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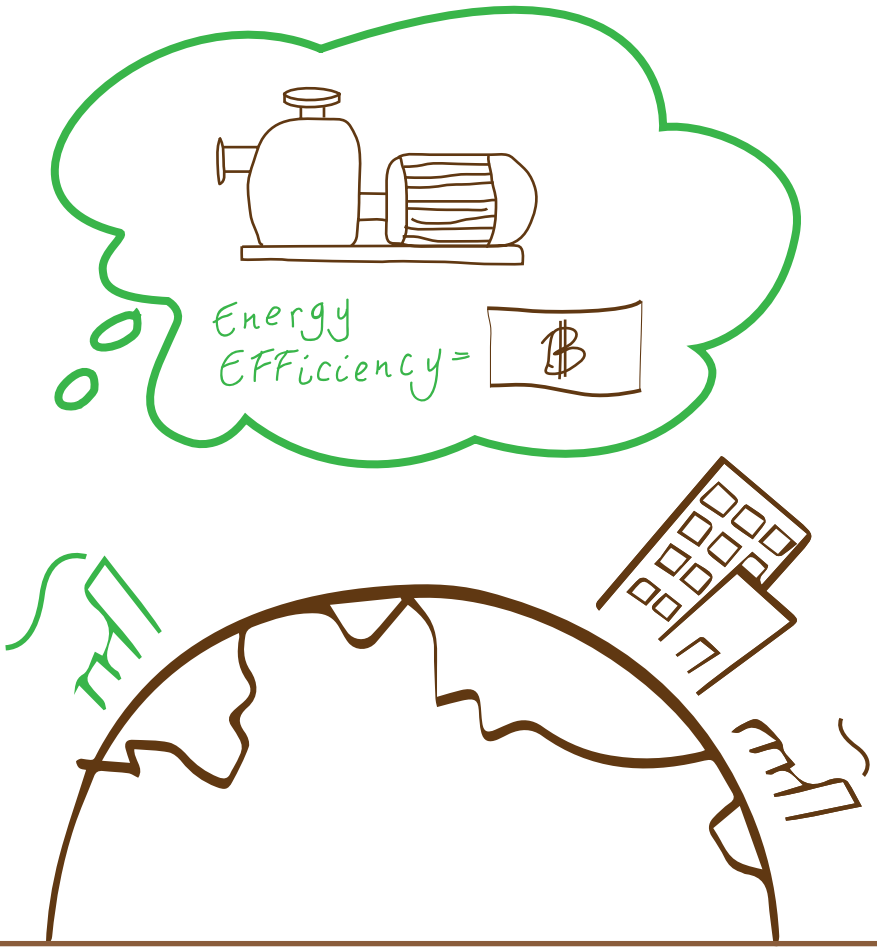
GUIDELINE
Evaluation of Industrial Energy Efficiency Project for Industries

INDUSTRIAL ENERGY EFFICIENCY PROJECT



กระทรวงอุตสาหกรรม
Ministry of Industry

Department of Alternative
Energy Development and Efficiency
MINISTRY OF ENERGY

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Thailand's Energy Situation

1.1 Introduction

The need for importing petroleum significantly increases to 45% of the total energy consumption in Thailand. The amount accounts for over 55% if including natural gas, coal mining and electricity imports from neighboring countries. Heavy reliance on energy imports has been a serious concern over national security amid highly unstable fuel cost, falling short of energy resource in the global community and political conflicts in oil-producing countries. The record-high oil price of US$ 147 in 2008 much affected the world economy and has become a wake-up call for Thailand to come up with a well-planned macroeconomic development including energy consumption strategy.

1.2 Energy situation in 2013

1.2.1 Domestic consumption, production and primary commercial consumption

Commercial energy imports including crude oil, natural gas, condensate, petroleum products, coal-fired power and hydropower in 2013 accounted for two million barrels of oil equivalent (BOE). The amount grew up by 1.2% compared to the previous year.

- Natural gas shared the highest proportion of energy consumption accounted for 917,015 BOE per day (46% of the total energy consumption). The percentage increased by 3.2% compared to Year 2012.
- Crude oil consumption came second at 727,559 BOE per day (36% of the total energy consumption). The percentage increased by 2.6% compared to Year 2012.
- Coal and lignite power accounted for 313,320 BOE per day (16% of the total consumption), reduced by 4.4% compared to Year 2012.

- Hydropower and electricity imports stood at 46,635 BOE (2% of the total amount), reduced by 15.7% compared to Year 2012.

1.2.2 Energy consumption value

In 2013, the energy consumption value accounted for 2.13 trillion Baht. The expenditure increased by 0.9% compared to Year 2012. The following is the summarized details.

- Petroleum product THB 1.327636 trillion
- Electricity THB 541.974 billion
- Natural gas THB 121.147 billion
- Coal/lignite power THB 25.315 billion
- Renewable energy THB 118.469 billion

1.2.3 Energy import value

Energy import cost the country 1.42 trillion Baht in 2013, reduced by 2% in the previous year. The following is the summarized details.

- Crude oil THB 1.073 trillion
- Natural gas and liquid natural gas (LNG) THB 146.944 billion
- Petroleum products THB 134.306 billion
- Coal THB 39.733 billion
- Electricity THB 20.168 billion

1.2.4 Energy export value

Thailand could export energy valued at 357.896 billion Baht in 2013, reduced by 10.8% in the previous year.

- Petroleum product THB 322.621 million
- Crude oil THB 30.927 billion
- Electricity THB 4.348 billion

1.2.5 Renewable energy development

The domestic consumption of renewable energy in 2013 was at 10.9%, compared to 9.9% in 2012. Biomass shared the highest proportion of the total renewable energy production. Ethanol production increased twice as much of the country's biomass capacity as in 2012.

Table 1.1 Proportion of renewable energy production

Type	Unit	2012	2013
1. Electricity Production			
- Wind energy	Megawatt	110.93	222.71
- Solar power	Megawatt	250.68	635.48
- Small-scale hydropower	Megawatt	96.03	104.77
- Biomass	Megawatt	1,956.85	2,230.05
- Biogas	Megawatt	172.85	262.73
- Biogas (Napier grass)	Megawatt	-	-
- Waste to energy	Megawatt	42.72	47.48
- Renewable energy	Megawatt	0.3	0.3
Total amount of renewable energy for electricity production	Megawatt	2,633.06	3,503.52
	ktoe	1,138.00	1,313.00
2. Heat energy			
- Solar power	ktoe	3.60	4.50
- Biomass	ktoe	4,346	4,769
- Biogas	ktoe	458	477
- Waste to energy	Ktoe	78.20	85
Total amount of heat energy for electricity production	Ktoe	4,885.80	5,335.50
3. Biofuel			
- Ethanol	Million liters/ day	1.29	2.53
- Biodiesel	Million liters/ Day	2.54	2.78
- Renewable fuel applied to diesel	Renewable fuel for diesel	-	-
- Compressed biogas (CBG)	Ton	-	-
Total renewable energy for biomass production	Million liters/ Day	3.83	5.31
	Ktoe	1,270	1,563

Type	Unit	2012	2013
Total domestic consumption of renewable energy	Ktoe	7,294	8,211
Final energy consumption	Ktoe	73,316	75,214
Proportion of renewable energy per final energy consumption within the country		9.9%	10.9%

Source: Energy Policy and Planning Office, Ministry of Energy, Thailand

1.2.6. Electricity Consumption

- Electricity production capacity of 33,681 Megawatt increased from the previous year by 3.32%. Major electricity providers are:
  - Electricity Generating Authority of Thailand (EGAT) 45%
  - Independent power producer (IPP) 38%
  - Small power producer (SPP) 10%
  - Electricity import 7%

- Electric power consumption accounted for 165.560 billion units, increasing by 2.3%. The amount of electric power consumption can be categorized below.
  - Industrial sector (46%)
  - Household (23%)
  - Business sector (23%)
  - Agricultural sector and others (8%)

1.3 Availability of energy saving measure/mechanism

Mechanism and measure available for promoting energy saving in Thailand can be summarized as follows:

Mechanism 1: Energy-saving measure by the Board of Investment of Thailand (BOI)

The Board of Investment of Thailand has implemented a measure aimed at increasing production efficiency and encouraging entrepreneurs already receiving investment support from BOI and those who has not yet listed under BOI support to afford investment in effective energy-saving machinery, renewable energy aimed at lowering environmental impact, innovative research and development for overall

manufacturing efficiency. The following three measures can be applied to this mechanism.

1. Investment support on renewable energy use. Entrepreneurs interested in the program can submit their investment plans on energy-saving machinery and renewable energy use for lowering environmental impact following the BOI requirements

2. Investment support on increasing efficiency of machinery. Any entrepreneur interested in the program needs to submit an investment plan in accordance to BOI requirements for example adopting an automatic system for use with its production line.

3. Investment support on research and development (R&D) and engineering design. Any entrepreneur interested in this measure will have to submit an investment plan on research and development and/or engineering design following BOI requirements. Actual investment must be over 1% of the projected three-year sales target starting from the day the entrepreneur submitted the plan for BOI support. In case of small and medium-sized enterprises (SMEs), operators will have to invest a minimum of 0.5% in R&D and/or develop engineering design based on its three-year target, starting from the day the operator submitted the plan for BOI support. Energy-saving machinery imported by SME entrepreneurs will exempted from import tax. Operators will also earn incentive of income tax reduction by 50% of its investment cost (excluding property and maintenance cost). The amount of income tax will be calculated based on ongoing business income.

Mechanism 2: Investment grant by the Department of Alternative Energy Development and Efficiency (DEDE) and the Energy Policy and Planning Office (EPPO), Ministry of Energy

Operators interested in applying for the investment grant, the two agencies: DEDE and EPPO will support 10-30% of the investment grant following conditions of the energy conservation fund.

