

CO-GENERATION

An Energy Efficient Technology



This guide is to explain the energy efficient technology of co-generation and the opportunity available for sale of excess energy to enhance the cost benefits

Information Booklet

2019 Edition

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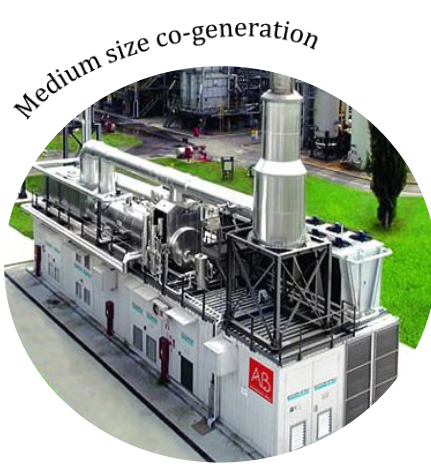
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PART A- Co-generation in General

Introduction

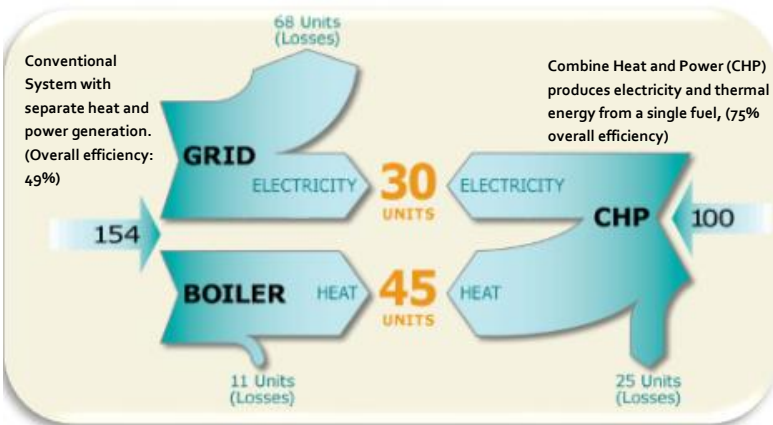
The purpose of this guide is to provide information on the cost benefit of co-generation and the platform available for the co-generators, to sell the excess energy generated by the co-generation facilities to the wholesale electricity market operated by the Single Buyer under the New Enhanced Dispatch Arrangement.



Co-generation System

Co-generation is an energy efficient technology which enables the simultaneous production of two different forms of useful energy, typically electricity and thermal energy from a single primary energy source. The electricity generated is normally for onsite use and any excess may be exported to the local utility network. Thermal energy produced may be used for industry processes or to produce steam, hot water or hot air for drying or warming or chilled water for cooling purposes.

The overall efficiency of energy use in a co-generation system can be up to 75% and more.



Conventional System with separate heat and power generation compared with co-generation in overall efficiency

A co-generation facility with small gas turbine plant can save more than 40 per cent of the primary energy when compared to the electricity generated by a fossil fuel fired power plant and thermal energy produced by a boiler. In addition to saving of fossil fuels, co-generation will reduce carbon dioxide (CO₂) emission since less fuel is used and reduce losses in the transmission and distribution lines as electricity is generated on site or near the loads.

Application of co-generation

Petrochemical Industries



Hospital



District cooling



Manufacturing/heavy industries

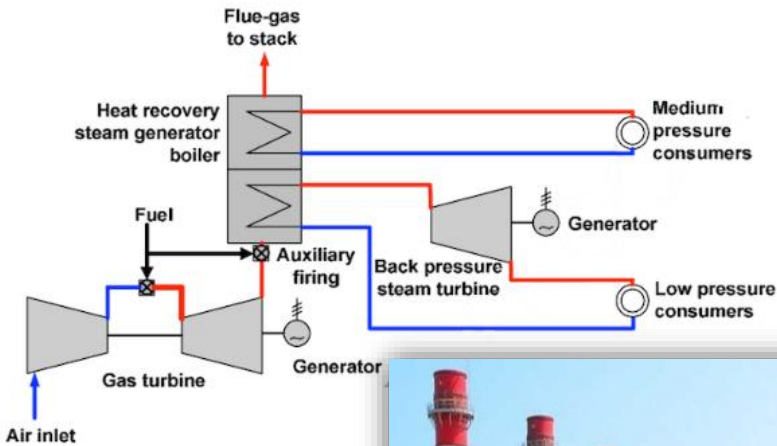


The benefits of co-generation can be briefly summarized as follows:

