a highly advanced form with sophisticated drives and high efficiency mechanisms just to squeeze the last few percentage points in performance efficiency.

Apart from electricity, most industry and manufacturing processes require a significant secondary form of energy. This could be hot air for drying (e.g. the ceramic industry), steam (e.g. pulp and paper, chemicals, oleo industries) or even chilled water used in air-conditioning applications (e.g.semiconductor, commercial developments).

Many schemes and methods for reducing, conserving and eliminating energy consumption have been devised. Some of these improve the way energy in utilised while others address the way in which it is produced (or rather converted from one form to another). This article aims to discuss the latter in the form of cogeneration.

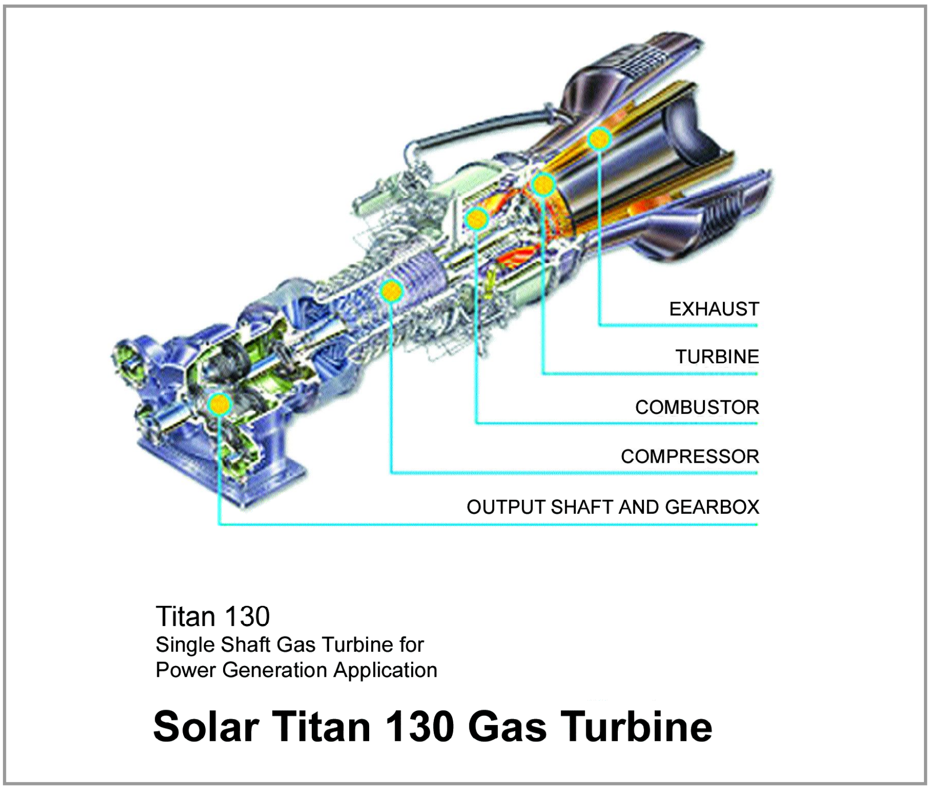

Figure 1: Solar titan 130 gas turbine

THE FUNDAMENTALS OF COGENERATION

The basic definition of cogeneration is the generation of one or more useful forms of energy from a single fuel source. While this may sound complicated, it simply means utilising waste energy from one process to improve the efficiency of another. For most industries, this translates to generating electricity and some form of heat that can be utilised in the manufacturing process. Hence, another name for cogeneration is "Combined Heat and Power (CHP)" plants.

A well-designed and operated cogeneration scheme will always provide better energy efficiency than conventional energy solutions, leading to both net energy and cost savings. Conventional thermal power plants typically waste up to 65% of the original fuel input through heat loss, line transmission losses and other inefficiencies. A cogeneration plant captures the wasted heat energy that would have been otherwise lost thereby more than doubling the energy efficiencies that could be attained with conventional power plants.

AN INSIGHT ON GAS TURBINE COGENERATION

The gas turbine cogeneration plant best illustrates the effective ulitisation of waste energy from one process to improve the efficiency of another. Gas turbines have been used for many years now in Malaysia in a variety of applications. Most commonly they are associated with power generation but they also perform a variety of tasks in the oil and gas industry including pumping, gas injection and compression applications. In fact in Malaysia if you are connected to the natural gas pipeline most probably the gas you are consuming has been through a compression station with industrial gas turbines running the compressors. While it can also be used to power many types of driven equipment, electricity is perhaps the most universally used form of energy in today's industry.