Mechanism 3: Energy Service Company (ESCO) Capital Fund

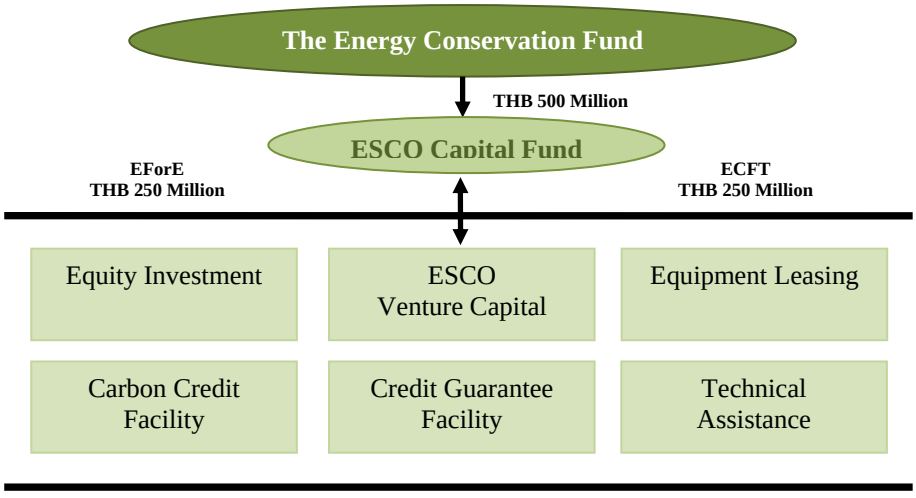
Based on the energy conservation fund, the Department of Alternative Energy Development and Efficiency (DEDE) is the main agency overseeing the ESCO Revolving Fund project aimed at supporting operators lacking funds to develop their business projects by investing more in energy conservation and renewable energy. The objectives of the project are:

1. To promote increasing investment in energy conservation and renewable energy in the private sector

2. To encourage operators to reduce their energy cost

3. To promote up-to-standard and high-quality energy management plan among business sector

4. To increase the use of energy-saving, renewable energy equipment that meets high quality and standard.



Source: Energy Policy and Planning Office, Ministry of Energy, Thailand

Figure 1.1 Model of energy-saving and renewable energy investment promotion

Type of investment

1. Equity Investment The ESCO Revolving Fund will be invested in energy-saving and energy conservation projects.

2. ESCO Venture Capital The ESCO Revolving Fund will be invested in the newly-issued shares of energy management companies so that they will have adequate fund for operating energy-saving business.

3. Equipment Leasing Business operators will receive lease agreement from ESCO Revolving Fund for purchasing energy-saving and renewable energy-dependent equipment. Business operators will have to return a fixed long-term rental payment including interest throughout the leasing period.

4. Carbon Credit Facility Through the ESCO Revolving Fund, operators will be facilitated to conduct a paper on Clean Development Mechanism (CDM) development program. Details will include Project Idea Note (PIN) and Project Design Document (PDD). The ESCO Revolving Fund will also act as a middle-man to facilitate carbon credit purchasing from energy conservation and small-scaled renewable energy projects and to bundle up these projects so that they can sell carbon credit.

5. Credit Guarantee Facility The ESCO Revolving Fund together with financial institutions will provide credit guarantee for business operators to access loan program from commercial banks by acting as a surety for the project valued less than 10 million-baht.

6. Technical Assistance The ESCO Revolving Fund will provide technical assistance for example energy audit cost or feasibility study cost within 100,000-Baht budget under the conditions that the business operator will have to follow energy-saving and renewable energy measure. Any violation in the conditions will result the business operator's obligation to full repayment to the ESCO Revolving Fund.

Chapter 2
Energy saving Measures by Industrial Sectors

2.1 Overall energy consumption in the industrial sector

Industries need electricity and/or heat power from fuel for utilities and processing procedure. The amount of fuel usage will depend on different systems and equipment as shown in Figure 2.1 :

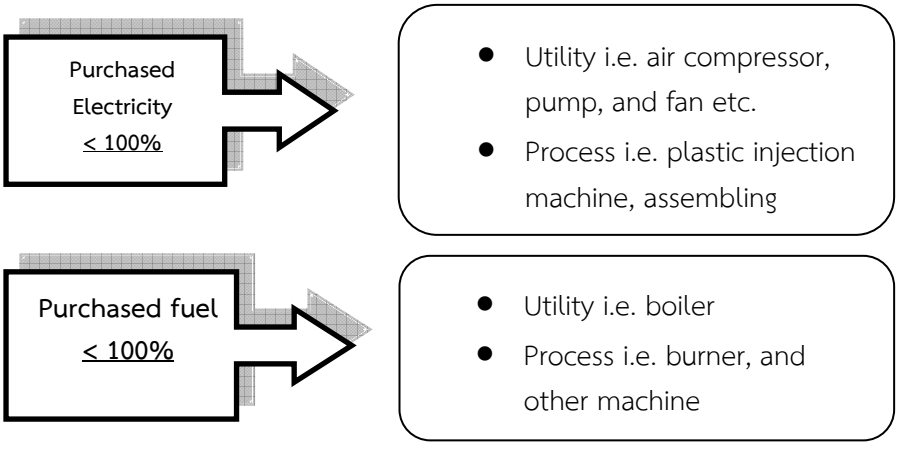


Figure 2.1 Fully energy purchase and Process-Utility in Factory

In addition, energy production from waste heating system, electricity system and cogenerating system may be considered for using in a bid to reduce energy consumption and fuel cost as shown in Figure 2.2 :

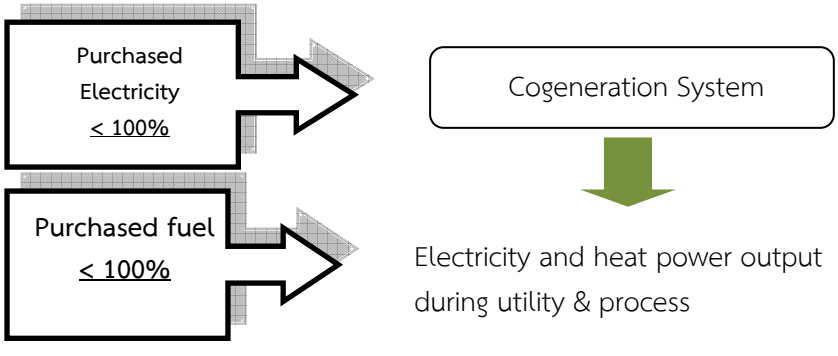
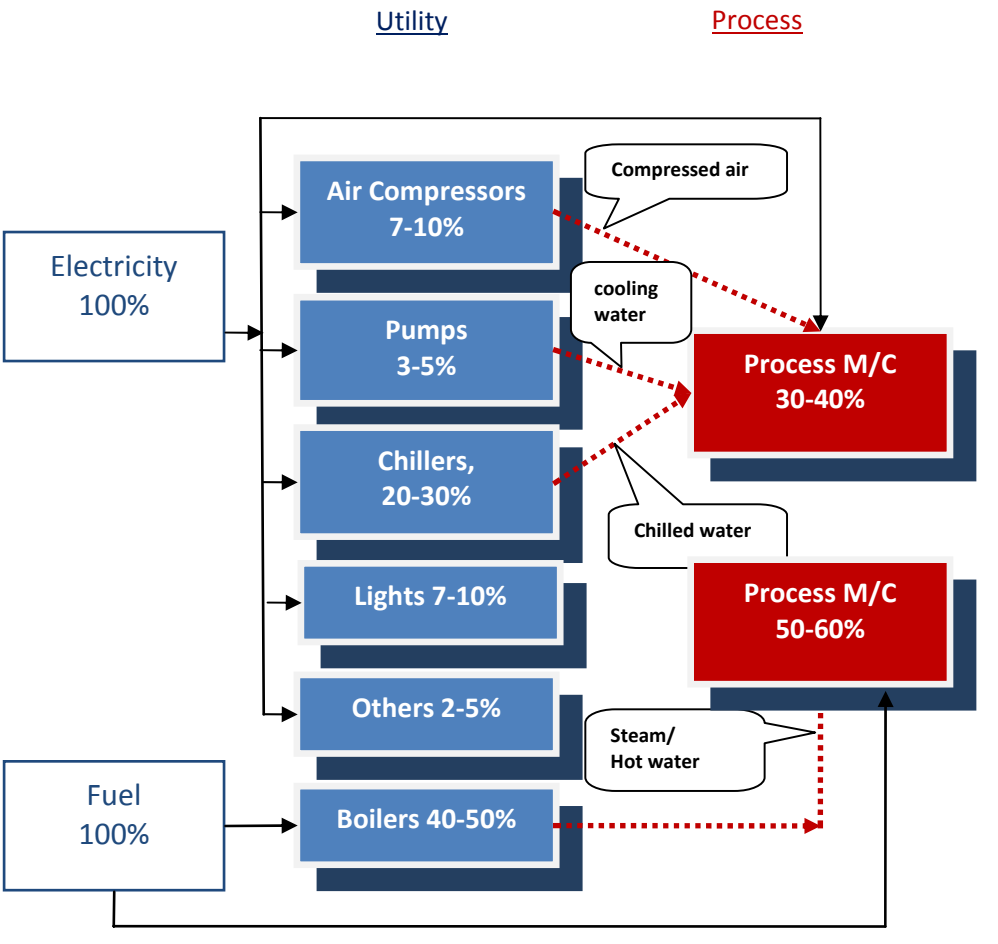


Figure 2.2 Partly Energy Purchase and Process-Utility in Factory

2.2 Type of energy use at industrial sector

Energy use among usual industries can be explained in Figure 2.3 :



Source : Energetics Pty, Energy Audit Expert Review, Australia

Figure 2.3 Diagram of energy use by industries

From the diagram above, these are major equipment for utilities and processing.

- Air Compressors

  The machine needs electricity and power source to drive manufacturing system in a form of compressed air and valve controller. It is also used for blow drying moist of the products.

- **Pumps**
  Electricity is the power source of the equipment to drive liquid (e.g.water) for cooling, cleaning, mixing etc. in manufacturing process.
- **Chillers**
  Electricity is the power source of the equipment producing cool water for manufacturing machine and/or air conditioning process.
- **Lighting**
  The equipment also needs electricity power to provide sufficient lighting in the working space.
- **Boilers**
  The machine uses electricity and fuel power for steam/hot water production for heat transfering to the machine in the manufacturing process.