- i) improve efficiency in the use of energy resources;
- ii) saving in operation costs with reduced energy costs;
- iii) improve profitability and competitiveness of the business;
- iv) reduce peak system demand and operation of less efficient peaking plants;
- v) reduce demand and energy losses in transmission and distribution of electricity;

In addition, co-generation will also encourage private investment in generation using energy efficient technology and use of renewable energy resources. It will generate business opportunities and stimulate growth of the small and medium local enterprises in the manufacturing and supply of equipment and parts and contribute to job creation for the locals, particularly in plant operation and equipment services.

High Efficient Combined Cycle Co-generation



The success of a co-generation facility is depending on many factors such as:

- i) technology;
- ii) type of fuel used;
- iii) size of the plant;
- iv) optimized use of heat produced and electricity generated;

- v) daily and annual load profiles;
- vi) annual full load operating hours;
- vii) opportunity for sales of excess energy produced;
- viii) electricity and fuel prices;
- ix) electricity top up and standby charges;
- x) tax incentives; and
- xi) and energy policy of the country.

Criteria for Promotion of Co-generation

In promoting co-generation, the emphasis will be on the following areas:

- (a) Technical
 - i) known technologies with low risk in implementation and operation;
 - ii) base load energy production;
 - iii) readily available fuel sources; and
 - iv) no extensive modification or reinforcement to the existing electricity supply networks.
- (b) Commercial
 - i) benefits from an economy-wide perspective, rather than from the energy-sector's perspective only;
 - ii) wider cost and supply benefits of co-generation for the electricity supply industry; deferral of network capital,

relief of network constraints and reduction in network losses by distributed generation;

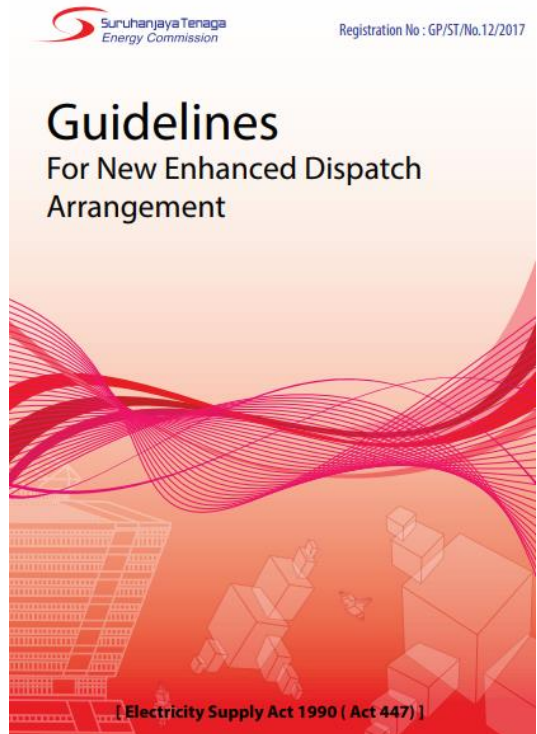
- iii) commercial/manufacturing/industry facilities which can provide scale and continuous energy delivery;
- iv) use of industrial and agriculture wastes and renewable resources; and
- v) innovation in the use of waste heat, particularly the low-grade heat.

Sale of Excess Energy Under New Enhanced Dispatch Arrangement (NEDA)

In the past, a co-generator cannot export and sell the excess energy generated in the facility through the electricity supply network unless there is a power purchase agreement with the electricity supply company. This is one of the reasons affecting the wider use of co-generation, particularly in the small and medium size industry and commercial sectors, as the sale of excess energy may be a factor affecting the consideration in investment in co-generation.