The way a gas turbine works is by drawing in air through a series of rotating compressors. These compress the air before sending it through to a combustion chamber. Here fuel, typically natural gas, is injected and ignited. The expanding hot gasses pass through a set of turbine rotors driving a shaft that rotates the generator, usually through a reduction gearbox.

In a simple plant for generating electricity this process stops here. The hot gasses are then exhausted into the atmosphere. This is called an ***open cycle power plant***. In some power plants the thermal energy contained in the hot gasses are recovered in heat recovery steam generators which subsequently drive a steam turbine that generates more electricity off the recovered heat. This is called a ***combined cycle power plant***. The limits of today's technology in materials and design allow for around 40% efficiency for open cycle gas turbines and around 50% for combined cycle gas turbine power plants.

What a cogeneration plant does differently is in how the gas turbine's exhausted heat energy in used. Instead of trying to generate more electricity, the heat energy in the hot exhaust gasses are used in the most direct form possible to generate steam, hot air for drying, hot water, chilled water in an absorption chiller or any combination of these. Since these forms of energy are more directly utilised, they are also more efficient in converting thermal energy into these other forms useful in industry or manufacturing operations. The added step of converting it back into electricity with its own intrinsic losses, as in a steam turbine for a combined cycle plant, is taken out of the equation.

Cogeneration plants are typically much smaller than a municipal or utility power plant supplying electricity to the grid. A typical cogeneration plant has an electricity generating capacity of about 1 – 20 MW compared with above 100MW for a utility power plant. This allows the cogeneration plant to be strategically built in the immediate vicinity of the factory or commercial development plot that it serves. Because of its close proximity, the electricity generated from the cogeneration plant does not require a large transmission or distribution network to be connected to the factory. In fact this is why cogeneration schemes are also known as "On Site Power Generation". How this benefits the customer is that with complex transmissions and distribution networks out of the way, almost 5 -7% of losses associated with the transmission of electricity over large distances are also eliminated.

When examined individually, the components of the cogeneration plant may not be particularly efficient in themselves. The essential concept is in how the individual components work together as a total system to be more efficient than conventional energy solutions that do not have interaction between the electrical supply and thermal energy demands.

A cogeneration gas turbine typically has efficiencies that range from 25%-35% (up to 40% for larger utility machines) while a heat recovery steam generator's conversion efficiency would be slightly lower than a similar sized package boiler. However when a cogeneration gas turbine operates with a heat recovery steam generator, the combined system can easily deliver a net thermal efficiency of around 85% while meeting the same electricity and steam demands. Conventional grid import and package boilers operating separately would be hard pressed to deliver a 65% overall thermal efficiency. Yet it is the latter's conventional system with all it's inefficiencies that predominantly supplies our industries today.

THE MALAYSIAN SCENE

In Malaysia today, there are certain misconceptions about cogeneration that color the general public's opinion. Chief among these is the idea that the Government and Utilities do not support cogeneration.

It is hard to agree with this point of view given that currently Malaysia offers a raft of incentives for investors in cogeneration plants. These incentives are available for companies entering into performance contracting schemes, Energy Service Companies (ESCOs) or investors in cogeneration plants serving their own energy needs. The Energy Commission evaluates applications for import duty and sales tax exemptions for cogeneration equipment while MIDA processes Investment Tax Allowance and Pioneer Status applications for energy efficient investments. All in all we have