2.3 Energy Saving Potentials

An example of Energy conservation measure categorized into type of industries is show in Table 2.1

Table 2.1 Energy saving potentials based on type of industries

General industries	**Estimated energy saving (%)**
Using high-efficiency motor	2 - 5%
Variable Speed Drive adjustment (VSD)**	30 - 50%
Boiler Economizer Measure*	1 - 5%
Waste heat recovery of air compressor)	80%
High-efficiency air compressors **	5 - 20%
High-efficiency boilers	10 - 15%
Insulation	20 - 30%
Food/steel/paper/non-metal industries	**Projected energy saving (%)**
Usings Heat Exchanger/Regenerator/ Recuperator/Recuperative Burner/Regenerative Burner/Waste Heat Boiler**	10 - 50%
Installation of cogeneration system**	30 - 40%

Source: Energetics Pty, Energy Audit Expert Review, Australia

Note: *Estimated energy saving (%) compared to previous energy consumption of the system/equipment prior to improvement.

**Details and explanation of measures and case studies are in appendices

2.4 Case study on energy saving project

This following energy-saving case study showcases different options for energy-saving project operations based on technology, effectiveness and price per unit. Financial factors such as investment, cost saving and breaking even as well as single or multi-investment projects will be taken into account as shown below:

Boiler (Figure 2.4)

Figure 2.4 Boiler

Input energy : Fuel (for burning), Electricity (for motor and controlling equipment)
Outputs : Steam, hot water (via heat exchanger)
Energy loss : Flue gas 15-20%, Water Blowdown 2-5%, Surface temperature 1-2%

Consideration of technical factors relating to energy saving measure

- Amount of steam use and steadiness of steam use
- Temperature and amount of flue gas
- Efficiency of boiler
- Period of boiler usage
- Others

An example of the potential and cost of improvement technology for boiler is shown in Table 2.2

Table 2.2 Example of potential and cost of improvement technology

Technology	Size (kg/hr)	Efficiency (%)	Estimated Cost	Unit	Remarks
Economizer[3)]	3,000	+4%	89	B/kg/hr	
Waste Heat Recovery Boiler[4)]	3,000	91%	1,753	B/kg/hr	Boiler eff = 80% Overall eff = 91%
High Eff.Boiler[5)]	3,000	94%	865	B/kg/hr	

Source : Economizer by USDOE (Energy Tips), Waste Heat Recovery Boiler by Switch Asia Program, High Eff. Boiler by MIT

Note: 1. Efficiency/unit referred in the table is based on some producers and only used as an example.
2. Estimated cost is investment in the project of steam production per unit.
3. Economizer is heat exchange equipment used for boiling water to use and for energy saving.
4. Waste Heat Recovery Boiler is the machine used for recycling heat and reducing energy consumption during the steam production process.
5. High Eff. Boiler is designed based on energy-saving purposes. As a result, waste proportion is very low.

Consideration of financial factor

- Fuel cost per unit including steam purchasing and selling (if any)
- Investment in equipment including installation and relocation (if any)
- Value of unused equipment
- Maintenance cost for existing and new equipments
- Cost due to any cancellation of manufacturing process
- Others

An example of the boiler's energy saving potential is shown in Table 2.3

Table 2.3 Example of energy saving potential of boiler

ECMs	Implement	Saving	Unit	Investment	Unit	Payback	Unit
1. Install Economizer	☑ Yes	266,611.61	[B/y]	266,611.61	[B]	1	[y]
2. Waste heat recovery boiler	☐ Yes	3,506,713.99	[B/y]	5,260,070.99	[B]	1.5	[y]
3. Use High Eff. Boiler	☑ Yes	1,441,096.05	[B/y]	2,593,972.88	[B]	1.8	[y]
Total (All ECMs selected)		**฿5,214,421.65**	Baht/yr	**฿8,120,655.48**	Baht	**1.56**	Years
Total (some ECMs selected)		**฿1,707,707.66**	Baht/yr	**฿2,860,584.50**	Baht	**1.68**	Years

Source : The example of calculation using information referenced from Table 2.2

Note: Energy saving calculation and the payback period in Table 2.3 is based on NG fuel price at 0.30 Baht/MJ (1MMBtu=1,055MJ)

Air Compressor (Figure 2.5)

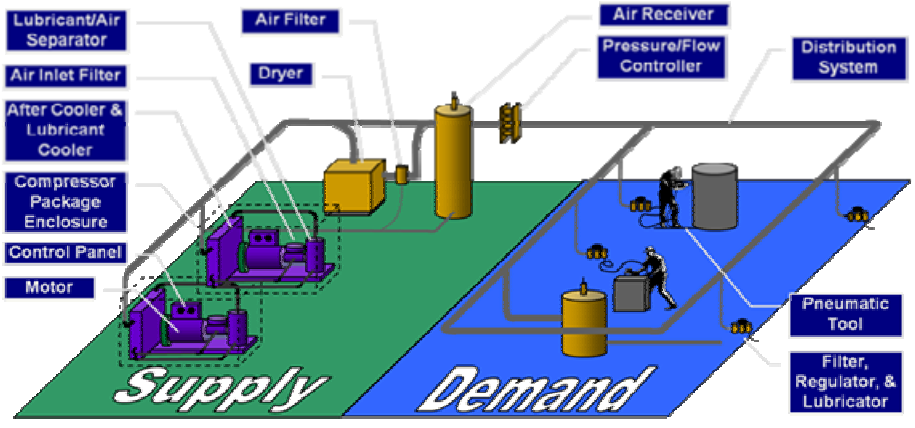


Figure 2.5 Air Compressor

Energy input : Electricity (for compressor)

Output : Compressed air

Energy loss : Heat from compressed procedure 70-80%, Loss at motor and other parts 10-15%

Consideration of technical factor relating to energy saving measure

- Type and demand for compressed air
- Pressure and leak of compressed air system
- Type of existing air compressor
- Capacity of existing air compressor
- Period of use
- Others

An example of the potential and cost of improvement technology for air compressor is shown in Table 2.4

Table 2.4 Example of potential and cost of improvement technology

Technology	Size (kW)	Performance	Estimated Cost	Unit
VSD Compressor[3)]	37	Up to - 35% less energy	40,000	B/kW
Multi-Stage Compressor[4)]	37	6 to 13% Increased eff.	20,000	B/kW
High Eff. Motors[5)]	37	2-7% higher eff. than general motors	5,000	B/kW

Source: Compressed air best practice , Sustainable Energy Authority of Ireland (SEAI) , Improving Compressed Air System Performance, Compressed air challenge, USDOE, Motor Energy Management : Opportunities & Cost Savings, www.motormatters.org, Energy Saving Potential and Opportunities for High-Efficiency Electric Motor, USDOE 2013

Note: 1. Efficiency/unit referred to in the table is based on some producers and only used as an example.
2. Estimated cost is an investment in electricity capacity per unit of the air compressor.
3. VSD Compressor is the air compressor which can adjust cycle speed of the motor in relation to workload for energy-saving purpose.
4. Multi-Stage Compressor can divide air compression in several stages. Heat will be released in between each compression stage for cooling down the temperature, leading to energy saving of the process.
5. High Eff. Boiler is designed based on energy-saving purposes. As a result, waste proportion is very low.

Consideration of financial factor

- Fuel cost per unit
- Investment in equipment including installation and relocation (if any)
- Value of unused equipment
- Maintenance cost for existing and new equipment
- Cost due to any cancellation of manufacturing process
- Others

An example of the Air compressor's energy saving potential is shown in Table 2.5

Table 2.5 Example of energy saving potential of the air compressor

ECMs	Implement	Saving	Unit	Investment	Unit	Payback	Unit	Remark
1. VSD air compressor	☑ yes	483,361.57	[B/y]	1,480,000.00	[B]	3.06	[y]	Viable for load<50%>
2. High eff. Motor*	☐ yes	14,695.05	[B/y]	185,000.00	[B]	12.59	[y]	Viable for load<75%>
3. Multi Stage compressor	☐ yes	137,398.70	[B/y]	740,000.00	[B]	5.39	[y]	Less power consumed as same amount of air produced by 1-stage
Total (All ECMs seleted)		635,455.31	Baht/yr	2,405,000.00	Baht	3.78	Years	
Total (some ECMs seleted)		483,361.57	Baht/yr	1,480,000.00	Baht	3.06	Years	

Source : The example of calculation using information referenced from Table 2.4

Note: Calculation of saving and payback per unit in the table is based on electricity price at 4 Baht/kWh and working hour at 8,760 hours/year

Cogeneration (Figure 2.6)

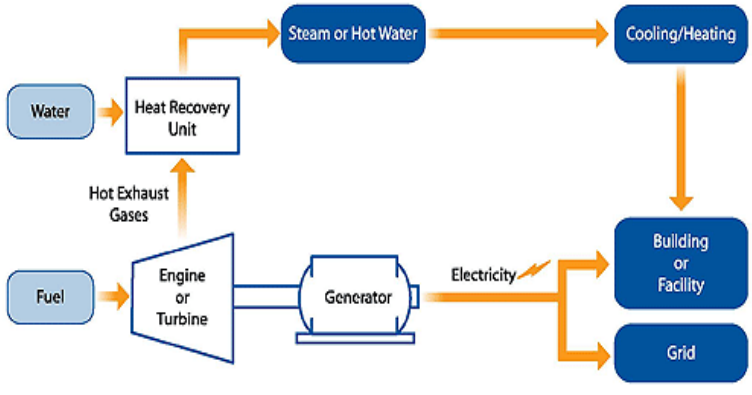


Figure 2.6 Cogeneration

Input energy : fuel (for burning)
Output : electricity, high-pressured steam
Energy loss : energy loss in the system 10-25%

Consideration of other technical factor relating to energy saving measure

- Heat to Power Ratio
- Peak demand on electricity
- Amount of equipment using waste heat from electricity generating
- Amount of cooling needed from waste heat by absorption chiller
- Others

An example of the efficiency and estimated cost of improvement technology for cogeneration is shown in Table 2.6

Table 2.6 Example of efficiency and estimated cost of improvement technology

Technology	Size (MWe)	Total eff. (%)	Estimated Cost[2)]	Unit	Remarks
Open Cycle-Gas Turbine	0.5-250	70-85%	31M-42M	B/MW	@32 Baht/USD
Combined Cycle-Gas/Steam Turbine[3)]	3-300+	90%	26M-114M	B/MW	@32 Baht/USD
Reciprocating Engine	0.01-5	70-80%	35M-70M	B/MW	@32 Baht/USD
Steam Turbine	0.5-250	80%	14M-35M	B/MW	@32 Baht/USD

Note : 1. Efficiency and per unit in the table is based on some producers and only used as a sample. (http://www.code-project.eu/wp-content/uploads/2011/04/CODE_CS_Handbook_Final.pdf, http://www.nrel.gov)

2. Estimated Cost is investment in the project per unit of electricity generation.

3. Combined Cycle Electricity = 33MWe, Steam = 52.6 t/h NG fuel cost at 26 Million Baht/MW, Combined Cycle Electricity = 110MWe, Steam = 630t/h Black Liquor fuel investment at 114 Million Baht /MWs

Factors affecting investment cost in general such as type of technology, money exchange rate for imported equipment, the availability of fuel or process heat as continuous energy input for cogeneration system running at 24 hours etc.