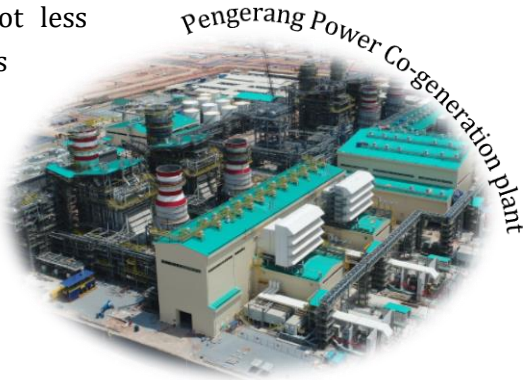
The New Enhanced Dispatch Arrangement (NEDA) introduced since 2017 has overcome such shortcoming by providing a platform for co-generators which do have power purchase agreements (PPA) with the electricity supply company to export and sell energy generated to the Single Buyer market. This will enhance financial viability with additional return to the investment on co-generation

Under NEDA, depending on the capacity of the co-generation facility, a co-generator without a power purchase agreement with the electricity supply company can participate in NEDA under one of the following categories:



(i) Large Merchant Generator

A large co-generator with generation facility of not less than 30MW which is connected to the Grid System and subject to central dispatch by the Grid System Operator can participate as Large Merchant Generator.



(ii) Price Taker

A small or medium size co-generator with generation facility from 100kW up to below 30MW (herein after referred to as “SPP-Cogen”) which are not subject to central dispatch by the Grid System Operator can participate as Price Taker.



For more details of the market arrangement, please refer to the Guidelines for New Enhanced Dispatch Arrangement at the Energy Commission website.

A large co-generator with generation facility of not less than 30MW can participate in the daily bidding system to



sell excess energy to the Single Buyer market by offering half hourly Price Quantity Pair [(x) RM/kWh for (y) kW] to the Single Buyer similar to other Large Merchant Generators. If its offer is lower/equal to the System Marginal Price and is accepted and scheduled by the Single Buyer and the energy dispatched by the Grid system, the energy delivered to the Grid System will be paid at the bid price (Price as Bid).

As a Price Taker, a SPP-Cogen with generation facility of 100KW to less than 30MW can sell excess energy generated to the Single Buyer through the electricity supply company without having to participate in the daily bidding process. The energy delivered to electricity supply networks will be paid the actual half hourly System Marginal Price which depends on market fuel prices, system demand and availability of system generation.

Examples of System Marginal Prices for certain days in the month of April 2019 are as shown in Appendix A for reference.

PART B – Promotion of SPP-Cogen

This section describes the conditions and requirements for a co-generator to be eligible to participate as a SPP_Cogen under the category of Price Taker in NEDA to export and sell excess energy to the Single Buyer Market.

Qualifying Requirements as SPP-Cogen

To qualify as a SPP-Cogen, the co-generation facility shall meet the following requirements:

- a) Economic Requirements
 - i) The size of the co-generation facility shall be based on economically justifiable demand of thermal energy required; and
 - ii) The cost of electricity produced by the co-generation facility is cheaper than the average generation cost of the electricity supplied by the electricity supply company.

The example of cost benefit calculation is as shown in Appendix C.

- b) Efficiency Requirements
 - i) The overall efficiency of the co-generation facility shall be not less than 70%.

c) Capacity Requirements

- i) The co-generation facility shall be less than 30MW but not less than 100kW.

d) Technical Requirements

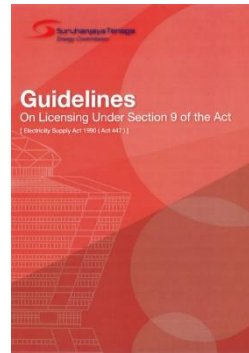
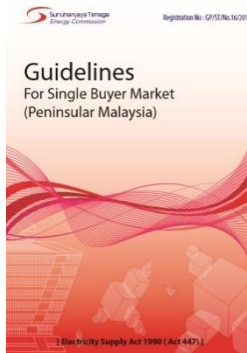
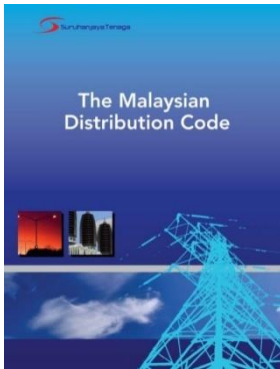
- i) The primary energy resource must be used to simultaneously produce thermal energy and electricity either by “topping cycle” or “bottoming cycle”;
- ii) The generating facility must comply with the Distribution Code, Guidelines for Single Buyer Market, Guidelines for New Enhanced Dispatch Arrangement and other relevant legal and regulatory requirements, where applicable; and
- iii) The connection, protection, control, communication, metering, information exchange and other operational and technical requirements of the co-generation facility shall comply with the Distribution Code and Grid Code where applicable, unless approved by the Energy Commission otherwise; and
- iv) The electricity supply company shall provide connection to the SPP-Cogen for the export and sale of energy on successful completion, testing

and commissioning of the co-generation facility per the license conditions, the Distribution Code and the Grid Code, where relevant.