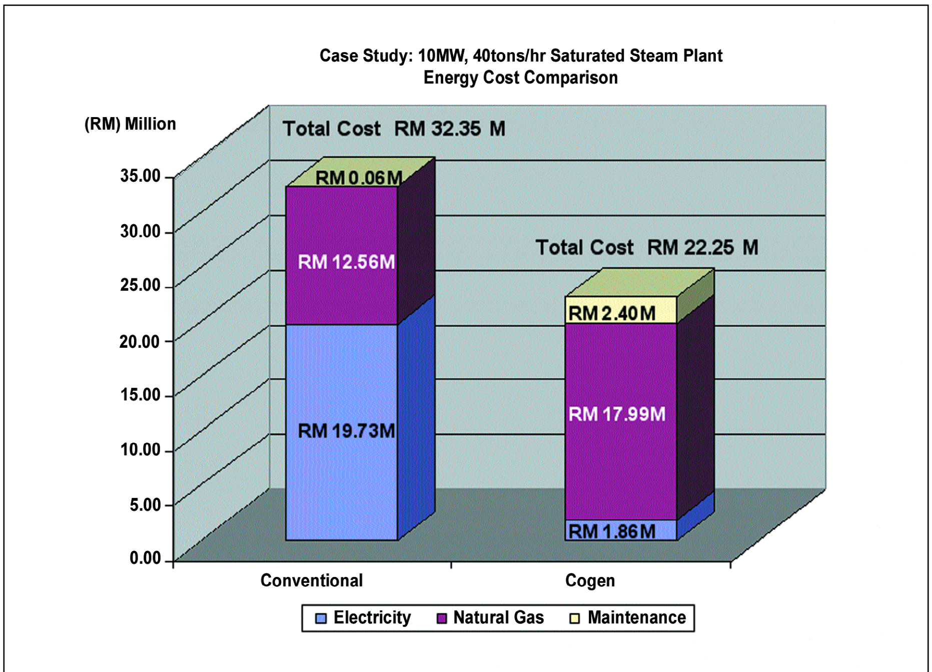

Figure 2: Case Study – 10MW, 40 tons/hr saturated steam plant energy cost comparison

Table 1: Case Study – 10MW, 40 tons/hr saturated steam plant economic feasibility summary

Electricity Tariff	E2
Gas Tariff	RM12.87 / mmbTU
Annual Operating Hours	8,400 Hours
Cogen Plant Cost	RM34,200,000
Less Invest. Tax Incentive	RM5,540,000
Net Investment	RM28,660,000
Annual Saving	RM10,100,000
Returns on investment	29.5% / 35.3*%
Plant Payback	3.39 years / 2.83* years

* *based on Investment Tax Allowance benefits*
Plant configured for 2 x 4.8MW gas turbine with grid top-up and 50% standby

in place an attractive set of incentives offered by the Government, a clearly published definition of cogenerator's top-up and standby rates as well as qualified turnkey contractors and engineering consultants.

We are also fortunate to have in the country expertise to implement these projects, from equipment supply to full turnkey execution. Several Malaysian companies have been in this business successfully for many years now and provide comprehensive project and after sales maintenance services. Part of the ability to invest in local based expertise and resources has been a direct knock on effect from the oil and gas industries where these gas turbines, of the range typically used for industrial cogeneration, have been in use for over 30 years in our local petroleum industry.

Every effort must be made to conserve our natural resources and ensure their sustained availability and productivity while considering related human social and economic needs. While we are still a far way off a liberalised generation and grid system, for example as practiced in the United Kingdom, these incentives are definitely a step in the right direction towards responsible usage of our finite natural resources.

PROJECT IMPLEMENTATION MODELS

There are a few implementation models that can be considered for cogeneration. The end user may choose to invest entirely out of internal funds, leverage a bank loan for construction or employ the services of an ESCO. Typically an ESCO will construct the cogeneration plant out of their own funds and the end user benefits from the usage of such a plant for a certain fee. This benefits both parties as the ESCO specialises in operating and maintaining the cogeneration plant while the end user benefits from lower energy costs. In addition, the end user need not worry about the performance and running of the cogeneration plant freeing them to concentrate on their core business expertise. The net effect is that cost of manufacturing is lowered offering increased market competitiveness and business resilience. This is why cogeneration sometimes is classified as a strategic solution rather than just another equipment investment.

CONCLUSION

From a macro-economic perspective, cogeneration improves the nation's competitiveness as well as the economic resilience of our industrial sector. In addition to direct cost savings, cogeneration yields significant environmental benefits through using fossil fuels more efficiently. Particular, it is a highly effective means of reducing carbon dioxide (CO_2) and sulphur dioxide (SO_2) emissions. Oxides of nitrogen (NO_x) are also generally reduced through the introduction of modern combustion technology.

The traditional electricity system as we know it may well evolve beyond recognition as global and national pressures gain momentum to reduce emissions and a more holistic approach is taken to evaluating power generation, supply, and the provision of energy services to end users. In time an increasing proportion of new power will come from a range of small embedded generators, including cogeneration.

The reality of business is such that all good intentions have to be backed by solid financial rewards. This is no different for cogeneration. The underlying theme is that the monetary value of energy savings are adequate to pay for the initial cost of the plant plus a certain return on investment. Fortunately, in this aspect investing in cogeneration is already an accretive investment. Throw in the incentives available and we have a very attractive package in terms of investment costs versus returns on investment. ■