Consideration of Financial factor

- Purchasing and selling price of electricity and fuel cost per unit including steam buying and selling (if any)
- Cost of investment in equipment including installation
- Operation and maintenance cost
- Cost due to any cancellation of manufacturing process
- Others

An example of the cogeneration projects energy saving potential is shown in Table 2.7

Table 2.7 Example of energy saving potential of cogeneration projects

ECMs	Implement	Saving	Unit	Investment	Unit	Payback	Unit	Remark
Gas turbine + HRSG Boiler (Co-generation)	☑ Yes	8,188,288.45	[B/y]	31,000,000.00	[B]	3.79	[y]	
Gas turbine + HRSG Boiler +Absorption Chiller (Tri-generation)	☐ Yes	27,872,752.45	[B/y]	56,000,000.00	[B]	2.01	[y]	
Total (All ECMs selected)		36,061,040.90	Baht/yr	87,000,000.00	Baht	2.41	Years	
Total (some ECMs selected)		8,188,288.45	Baht/yr	31,000,000.00	Baht	3.79	Years	

Note: Energy saving calculation and the payback period in Table 2.7 is based on NG fuel price at 0.30 Baht/MJ (1MMBtu=1,055MJ)

In conclusion, it is crucial to evaluate energy saving potential from not only technology/new equipment for project improvement but also energy use of existing technology according to this following model:

Energy Saving = Baseline – Post Installation

Controlled Variables are

- Hours of machinery/equipment use prior to and after improvement
- Working load (%) of machinery/equipment prior to and after improvement
- Fuel cost per unit

2.5 Life Cycle Cost Analysis

In some case, only assessment of energy saving may not be sufficient for overall project outlook. Life-cycle cost analysis (LCCA) will come in handy for analyzing cost effectiveness of the investment throughout life cycle of the project.

LCCA is an economic tool for considering cost during the beginning period of the project, working process, maintenance and dissolving in a bid to determine options for operating the project. Cost may vary depending on different processes. The key is the long-term plan to ensure the highest cost effectiveness and lowest cost.

Life-Cycle Cost (LCC) will be used for determining energy efficiency index of the facility. LCC is an economic index used for assessing suitability of the project including capital cost, operational cost, fuel cost, maintenance, and scrap from the system. Cost throughout the process will be analyzed and changed into present value depending on variations of resale and scrap value, fuel, water and maintenance cost in according to the following model:

$$LCC = I_0 + Repl - Res + E + W + OM\&R + O$$

LCC	=	Total Life Cycle Cost in Present Value of given alternative
I_0	=	Initial Investment Cost
Repl	=	Present Value capital replacement cost
Res	=	Present Value residual (resale value, scrap value, salvage value) less disposal costs
E	=	Present Value Energy Cost
W	=	Present Value Water Cost
OM&R	=	Present Value non-fuel operating, maintenance, and repair costs
O	=	Present Value of Other costs (e.g. contract costs)

Calculation Example: LCC- Base Case : Conventional Design

Cost effectiveness of project investment is based on two conditions-usual condition with constant air volume (CAV) and non-heat control and utilization design and alternative option of constant air volume with night-time setback and economizer mode. The condition with lower LCC will be considered for investment.

Source : Life Cycle Costing Manual, USDOE

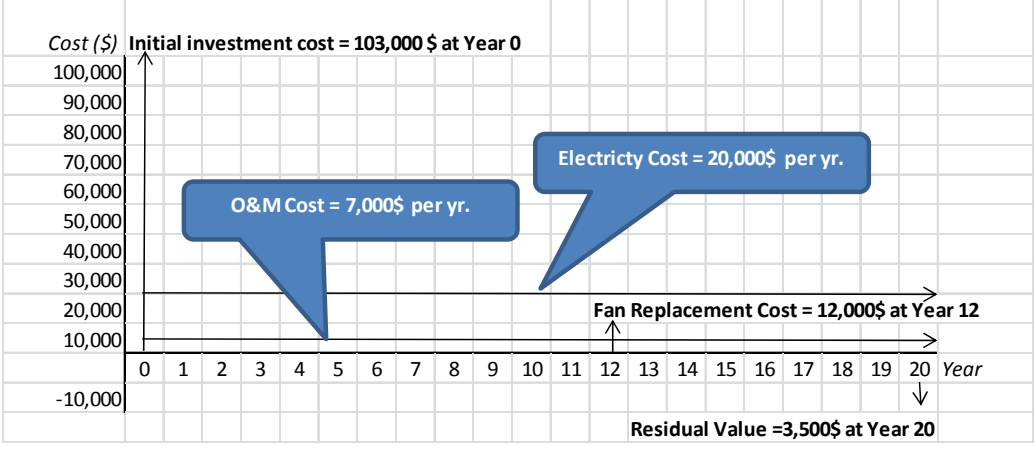
Information overview:

Location	Washington, DC; DOE Region 3
Discount Rate	3%
Fuel cost	Electricity $0.08/kWh
Equipment life cycle	20 years

Cash flow can be calculated based on the information above as follow:

- Initial investment cost ; Lump sum cost = $103,000
- Cost of changing fan at the end of the 12th year = $12,000
- Scrap and salvage value at the 20th year = $3,500
- Fuel cost per year = $20,000 (250,000 kWh at $0.08/kWh)
- Annual maintenance cost = $7,000

Cash Flow Projection model can be shown in Figure 2.7



Source : Life Cycle Costing Manual, USDOE

Figure 2.7 Cash Flow Diagram for Conventional HVAC Design

Present value also have to be calculated to evaluate cost at different period as shown in Table 2.8

Table 2.8 Present Value Calculations Conventional HVAC Design

		Discount rate (r) =	**3%**	
Cost ($)	Value (1)	Discount Factor = $1/(1+r)^n$ (2)	Present Value (1)x(2)	Remark
Initial investment	103,000	1.000	103,000	n= 0 (year 0)
Fan replacement	12,000	0.701	8,412	n=12 (year12)
Electricity	20,000	14.875	297,500	n=1-20 (year1-20)
O&M	7,000	14.875	104,125	n=1-20 (year1-20)
Total Cash out-Flow			**513,037**	
Residual value	3,500	0.554	1,939	n=20 (year20)
Total Cash in-Flow			**1,939**	
Total Life Cycle Cost			**511,098**	

(Total Cash out- Total Cash in)

Source : Life Cycle Costing Manual, USDOE

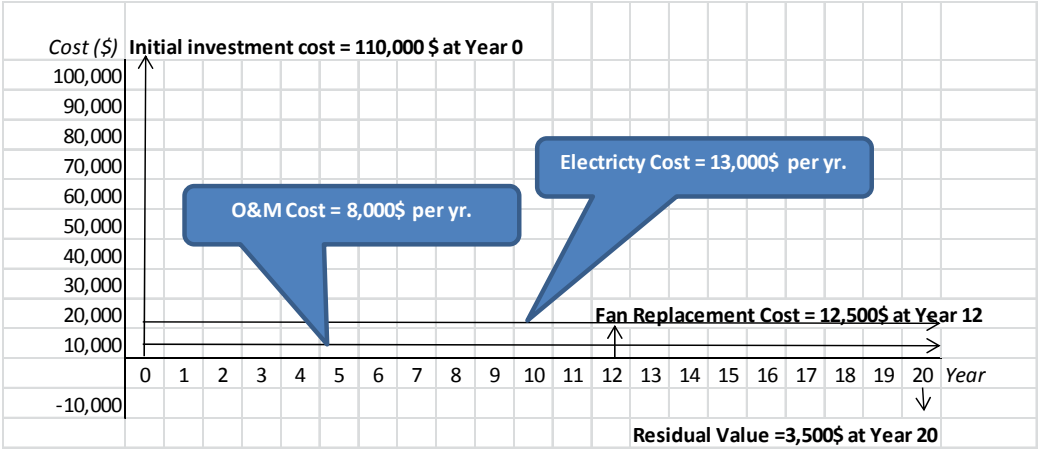
Conclusion Base Case: Conventional HVAC Design with Life-Cycle Cost (LCC) = **$511,098** throughout the life cycle of 20th year.

Calculation Example: LCC- Alternative Case : Energy Saving Design

According to energy-saving HVAC designed with night time set-back for heating and air-conditioning and economizer cycle, cash flow model can be displayed as follow:

- Initial investment cost ; Lump sum cost = $110,000
- Cost of changing fan at the end of the 12th year = $12,500
- Scrap and salvage value at the 20th year = $3,700
- Fuel cost per year = $13,000 (162,500 kWh ที่ $0.08/kWh
- Annual maintenance cost= $ 8,000

Cash Flow Projection can be displayed in Figure 2.8



Source : Life Cycle Costing Manual, USDOE

Figure 2.8 Cash Flow Diagram: Energy Saving HVAC Design

Present value also has to be calculated to evaluate cost at different period as shown in Table 2.9

Table 2.9 Present Value Calculation for Energy Saving HVAC Design

		Discount rate (r) =	**3%**	
Cost ($)	Value (1)	Discount Factor = $1/(1+r)^n$ (2)	Present Value (1)x(2)	Remark
Initial investment	110,000	1.000	110,000	n= 0 (year 0)
Fan replacement	12,500	0.701	8,763	n=12 (year12)
Electricity	13,000	14.875	193,375	n=1-20 (year1-20)
O&M	8,000	14.875	119,000	n=1-20 (year1-20)
Total Cash out-Flow			**431,138**	
Residual value	3,700	0.554	2,050	n=20 (year20)
Total Cash in-Flow			**2,050**	
Total Life Cycle Cost			**429,088**	

(Total Cash out- Total Cash in)

Source : Life Cycle Costing Manual, USDOE

Conclusion Base Case : Conventional HVAC Design with Life-Cycle Cost (LCC) = **$429,088** throughout the life cycle of 20th year.