Legal and Regulatory Requirements

The SPP-Cogen shall comply with the following requirements:

- i) The SPP-Cogen must possess a public license for generation and supply of electricity issued by the Energy Commission;
- ii) The SPP-Cogen must register with the Energy Commission under the Guidelines for Single Buyer Market as a market participant, and as a NEDA participant under the Guidelines for New Enhanced Dispatch Arrangement;
- iii) The SPP-Cogen shall comply with the legal requirements and the licence conditions and the Grid Code, Distribution Code, Guidelines for Single Buyer Market, Guidelines for New Enhanced Dispatched Arrangement where relevant;
- iv) The SPP-Cogen can only dispatch power to the Distribution Network after all pre-requisite legal and regulatory requirements have been fulfilled.



Operational Matters

- i) The SPP-Cogen shall provide details of the annual generation plan of the co-generation facility and declare the annual available energy for export to the Single Buyer;
- ii) The SPP-Cogen shall use its best endeavors to deliver not less than 70% of the annual declared available of energy for export as declared by the SPP-Cogen in the annual generation plan unless for reasons not attributed to the SPP-Cogen;
- iii) The SPP-Cogen shall submit day ahead forecast of planned generation of its generation facility to the Single Buyer in accordance with format and time schedule in the NEDA Rules;

- iv) The electricity supply company shall accept all energy supplied by the SPP-Cogen unless under such system emergency situations that the importing of such energy will place the safety and security of the electricity supply networks at risk;
- v) The SPP-Cogen shall take immediate action to comply with any emergency instructions of the control center of the electricity supply company if the security of the electricity supply networks is at risk; and
- vi) The minimum export capacity by a SPP-Cogen shall be not less than 100kW.

Interconnection Voltages

Depending on the top up/standby demand of the co-generation facility, the interconnection voltages to the electricity supply networks adopted by the electricity supply company are generally as follows:

- i) Up to 1.0MW : 415 V or 11kV
- ii) 1.0MW to 10.0MW : 11kV or 33kV
- iii) 10.0MW to 30.0MW : 33kV

Top Up and Standby Charge for Power Supply

A SPP-Cogen shall enter into a commercial agreement with the electricity supply company if standby and top up power are required to be provided by the electricity supply company.

The standby and top up power charges of the electricity supply company will be as published and approved by the Government.

To facilitate the electricity supply company in planning and arranging for supply of standby power, the SPP-Cogen shall coordinate with the electricity supply company on the annual maintenance programs.

The current top up and standby charges are as shown in Appendix B for reference.

Gas Price

The gas price for the co-generation facility will be the regulated tariffs for the commercial and industrial sectors approved by the Government for Petronas and Gas Malaysia Berhad whichever relevant. However, the SPP-

Cogen may also source for its own gas supply from other supplier with the third party access arrangement as provided for under the Gas Supply (Amendment) 2016, Act A1515.

Glossary

Terms	Meaning
Bottoming Cycle	The energy input to the co-generation facility is first applied to produce useful thermal energy and the reject heat emerging from the process is then used to produce power.
Co-generation	A process whereby a single fuel source is used for the simultaneous production of thermal energy and electrical or mechanical energy.
Co-generation Facility	A facility with one of more co-generation plant.
Co-generator	A person who owns or operates a co-generation facility

Terms	Meaning
Electricity Supply Company	An entity which is licensed under the Electricity Supply Act to supply and distribute electricity.
Distribution Code	A document issued by the Energy Commission containing rules, principles and procedures to facilitate planning, development, operation and maintenance of and connection to an electricity distribution system in Peninsular Malaysia.
Economically Justifiable Demand	Demand that does not exceed the needs for heating or cooling and which would otherwise be satisfied at market conditions by energy generation processes other than co-generation.
Generator	A person who is licensed under the Electricity Supply Act 1990 to generate electricity.