Hence, comparasion of Life-Cycle Cost between using the general air conditioning system and the energy-saving one can be illustrated in Table 2.10

Table 2.10 LCC Selection

Ranking	Alternative Analyzed	Present Value (PV)				
		Initial	Energy	O&M	Other	Total LCC
2	Conventional HVAC Design	103,000	297,500	104,125	6,473	511,098
1	Energy Saving HVAC Design	110,000	193,375	119,000	6,713	429,088

The Lower LCC (Energy Saving HVAC Design) is selected with net saving = 511,098 - 429,088 = 82,010$ in 20 years.

Conclusion: Decision is made by using Energy Saving HVAC Design operation mode which has lower LCC. Net savings = $82,010 ($511,098 - $429,088) at present value when calculating based on 3% discount rate.

Chapter 3

Energy Efficiency Project Financing

This chapter focuses on finanial mechanism available for business operators to restore buildings, enhance machinery capacity for industrial energy efficiency (IEE). There are two financial sources: the government and the financial institutions.

3.1 Government sector

Since 2002, different projects have been undertaken to reach out to industrial, real estate and household sectors in a bid to achieve the energy-saving goal set by the Department of Alternative Energy Development and Efficiency, Ministry of Energy via the Energy Efficiency funding program. There are two mechanisms: the government and the financial institution, helping run the energy-efficiency project (EE). Since financial insitutions understand more in details about the EE project, the government therefore downplays its role in funding administration. At present only ESCO Program and ESCO Revolivng Fund are still managed by the government. Here are the details:

1) ESCO PROGRAM

Initiated by the government, the ESCO program is aimed at helping administrative expenses among the ESCO networks in a bid to stimulate a number of ESCO services, and build trust among commercial banks on ESCOs, leading to better technical risk assistance. There are five commercial banks participating into the program. The brief detail of ESCO Program is shown in Table 3.1

Table 3.1 ESCO Program

Objective	To support ESCO financial mechanism, quality and standard. • To encourage efficiency of ESCO mechanism • To expand number of ESCO services • To develop ESCO service to meet international standard
Activities	Create a network between banks and energy-saving companies (ESCO – Bank Networking via 3-4 joint seminars/year in order to create awareness of coordination and work flow leading to proper ESCO fund management.
Duration	Year 2008 - present
Project Supervision	The Institute of Industrial Energy under Federation of Thai Industries (FTI)
Target	Industrial Factories and/or Energy Service Company – ESCO
Total Budget	Estimated 35 Million Baht
Source of Funding	ENCON Fund via the Department of Alternative Energy Development and Efficiency, Ministry of Energy
Co-partner banks	1. Krung Thai Bank 2. Kasikorn Bank 3. Thai Military Bank 4. CIMB Thai Bank 5. Thanachat Bank
Result of the project	As of 2013, ESCO has made Guaranteed Savings Contracts (GSC) with value of 7.60 billion THB. Of the total, 6.81 billion THB investment is in the industries and 77.71 million THB in building constructions.

Source: Department of Alternative Energy Development and Efficiency, Ministry of Energy, 2014

As on January 2015, there were 57 ESCOs registered with the Institute of Industrial Energy. Of the total, 75% of the project is still ongoing. ESCO services can be categorized into two methods.

1. Guaranteed Saving

The guaranteed saving will be provided to entrepreneurs investing in the project on their own. If the saving does not reach the specified guarantee, ESCO will compensate for the deficiency.

2. Shared Saving

The ESCO makes an equity investment through the shared saving agreement between the ESCO and the project owner in energy efficiency or renewable energy projects.

2) ESCO REVOLVING FUND

The project is aimed to support entrepreneurs having viable energy efficiency projects but lacking funds. Methods of assistance can be undertaken directly and indirectly via equity investment, ESCO venture capital, equipment leasing and funding support on audit and feasibility study to buid trust in ESCOs. The detail of ESCO revolving fund is shown in Table 3.2

Table 3.2 ESCO Revolving Fund

Objective	To promote investment in energy conservation and energy efficiency projects via ESCO mechanism.
Duration of the project	2008 – present
Project supervision	Department of Alternative Development and Efficiency (DEDE)
Operational agencies	1. Energy for Environment Foundation (EforE) 2. The Energy Conservation Foundation of Thailand (ECFT)
Type of services	• Equity Investment • ESCO Venture Capital • Equipment Leasing • Credit Guarantee Facility • Energy Audit or Feasibility Study
Source of Fund	Energy Conservation Promotion Fund (ENCON Fund)
Targets	Energy Efficiency Projects under the Section 7 and Section 17 of Energy Conservation Promotion Act B.E. 2535 (1992) aimed

	to promote energy conservation in the country.
Credit Limit	500 Million Baht/year

Details of the ESCO Revolving Fund can be summarized in the Table 3.3

Table 3.3 Type of Services

Type of Services	Equity Investment	ESCO Venture Capital	Leasing	Credit Guarantee for Financial Institutions	Financial Support on Energy Audit Feasibility Study
Proportion of co-investment	10-50%	Less 30%	100%		
Maximum credit	50 million THB	50 million THB	10 million THB	10 million THB	100,000 THB
Major share holder	No	No			
Duration	5-7 Years	5-7 Years	5-7 Years		
Interest Rate	4% Flat	4% Flat	4% Flat		
Budget Administration	Administrative Board	Not specified			
Repayment	Stock selling	Stock selling			
Stock price	Following terms of agreement	Following terms of agreement			

The weakness of this financial scheme is that interest flat rate is still high compared to the effective rate.

It is worth noting that interest rate of ESCO Revolving Fund will be calculated on a flat rate basis at 4% per year, which is equal to the effective rate at 7-8% per years.

3.2 Commercial banks

Here are details of financial products available for energy efficiency project.

- Most commercial banks do not have financial products specifically designed for energy efficiency projects. Some banks offer credit for operators looking for opportunities to invest in energy efficiency project and building construction. Some banks also offer financial products for both energy efficiency (EE) and renewable energy (RE) projects.
- Different commercial banks offer different energy efficiency credits and services for various target groups. Scale of business and its turnover will depict the amount of credit limit.
- Features of energy loan products i.e. repayment period, interest rate, fee amount and guaranteed services are distinct and different from each other.
- Individual banks will come up with their own terms of requirement for credit approval. Details in the terms of requirement are usually designed for general business investment, not specifically for energy efficiency project.
- No ESCO-certified requirement for most energy loan credits offered by most commercial banks.
- Most banks are willing to provide financial support to their old clients seeking funds for investing in energy efficiency projects.
- Due to limitation in raising deposits, interest rate of government banks is higher than commercial banks. However, most entrepreneurs, particularly those facing financial instability, lack access to credits offered by commercial banks and that they are willing to absorb the higher interest rate required by government banks.
- Some banks prioritize credits for ESCO service and adopt it as a mechanism to ensure technical risk. However, entrepreneurs are not allowed ESCOs to use their report as a guarantee for credit approval.
- Some banks will consider ESCO credibility and profiles involving energy efficiency projects prior to credit approval on case by case basis while some banks will have a list of ESCOs evaluated and approved for loan programs and technical assistance.
- Some banks prioritize credits for equipment suppliers and come up with a list of equipment suppliers approved for loan programs and technical assistance similar to ESCOs.

- Most banks want to list ESCOs, which are credible for credit approval, but do not want to negotiation or get involved in hiring system between entrepreneurs and ESCOs.

1) K-Bank

Details of energy-saving funds are in Table 3.4 and Table 3.5

Table 3.4 K-Energy Saving Guarantee Program

Name of Product	สินเชื่อรับประกันการประหยัดพลังงานกสิกรไทย (Thai) K-Energy Saving Guarantee Program (English)
Objectives	• To assist business operators to reduce energy use and save energy and prduction cost. • To enhance long-term market competitiveness to the industries. • To encourage business operators to integrate energy efficiency as part of their Corporate Social Responsibility.
Key Features	Credit provided to Energy Service Company (ESCO), which certifies energy-saving performance of the energy project according to the Memorandum of Understanding (MoU) on "Energy Conservation Promotion by ESCO System Project" between the bank and the Institute of Industrial Energy, the Federation of Thai Industries.
Started Year	2011
Target Group	Medium size entrepreneur with more than 50 million THB of the annual sale turnover
Type of Credit	Long-term commercial credit and K-Equipment Leasing
Credit Limit	100% of project investment (including ESCO service and consultation fee). No credit limit.
Repayment	Subject to K-Bank's rules and regulations

Interest Rate	Subject to K-Bank's rules and regulations
Fee	Subject to K-Bank's rules and regulations
Credit Guarantee	Subject to K-Bank's rules and regulations
Conditions	ESCO report on enegy-saving performance is required.
Total of credit	5 billion THB
Credit Criteria	Business Credit Criteria
Energy-saving Company (ESCO)	Qualifications of ESCOs must meet K-Bank requirements of the total 50 ESCOs, 10 are qualified.
Target Group	Medium size entrepreneur with more than 50 million THB of the annual sale turnover
Project status	Ongoing

Table 3.5 K-Top Up Loan for Energy Saving : Lighting Solution

Name of Product	โปรแกรมสินเชื่อประหยัดไฟกสิกรไทย (Thai) K-Top Up Credit for Energy Saving : Lighting Solution (English)
Objective	To assist business operators in reducing energy by replacing lighting system to the energy-saving one.
Advantage	The credit can be approved within 2 business days
Started Year	2013
Target Group	The project with the energy use of 12 hours/day or more
Credit Type	Long-term credit
Credit Conditions	Not more than 3 million THB covering a total project investment, equipment, consultation fee and ESCO operational cost.
Debt repayment period	3 years
Interest Rate	Subject to K-Bank's rules and regulations
Fee	Subject to K-Bank's rules and regulations
Credit Guarantee	N/A for present customers
Current Status	Existing
Conditions	The product warrantee provided by the supplier and/or a performance report by ESCO is required.
Total Credit Line	500 million THB
Credit Criteria	Subject to K-Bank's rules and regulations
ESCO & Supplier	ESCO and supplier must pass the selection criteria established by the bank.
Project status	Ongoing

2) Bangkok Bank

Details of Bangkok Bank's energy-loan is in Table 3.6

Table 3.6 Bualuang Green Loan

Name of Product	สินเชื่อบัวหลวงกรีน (Thai) Bualuang Green (English)
Objective	To support business operators to invest in energy efficiency projects, enhance energy use management, and produce environmental-friendly products
Key Features	No credit limit
Started Year	2008
Target Group	All business operators
Credit Type	Long -term credit
Credit Line	More than 1 million THB
Debt repayment duration	Depending on feasibility of each project
Interest Rate	Special interest rate, MLR/ year or lower
Fee	No administration fee, 0.25% of total credit approval, Other fees are subject to the bank regulations.
Credit Guarantee	Subject to rules and regulations of the bank
Total of credit	10 billion THB
Credit Criteria	Subject to rules and regulations of the bank
Project Status	Ongoing

3) Krung Thai Bank

Details of Krung Thai Bank's energy-loan is in Table 3.7

Table 3.7 KTB Green Loan

Name of Product	สินเชื่อกรุงไทยประหยัดพลังงาน (Thai) KTB Green Loan (English)
Objective	To support business operators to invest in energy efficiency project using renewable and clean energy for their own consumption or sell to grid.
Key Features	The repayment period is flexible
Started Year	2010
Target Group	Medium size entrepreneurs
Credit Type	Long -term credit and working capital
Credit Line	20 million THB onward per application
Debt repayment duration	Term Loan (T/L) with the period of not exceeding 10 years Grace period is deemed necessary based on borrower' s cash flow estimation
Interest Rate	MLR up to MLR + 0.5 depending on the sale volume
Fee	Fee from 0.75% - 1.5%.
Credit Guarantee	Subject to rules and regulations of the bank
Total of credit	15,000 million THB
Credit Criteria	Subject to rules and regulations of the bank
Project status	Ongoing

4) CIMB Thai Bank

Details of CIMB Thai Bank's energy-loan is in Table 3.8

Table 3.8 Clean Energy Loan

Name of Product	**สินเชื่อพลังงานสะอาด** (Thai) Clean Energy Loan (English)
Objective	To support business operators on energy efficiency projects including energy lost protection, utilization of waste heat and renewable energy, improving electricity systems by using power factor, peak demand reduction, load adjustment, high efficiency equipment as well as high-efficiency equipment.
Started Year	2014
Target group	Business operators in industrial and real estate sectors
Credit Type	Long Term Loan (LTL)
Credit Limit	Not more than 50 million THB covering all expenses i.e. industrial equipment, installation, consultation fee for design, control, ESCO saving guarantee, transportation, demolition cost, import tax and VAT.
Debt repayment period	7 years
Interest Rate	Subject to the bank's rules and regulations
Bank Fee	Subject to the bank's rules and regulations
Project status	Ongoing

Chapter 4
Understanding Loan System of Thai Bank

4.1 Commercial Bank and Specialized Financial Institutions

All 16 commercial banks, and four state-owned banks in Thailand are equipped with financial capacity to provide financial loan program for energy efficiency projects. Details and conditions of credit approval however may vary according to the Table 4.1

Table 4.1 Assets and credits of individual banks in Thailand

Bank		Assets	Credit	% Share	
1	BBL	2,502,750	1,615,612	14.25%	55.75%
2	Kbank	2,092,060	1,380,089	12.18%	
3	KTB	2,502,231	1,654,527	14.60%	
4	SCB	2,383,608	1,669,018	14.72%	
5	TCAP	992,290	728,985	6.43%	17.63%
6	BAY	1,074,348	801,552	7.07%	
7	TMB	765,345	467,357	4.12%	
8	CIMB	278,362	163,751	1.44%	10.66%
9	UOB	408,027	248,001	2.19%	
10	TISCO	342,030	275,052	2.43%	
11	KK	234,295	184,720	1.63%	
12	TCR	25,912	19,499	0.17%	
13	LH BANK	148,719	102,215	0.90%	
14	ICBC	148,128	102,730	0.91%	
15	CHARTER	254,833	99,420	0.88%	
16	MEGA	17,549	13,423	0.12%	
17	SMES	88,303	93,814	0.98%	15.96%
18	EXIM	75,716	67,527	0.71%	
19	GSB	2,174,959	1,539,385	16.16%	
20	IBANK	116,421	108,257	1.14%	

4.2 Credit Approval Process

The process can be summarized as follow:

4.2.1 Pre-Credit Approval Process

The pre-credit underwriting process consists of two sub-categories: setting direction for credit support and product development procedure.

1) Direction of credit support

The unit responsible for setting direction of credit is usually available at most banks. In spite of having different names, such unit is usually attached to the risk management section of the bank. Its main responsibilities include:

- **Business Research**

To evaluate business trend for credit consideration and indicate INDEX for measuring opportunities and threats of different businesses.

- **Portfolio Management**

To analyze the current credit portfolio in terms of business area, type of business, income, credit limit, and financial loss, etc.

- **Credit Policy**

To set a target and a framework and priority of each loan program that the bank would like to promote based on the result of business research and portfolio analysis. It is interesting to learn that specific policy on industrial energy efficiency loan program are not available at most banks.

- **Credit Standardization**

Financial data of bank's customers will be analyzed to indicate benchmark of financial ratio. The result will be used as a framework for credit consideration.

2) Product Development

Most banks are usually equipped with a unit working on loan program development. Bank staff working with this unit will have to study market needs together with loan programs promoted by competitors in a bid to identify and differentiate its target groups and loan programs from the competitors. This unit will work closely with customer relations department, credit policymaking and standardization agencies and credit and risk management agencies.

4.2.2 Credit Approval Process

The credit approval process can be categorized into the following steps:

1) Credit Marketing

Customer Relations Unit hold major responsibility of credit marketing by encouraging customers to use the services, coordinating with related parties to seek information details essential for credit approval consideration. At the beginning, the staff in this unit will work with internal team to forward each submitted project to the loan approval panel for consideration. Other tasks include explaining conditions of each loan programs for customers, coordinating with legal department and credit guarantee, monitoring and evaluating debt repayment of each customer. Customer relations department of some banks also has a role in preparing financial projection. Hence customer relations department is considered the most crucial mechanism of the credit approval process.

Based on assets, credit line and/or annual income, customers can be categorized in three groups: wholesale, SMEs and retail. The wholesale group is also further sub-categorized into different business types whereas the SMEs Group is divided into areas similar to the retail group.

Most banks are usually equipped with the so-called business centers for providing services specifically for SMEs entrepreneurs in different ares. Most bank branches will be working as a coordinator sending any credit application and related queries to the business center for consideration. Some business centers can file the credit application directly to the credit approval board for consideration. However some business centers will have to forward the credit application to the customer relations department for consideration first.

2) Credit Analyst or Underwriter

Most banks will separate the financial analysis unit from the customer relations unit to effectively perform “Check and Balance” of the credit consideration. How the two units work can be summarized as follow:

1. Working together during the credit evaluation process.
2. Working separately. The customer relations officer work on preliminary credit evaluation and forward to finance analyst for further evaluation.

Credit analysts are usually working at the headquarter and/or business centers. The consideration should be finanlized within 1 - 1.5 month-timeframe. However insufficient details needed for credit approval may cause a delay in reality.

3) Credit Evaluation

Apart from cross checking between the customer relations officer and the credit analyst working on the credit approval, the Credit Evaluation Section is also set as the third check on credit approval criteria and other related conditions before finalizing credit approval.

4) Credit Approval

The task of credit approval, especially for consumption loan, will be decentralized to bank outlets at different areas. However loan programs for SMEs are still handled by several committees including the credit committee, the management committee and the bank committee at the head office to consider suitability of the proposed project and credit limit before making the final approval.

4.3 Credit Underwriting Practice

The so-called "The 5 C's of Credit" criteria for considering feasibility of credit approval for the industrial energy efficiency (IEE) projects has been implemented by banks worldwide for more than 50 years. The criteria is usually set on five factors of repayment ability: character, capital, capacity, credit guarantee and condition.

Character refers to characteristics of each money borrower, business experience, business capacity and financial reputation. Capital reflects balanced investment potential and debt proportion. A suitable debt service ratio will reflect the borrower's repayment capacity and its contribution to the project. Capacity helps measure the money borrower's repayment capacity by comparing its income to the recurring debt. Capacity may also be considered from production capacity, income, cost and expenses and management. credit guarantee such as property and assets helps secure the creditor's compensation to the bank in case of repayment failure. Condition of the surrounding may also influence product efficiency, income, production cost, operational expenses and other related economic, social and political factors.

However most banks will consider credit approval of industrial energy efficiency projects similar to other industries mainly because of 1) inability to differentiate energy-saving cash flow from the business operation cash flow and 2) low credit guarantee that banks providing loan program for industrial energy efficiency projects are entitled compared to general loan programs.

There are some banks administrating project finance and providing loan program for industrial energy efficiency projects and under the condition that the Thai Credit Guarantee Corporation will provide full credit guarantee (not more than five million THB) or under the condition that the client has a good debt repayment record, and its credit limit is not higher than its previous credit submission.

4.4 Credit Underwriting Tools

Banking companies use both qualitative and quantitative tools for analyzing and evaluating the 5C's put in practice by individual clients. See the summary of credit analysis tools and credit underwriting factors in Table 4.2

Table 4.2 Tool for Credit Analysis

Factor	Credit Rating	Expert System	Financial Projection	Assets Appraisal	Business Research
Character	✓	✓			
Capacity		✓	✓		
Capital		✓			
Collateral		✓		✓	
Condition		✓			✓

1) Credit Rating

A quantitative tool for evaluating potential of the credit borrower. Factors for consideration include marketing, production, management, business trends and most importantly financial statement. For Small and Medium Enterprises (SMEs), credit rating result may be used as a screening base in case of difficulties in finding credible financial record. Other banks also use the credit rating result to consider the rating and set the interest rate.

2) Expert System

The most important qualitative evaluation tool for considering credit for SMEs. The relevant financial officers must be equipped with expertise because of these following reasons:

- Credit evaluation is not directly related to financial statement but requires financial analyst expertise on financial statement evaluation.
- Some criteria may be a qualitative evaluation. Therefore skills and experiences of the financial analyst to evaluate the credit proposal are crucial.
- There is no tailor-made financial evaluation for the credit consideration due to numerous types of businesses undertaken by the credit borrowers.
- The tool which requires skills and expertise will be useful for evaluating credibility of financial statement among the SMEs.