Terms	Meaning
Grid Code (or Malaysian Grid Code)	A document issued by the Energy Commission containing rules, principles and procedures to facilitate coordinated planning, design, development, operation and maintenance of the grid system in Peninsular Malaysia.
Grid System	The electricity transmission network as defined in the Electricity Supply (Amendment) Act 2015.
Grid System Operator	The person responsible for operational planning, real-time re-scheduling, dispatch and control of the Grid System in compliance with the provisions of the Grid Code and coordinates all parties connected to the Grid System.
Guide	This document, the Guide for Promotion of Co-generation.
Guidelines for New Enhanced Dispatch Arrangement or New Enhanced	The document which sets out the principles, by which the Single Buyer used in scheduling the dispatch of generation, the determination of system marginal

Terms	Meaning
Dispatch Arrangement Rules (or NEDA Rules)	prices and the settlement of electricity delivered to and purchased by the Single Buyer in accordance with the New Enhanced Dispatch Arrangement.
Guidelines for Single Buyer Market (or Single Buyer Rules)	A document that sets out the objectives, roles and functions of the Single Buyer and the roles of other Participants in the Single Buyer market..
New Enhanced Dispatch Arrangement (NEDA)	The arrangement used by the Single Buyer in scheduling the dispatch of generation, the determination of prices of electricity purchased etc. in accordance with the NEDA Rules.
Overall Efficiency	The annual sum of electricity and useful heat output divided by the fuel input used for the heat and gross electricity production in a co-generation process calculated on the net calorific value of the fuel.

Terms	Meaning
Power to Heat Ratio	The ratio of electricity from co-generation to useful heat when operating in full co-generation mode using operational data of the specific unit.
Price Quantity Pair	The price (in RM/kWh) for a specific quantity of electricity (in kW or MW).
Price as Bid	The bid price of a specific quantity of electricity for a specific half hourly period offered by a generator to the Single Buyer.
Single Buyer	The person authorized by the Energy Commission to be responsible for the management of procurement of electricity and related services, which includes scheduling, procuring and settlement under Single Buyer Guidelines.
SPP-Cogen (or Small Power Producer with Co-generation facility)	A Co-generator with co-generation facility from 100kW to less than 30MW.

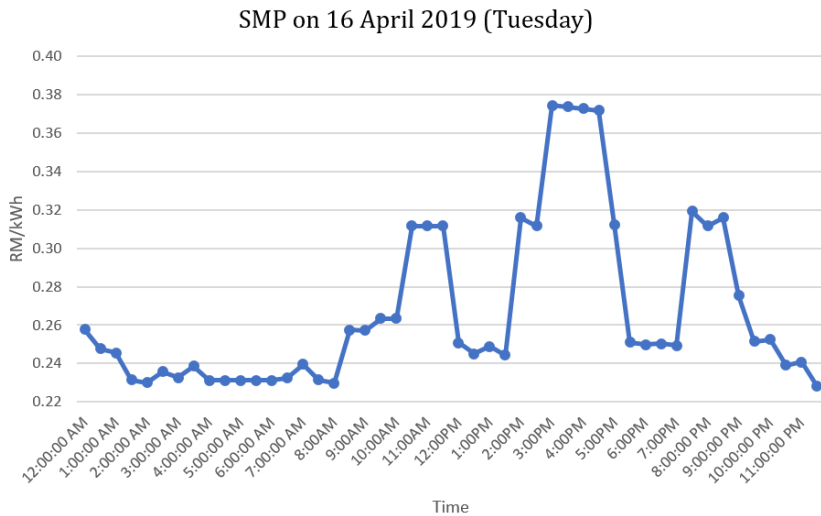
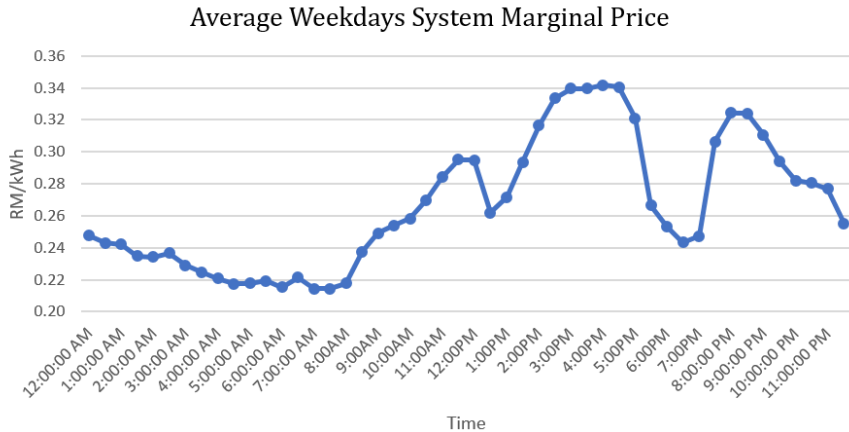
Terms	Meaning
Standby Power	The electrical energy or power provided by the electricity supply company to replace the energy ordinarily generated by the co-generation facility during an outage of the co-generation facility.
System Marginal Price	The variable price of the most expensive generation plant scheduled to meet the demand
Topping Cycle	The energy input to the co-generation facility is first applied to produce power output and the reject heat emerging from the process is then used to produce useful thermal energy.
Top Up Power	The electrical energy and/or power regularly supplied by the electricity supply company and used by the co-generation facility in addition to the electricity generated by the co-generation facility itself.

Terms	Meaning
Useful Heat	The heat production in a co-generation process to satisfy economically justifiable demand for heating or cooling.

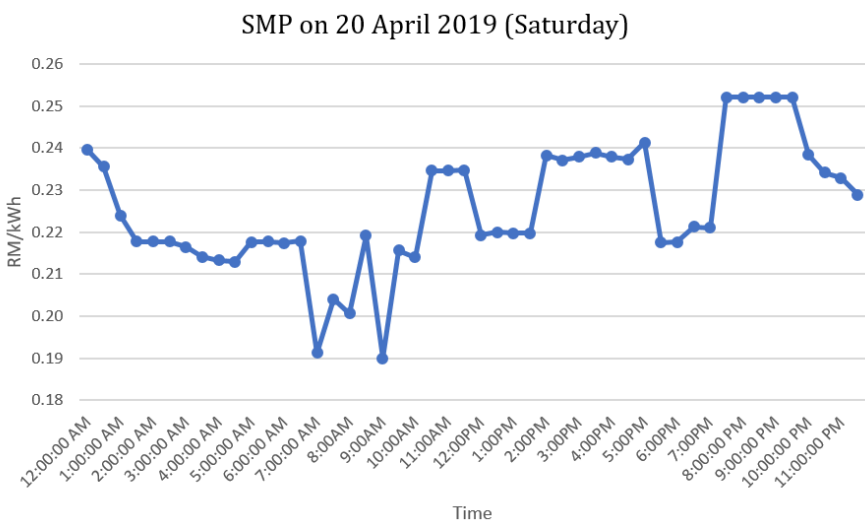
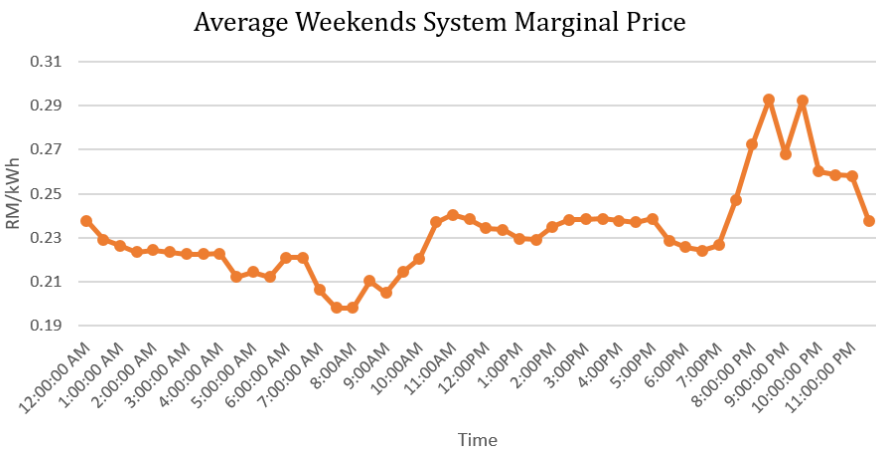
Appendix A