3) Financial Projection

It is also another important tool for determining debt repayment capacity and financial ratio. The core of this method essentially depends on information and hypothesis inputs. However, financial projection still has some loopholes mainly due to insufficient information provided by the project owners. Financial projection plans are usually prepared based on judgment of the financial analyst. Some banks also use Microsoft Excel as a working software but still not fully effective. Financial projection may be performed the analyst. In some cases, cash flow estimation is just enough for the credit consideration. Preparation of cash flow estimation, balance sheet and profit and loss statement may provide better financial overview but take longer time to do than financial projection.

4) Assets Appraisal

A process aimed at evaluating the value of assets such as land property, building and machineries that have been used as credit guarantee. The assets may be appraised by internal units or third party, depending on the value.

5) Business Research

The tool is used for identifying the current situation or the conditions of the business operators if it is a good time for them to extend or improve their businesses.

4.5 Credit Underwriting Criteria

Commercial banks will consider the Ability-to-Repay (ATR) as the first criteria for credit approval based on free cash flow during the projected period. The Ability-to-Repay depends on business operation and management, resource efficiency, profitability, liquidity and debt level as illustrated in the chart below:

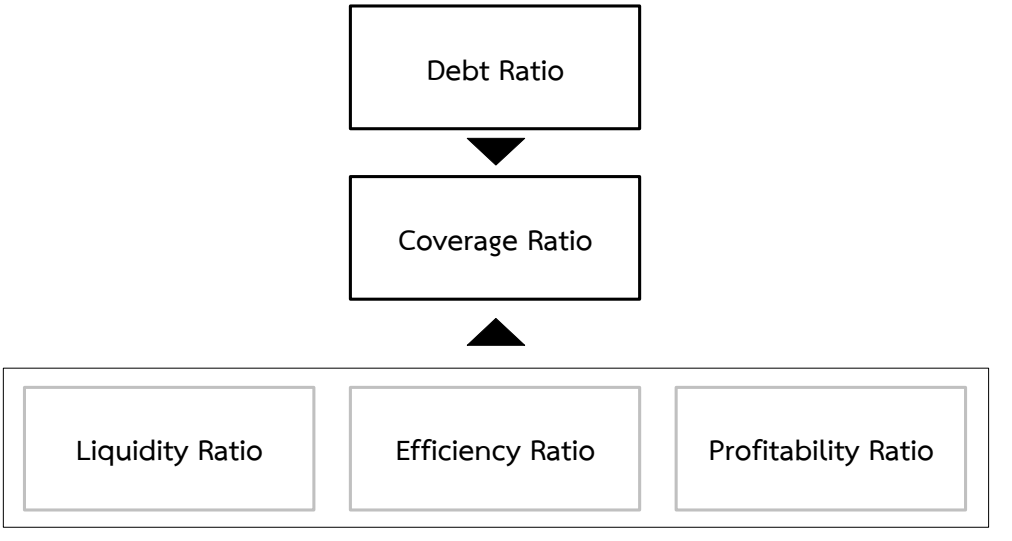


Figure 4.1 Factors Affecting the Ability to Repay (ATR)

Consideration of the ratio that indicates ATR is based on 1) Debt Service Coverage Ratio (DSCR), defined as payment capacity of both installment and interests when looking at cash flow, and 2) Simple Payback Period. The banks will also consider debt ratio which indirectly indicates debt repayment capacity based on: 1) Debt to Equity Ratio and 2) Loan to Value. These ratios could not be specified. Consideration is on case by case basis.

Other ratios such as the profitability ratio, efficiency ratio and liquidity ratio, normally defined as the basic financial ratio, are considered as less significant factor. Net Present Value (NPV) and Internal Rate of Return (IRR) will not be used for direct consideration of repayment capacity.

Table 4.3 Criteria and financial Ratio

Criteria	Financial Ratio	Priority			Proper Range
		1	2	3	
Ability to Repay	Debt Service Coverage Ratio	✓			1.2-1.5
	Interest Coverage Ratio		✓		
	Payback Period	✓			3-10
Debt burden	Debt to Equity	✓			1.5:1 - 2:1
	Loan to Value	✓			80-100%
	Debt to Income		✓		
Business growth and profitability	Growth rate		✓		
	Gross Profit Margin		✓		
	EBITDA		✓		
	Net Profit margin		✓		
Liquidity	Current Ratio		✓		
	Quick Ratio		✓		
Efficiency	Assets Turnover		✓		1
	Stock Turnover		✓		
	A/R & A/P Turnover		✓		
Financial Worthiness	Internal Rate of Return			✓	10%
	Net Present Value			✓	0
	Modified Internal rate of Return			✓	

Additional credit underwriting criteria that should be noted are:

1. Some banks work progressively with 100% of Loan to Value for IEE projects. The borrower therefore can get a full coverage of the investment. Some banks consider the Loan to Value to be less than 100%. The borrower will have to be responsible for its own investment.

2. Collateral or credit guarantee for IEE projects are usually required except the bank with proactive operation providing small loan programs to small IEE projects without further collateral or credit guarantee. Such special credit will only provide to existing customers with low credit line.

3. Normally, when the bank takes the credit underwriting consideration for IEE projects, flexibility of debt repayment will relate to the business cash flow. However, there is an exception for some banks where long-term policy on account management is not available. However fixed payment term for less than 7 years will be set instead unlike fixed-loan repayment period required for specific loan programs.

4. Some banks will use technical ratio for screening feasibility of each project prior to its debt repayment capacity i.e. a minimum of 20% energy saving rate.

5. For regular customers with the good record of debt repayment, most banks are ready to provide IEE loan with a low refusal rate.

6. Regarding the Credit Underwriting consideration, the bank will closely evaluate risks that may affect the payment. Bank staff usually perform market and financial risk assessment without any problems. However, the sub-contractor is usually outsourced to conduct technical risk assessment.

7. The bank will give priority to figures and assumption used for financial projection. Involving items include electricity unit saved, energy price forecast, change in production cost per unit including maintenance, and change in management cost i.e. wages for technical staff.

Chapter 5
Business Information for Bank Assessment

When asking for loan program support, business operators will usually have to submit the bank either financial plan, business plan or feasibility study. Some may have to go through personal interview for providing details essential for considering credit approval. Business plan is the most common document each entrepreneur will have to prepare for explaining business background, current performance and future project.

However from a survey on financial proposal and projection among related parties, most banks prefer feasibility study to others due to its concise, straightforward and tangible information useful for considering credit approval.

Table 5.1 Financial Proposal and Projection

Proposal Format	Accuracy	Reliability	Thoroughness	Necessity
Financial Plan	High	Medium	High	High
Business Plan	High	Medium	High	Low
Feasibility Study	High	Medium	High	Medium
Personal Interview	Low	Low	Low	High

In case entrepreneur cannot provide financial proposal, information from personal interview will be taken for consideration. However it may take time. Also it is interesting to note that previous projects without financial proposal usually lack creidibility and lead to financial loss.

Entreprenuers therefore should have to include both corporate and project information in the proposal.

Details of the business plan, explaining business background, current performance and future project can be explained in the following tables.

Executive Summary

The first part should provide the overall business background. The length should not be more than two pages. Concise information about marketing, manufacturing, administration and finance to point out opportunities, needs and benefits from the energy efficiency project.

Part 1: Objective of credit

Type of credit, credit line and how the credit will be spent should be clearly stated. For example, the operator applied for 10-million Baht long-term loan program for purchasing enery-saving requipment from domestic manufacturer and 5-million Baht for energy-saving from overseas manufacturer. The length should be half page.

Part 2: Preliminary details of the business

Overall details about the business

- Name of the business and address, factory name and address. Map to tell the location of the factory should also be included.
- Background of business and the owner
- Inspiration for business establishment
- Crucial change which affects business income and profit, chronologically.
- Difficulties that occur from the very beginning of the business to present. State reasons, how to solve the issues and result.

Part 3 : Project Information

- Entreprenuer should provide information about energy use over the past 3 years including type of energy, how the energy is used, energy cost and other issues.
- Explain necessity, alternative and projected outcome from using energy-saving equipment.
- Include newly-installed machinery cost, dismantling cost of old equipment, installation cost of new equipment, engineering consultation cost, etc.
- Indirect cost that may occur due to temporary manufacturing cancellation or reduced manufacturing capacity.
- Indirect cost that entrepreneur has to prepare a report for ESCO, which usually requires extensive financial details.

Part 4 : Merchandising and Marketing

All details about merchandise manufacturing and distribution i.e. brandname and brandmark, benefits, category, type of product, model, quality, specification, packaging, retail price, details about pre and after services, logistics and product warrantee. Targets can be more than one. Details about target characteristics i.e. sex, age, income, education, reason to focus on selected target group and reason why the target group buy the product. Distribution numbers and profits over the last 3 years based on type of products, distribution channel and target groups. List of competitors including these following details: year of establishment, market share, price, distribution channel, target group, strength and weakness and way to reach out to new group of clients.

Part 5: Manufacturing

- Manufacturing details should include factory location and map, factory and area size, major manufacturing machinery, highest manufacturing capacity, present manufacturing capacity
- Technological details and credibility of manufacturing standard should be provided together with information about international manufacturing standard and guarantee
- Details of manufacturing factors cover raw material, quality and price, labor quality and development, electricity, energy, tapwater and other utilities, quality control.
- Brief details about quality control procedure, storage place and how to store merchandise and materials
- Research and development and preparedness to meet client's needs
- Manufacturing cost and lists of manufacturing factors over the last three years

Part 6 : Management

Vision, Mission and Goal must be at least available. Vision necessity is dependent on business character. Short and long-term goal must be set. The short-term goal should be achievable in a year while mid-term goal should be 3-5 years and long-term goal can be after 5 years. Details included in the goal should be measurable and related to the mission. For organization chart, line of command including roles and responsibilities of each unit should be clearly stated. Staff characteristcs and numbers of staff categorized based on organization chart. For executive board members and shareholders, details about educational background and work experience and achievements should be provided.

Part 7 : Industrial Information

- Provide business overview both in demand size among the consumers and distribution supplies from competitors. Projected supply and production capacity should also be included.
- Emerging competition: details about feasibility of newly-emerged competitors should also be explained.
- Alternative products: show feasibility that comsumers may turn to alternative products.