Samples of System Marginal Price (SMP) for April 2019

(a) Sample SMP for weekdays



(b) Sample SMP for weekend



Appendix B

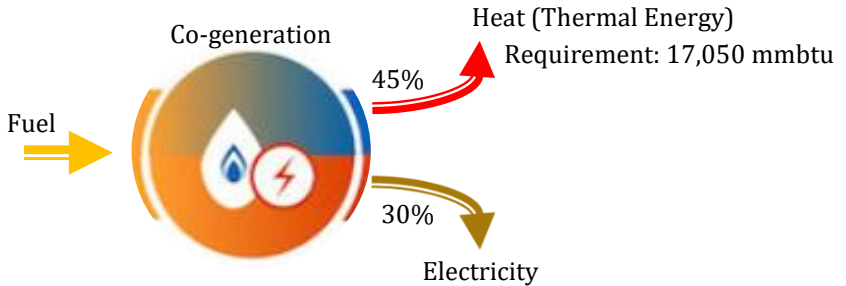
Current Top-Up and Standby Charges (2019)

TARIFF CATEGORY	UNIT	CURRENT RATE (1 JAN 2014)	
		TOP-UP	STANDBY
TARIFF C1 - MEDIUM VOLTAGE GENERAL COMMERCIAL TARIFF			
Maximum demand charge per month	RM/kW	30.30	14.00
For all kWh	sen/kWh	36.50	
TARIFF C2 - MEDIUM VOLTAGE PEAK/OFF-PEAK COMMERCIAL TARIFF			
For each kilowatt of maximum demand per month during the peak period	RM/kW	45.10	14.00
For all kWh during the peak period	sen/kWh	36.50	
For all kWh during the off-peak period	sen/kWh	22.40	
TARIFF E1 - MEDIUM VOLTAGE GENERAL INDUSTRIAL TARIFF			
Maximum demand charge per month	RM/kW	29.60	14.00
For all kWh	sen/kWh	33.70	
TARIFF E2 - MEDIUM VOLTAGE PEAK/OFF-PEAK INDUSTRIAL TARIFF			
For each kilowatt of maximum demand per month during the peak period	RM/kW	37.00	14.00
For all kWh during the peak period	sen/kWh	35.50	
For all kWh during the off-peak period	sen/kWh	21.90	

TARIFF CATEGORY	UNIT	CURRENT RATE (1 JAN 2014)	
		TOP-UP	STANDBY
TARIFF E3 – HIGH VOLTAGE PEAK/OFF-PEAK INDUSTRIAL TARIFF			
For each kilowatt of maximum demand per month during the peak period	RM/kW	35.50	12.00
For all kWh during the peak period	sen/kWh	33.70	
For all kWh during the off-peak period	sen/kWh	20.20	
TARIFF F1 – MEDIUM VOLTAGE GENERAL MINING TARIFF			
Maximum demand charge per month	RM/kW	21.10	14.00
For all kWh	sen/kWh	31.30	
TARIFF F2 – MEDIUM VOLTAGE PEAK/OFF-PEAK MINING TARIFF			
For each kilowatt of maximum demand per month during the peak period	RM/kW	29.80	14.00
For all kWh during the peak period	sen/kWh	31.30	
For all kWh during the off-peak period	sen/kWh	17.20	
TARIFF H1 – MEDIUM VOLTAGE GENERAL SPECIFIC AGRICULTURE TARIFF			
Maximum demand charge per month	RM/kW	30.30	14.00
For all kWh	sen/kWh	35.10	
TARIFF H2 – MEDIUM VOLTAGE PEAK/OFF-PEAK SPECIFIC AGRICULTURE TARIFF			
For each kilowatt of maximum demand per month during the peak period	RM/kW	40.80	14.00
For all kWh during the peak period	sen/kWh	36.50	
For all kWh during the off-peak period	sen/kWh	22.40	

Appendix C

Cost Benefit Analysis of a 1MW Co-generation Facility Based on Heat Demand



(i) Case 1

Assumption

Average Electrical Load: 1.0MW

Power to Heat Ratio: 1:1

Annual Operation Hours: 5,000 hours

Annual Thermal Energy Demand: 17,050 mmbtu or 5,000MWh

(Conversion Factor: 1.0MWh=3.41mmbtu)

Annual Electricity Demand: 5,000 MWh

Efficiency of Boiler: 80%

Efficiency of Gas Turbine Generator: 30%

Efficiency of Heat Production System of Co-generation Facility: 45%

Electricity Tariff of Electricity Supply Utility: RM 0.4/kWh

Gas Price: RM 30.00/mmbtu

Average Selling Price of Excess Electricity: RM 0.26/kWh (depending on System Marginal Price)

- (a) Business as usual with gas fired boiler to meet thermal energy demand and electricity purchased from electricity utility company to meet electricity demand.

Annual electricity cost: $\text{RM}0.4 \times 5,000,000\text{kWh} = \text{RM}2,000,000.00$

Annual fuel cost for boiler: $\frac{\text{RM } 30/\text{mmbtu} \times 17,050 \text{ mmbtu}}{0.8} = \text{RM}639,375$

Total energy cost: $\text{RM}2,000,000 + \text{RM}639,375 = \text{RM } 2,639,375$

- (b) A co-generation facility with gas turbine generator and heat recovery steam production system.

Annual fuel cost: $(\text{RM } 30/\text{mmbtu} \times 17,050\text{mmbtu})/0.45 = \text{RM}1,136,667$

Electricity produced by cogen facility: $\frac{17,050\text{mmbtu} \times 0.3}{0.45 \times 3.41} = 3,333 \text{ MWh}$

Top up electricity purchased from utility: $5,000 \text{ MWh} - 3,333\text{MWh} = 1,667\text{MWh}$

Cost of top up electricity purchased = $\text{RM}0.4 \times 1,667,000\text{kWh} = \text{RM } 666,800.00$

Total energy cost: $\text{RM } 1,136,667.00 + \text{RM } 666,800.00 = \text{RM } 1,803,467.00$

Cost benefit with cogen facility compared with business as usual

Annual saving in total energy cost: $\text{RM}2,639,375.00 - \text{RM } 1,803,467.00 = \text{RM } 835,908.00$

Case 2

Assumption

Average Electrical Load: 0.5 MW

Power to Heat Ratio: 0.5:1

Annual Operation Hours: 5,000 hours

Annual Thermal Energy Demand: 17,050 mmbtu or 5,000MWh
(Conversion Factor: 1.0MWh=3.41mmbtu)

Annual Electricity Demand: 2,500 MWh

Efficiency of Boiler: 80%

Efficiency of Gas Turbine Generator: 30%

Efficiency of Heat Production System of Co-generation Facility: 45%

Electricity Tariff of Electricity Supply Utility: RM0.4/kWh

Gas Price: RM 30.00/mmbtu

Average Selling Price of Excess Electricity: RM 0.26/kWh (depending on System Marginal Price)

- (a) Business as usual with gas fired boiler to meet thermal energy demand and electricity purchased from electricity utility company to meet electricity demand.

Annual electricity cost: $RM0.4 \times 2,500,000 = RM 1,000,000.00$

Annual fuel cost for boiler: $RM 30 \times 17,050 \text{ mmbtu} \div 0.8 = RM639,375.00$

Total energy cost: $RM 1,000,000.00 + RM639,375.00 = RM 1,639,375.00$

- (b) A co-generation facility with gas turbine generator and heat recovery steam production system.

Annual fuel cost: $\frac{RM 30/mmbtu \times 17,050 \text{ mmbtu}}{0.45} = RM1,136,667.00$

Electricity produced by cogen facility: $\frac{17,050 \times 0.3}{0.45 \times 3.41} = 3.333 \text{ MWh}$

Excess electricity produced: $3,333 \text{ MWh} - 2,500 \text{ MWh} = 833 \text{ MWh}$

Revenue from sale of excess electricity produced = $\text{RM}0.26 \times 833,000 \text{ kWh} = \text{RM } 216,580.00$

Total annual energy cost: $\text{RM } 1,136,667.00 - \text{RM } 216,580.00 = \text{RM } 920.087.00$

(c) Cost benefit with cogen facility compared with business as usual.

Annual saving in total energy cost: $\text{RM}1,639,375.00 - \text{RM } 920,087.00 =$
RM 719,288.00

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