Part 8 : Financial Situtaion

- Provide details about financial budget over the past 3 years and financial audit. In case financial budget does not reflect reality due to difficulties to access tax and financial documents, entrepreneurs should prepare papers giving evidence-based details about financial turnover and actual financial status certified by financial auditor.
- Estimated financial projection of the energy efficiency project. Financial ratio which shows payback period should also be provided. (Details will be in the next chapter)
- Financial projection prior to operating the energy efficiency project and debt repayment ability should also be clearly stated. (Details will be in the next chapter)

Part 9 : Risk and Risk Managment

Operators should include these following details in the last part:

- Market risk
- Manufacturing risk
- Management risk
- Financial risk
- Energy efficieny project and its risk

Chapter 6
Financial Feasibility Study

Both business operators and financial institutions have duties to come up with financial assessment of the project. The assessment can be undertaken into two steps: 1) financial projection as a financial assement tool and 2) financial projection as a procedure. Business operators will assess their financial worth while financial institutions will determining risk, debt repayment capacity and financial ratio.

6.1 Financial Projection Preparation

Financial Projection includes data of financial forecast shown in a form of table. Data will be taken from present business operation and projected financial hypothesis. Microsoft Excel software will be used for calculation due to its flexibility. Duration of financial projection may vary depending on business projects.

Financial Projection includes cash flow, balance sheet and profit and loss statement shown in the Table 6.1.

Table 6.1 Type of financial activities

Activity	Balance Sheet Projection	Income Statement Projection	Cash Flow Projection
Project investment	Accumulated depreciation	Depreciation	Investment cash
Change of energy cost and other manufacturing cost	Trade account payables, stock of raw materials	Sales cost	Cost for manufacturing
Administrative cost	Prepaid expenses Accrued expense	Administration cost	Cash for administration cost
Source of funding	Total credit	Interest	Cost for payment interest rate, withdrawal credit, debt repayment

There are three types of financial projection: financial projection of the project, financial projection of the operator prior to the energy efficiency project, and financial project after changing the compressor as shown in Table 6.2 to Table 6.8.

Financial projection of the project will display cash flow including

- Net cash in the first year due to changing compressor. Cash flow covers an installment of the new compressor, dismantling the old one, damages caused by manufacturing cancellation, selling old compressor.
- Net cash flow after changing compressor. Principally, financial projection duration depends of the working period of the new compressor. However the projection over a period of 10 years is normally put into practice.

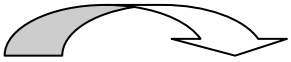
Financial Projection prior to the project

Projecting before changing the compressor will reflect financial statement reflecting performance and cash flow of the business.

Financial Projection after the project

Project after changing the compressor will reflect financial statusof and project of cash flow.

Table 6.2 Estimated cash flow of compressor replacement



List	Unit	Year 2014	Year 2015	Year 2016	Year 2017	Year 2024
Non-changing COMPRESSOR						
Maintenance cost of old COMPRESSOR	Baht	-	(100,000)	(110,000)	(121,000)	(235,795)
Electricity cost old COMPRESSOR	Baht		(5,019,705)	(5,571,507)	(6,197,745)	(13,063,530)
Changing new COMPRESSOR						
Maintenance cost of new COMPRESSOR	Baht	-	(40,000)	(40,000)	(60,000)	(60,000)
Electricity cost COMPRESSOR	Baht		(3,945,606)	(4,412,634)	(4,908,614)	(10,346,316)
Cost of new COMPRESSOR	Baht	3,000,000				
Selling old COMPRESSOR	Baht	50,000				
Selling new COMPRESSOR	Baht					500,000
Installing new COMPRESSOR	Baht	150,000				
Dismantling old COMPRESSOR	Baht	25,000				
Damage cost by cancellation of production	Baht	50,000				
Net cash	Baht	(2,725,000)	1,104,099	1,228,274	1,350,131	3,393,009

NPV (10%)	Baht	8,010,869
IRR		50%
SIMPLE PAYBACK	Year	2.3 ปี

Table 6.3 Estimated earnings prior to new compressor replacement

List	Unit	2013	2014	2015	2016	2017	2018
1. Income	Baht	30,935,961	33,744,946	36,808,987	40,151,243	43,796,976	47,773,741
2. Selling Cost	Baht	0,907,978	3,537,711	5,963,818	8,648,494	2,228,451	35,581,341
3. Depreciation	Baht	1,064,000	1,064,000	1,064,000	1,064,000	1,024,000	1,024,000
4. Preliminary Profit	Baht	8,963,983	3,143,234	9,781,169	10,438,749	10,544,525	11,168,400
5. Selling And Operation Cost	Baht	6,779,645	7,299,490	79,864,137	8,477,580	9,144,176	9,868,673
6. Profits Before Tax And Tax (EBIT)	Baht	2,184,337	1,843,745	1,917,032	1,961,169	1,400,350	1,299,728
7. Interest	Baht	525,000	375,000	225,000	75,000	0	0
8. Profit Before Tax	Baht	1,659,337	1,468,745	1,692,032	1,886,169	1,400,350	1,299,728
9. Tax	Baht	331,867	293,749	338,406	377,234	280,070	259,946
10. Net Profit	Baht	1,327,470	1,174,996	1,353,626	1,508,935	1,120,280	1,039,782

Table 6.4 Estimated financial status prior to new compressor replacement

Assets	Unit	2013	2014	2015	2016	2017	2018
1. Cash Flow	Baht	2,788,789	3,318,920	4,012,339	4,840,818	6,714,027	8,486,739
2. Debtor	Baht	2,577,997	2,812,079	3,067,416	3,345,937	3,649,748	3,918,145
3. Products in stock	Baht	154,986	174,402	192,352	212,242	238,795	263,605
4. Raw materials in stock	Baht	577,760	654,998	742,572	841,866	954,447	1,082,096
5. Total Assets	Baht	6,099,441	6,960,400	8,014,679	9,240,862	11,557,017	13,813,585
6. Preliminary Assets	Baht	44,000,000	44,000,000	44,000,000	44,000,000	44,000,000	44,000,000
7. Accumulative Depreciation	Baht	18,128,000	19,192,000	20,256,000	21,320,000	22,344,000	2,368,000
8. Net Assets	Baht	25,872,000	24,808,000	23,744,000	22,680,000	21,656,000	20,632,000
9. Total Assets	Baht	31,971,441	31,768,400	31,758,679	31,920,862	33,213,017	3,445,585
Debt and Investment Cost	Unit	2013	2014	2015	2016	2017	2018
10. Creditor	Baht	1,013,681	1,135,645	1,272,298	1,425,546	1,597,422	1,790,208
11. Long-Term Loan	Baht	4,500,000	3,000,000	1,500,000	0	0	0
Equity	Baht						
12. Registered Cost	Baht	17,000,000	17,000,000	17,000,000	17,000,000	17,000,000	17,000,000
13. Collective Profits	Baht	9,457,759	10,632,755	11,986,380	13,495,315	14,615,595	15,655,377
14. Total Debts And Cost	Baht	31,971,441	31,768,400	31,758,679	31,920,862	33,213,017	34,445,585

Table 6.5 Projected cash flow (prior to changing compressor)

List	Unit	2013	2014	2015	2016	2017	2018
1. Cash From Selling	Baht	30,721,364	33,510,864	36,553,650	39,872,722	43,493,165	47,442,344
2. Cash Paid For Production	Baht	20,911,949	23,512,493	25,932,688	28,614,429	32,195,710	35,541,013
3. Cash Paid For Services	Baht	6,779,645	7,299,490	7,864,137	8,477,580	9,144,176	9,868,673
4. Cash For Tax Payment	Baht	331,867	2,937,449	338,406	377,234	280,070	259,946
5. Net Cash In On Operation	Baht	2,697,902	2,405,132	2,418,419	2,403,478	1,873,209	1,772,713
6. Loan Interest	Baht	525,000	375,000	225,000	75,000	0	0
7. Net Cash In 2	Baht	2,172,902	2,030,132	2,193,419	2,328,478	1,873,209	1,772,713
8. Total Investment	Baht	0	0	0	0	0	0
9. Net Cash In 3	Baht	2,172,902	2,030,132	2,193,419	2,328,478	1,873,209	1,772,713
Source of financial investment	Baht						
10. Cost of registered investment	Baht						
11. Long-Term Loan: Deposit-Withdrawal	Baht						
12. Long-Term Loan: Repaymentl	Baht	1,500,000	1,500,000	1,500,000	1,500,000		
13. Net Cash In 4	Baht	672,902	530,132	693,419	828,478	1,873,209	1,772,713
14. Remaining Cash-Beginning Period	Baht	2,115,886	2,788,789	3,318,920	4,012,339	4,840,818	6,714,027
15. Remaining Cash-End Period	Baht	2,788,789	3,318,920	4,012,339	4,840,818	6,714,027	8,486,739

Table 6.6 Projected earnings (post compressor replacement)

List		Unit	2013	2014	2015	2016	2017	2018
1.	Income	Baht	30,935,961	33,744,946	36,808,987	40,151,243	43,796,976	47,773,741
2.	Selling Cost	Baht	20,907,978	23,543,120	24,737,295	27,291,219	30,712,874	33,889,655
3.	Depreciation	Baht	1,064,000	1,309,250	1,309,250	1,309,250	1,269,250	1,269,250
4.	Preliminary Profit	Baht	8,963,983	8,892,575	10,762,442	11,550,774	11,814,852	12,614,836
5.	Selling And Operation Cost	Baht	6,779,645	7,299,490	7,864,137	8,477,580	9,144,176	9,868,673
6.	Profits Before Tax And Tax (EBIT)	Baht	2,184,337	1,593,085	2,898,305	3,073,194	2,670,676	2,746,163
7.	Interest	Baht	525,000	475,000	400,000	200,000	75,000	25,000
8.	Profit Before Tax	Baht	1,659,337	1,118,085	2,498,305	2,873,194	2,595,676	2,721,163
9.	Tax	Baht	331,867	223,617	499,661	574,639	519,135	544,233
10.	Net Profit	Baht	1,327,470	894,468	1,998,644	2,298,555	2,076,541	2,176,930

Table 6.7 Projected financial status (post compressor change)

Assets		Unit	2013	2014	2015	2016	2017	2018
1.	Cash Flow	Baht	2,788,789	2,558,602	3,550,475	4,904,764	7,467,755	10,109,829
2.	Debtor	Baht	2,577,997	2,812,079	3,067,416	3,345,937	3,649,748	3,981,145
3.	Products in stock	Baht	154,986	174,443	183,204	202,187	227,566	251,071
4.	Raw materials in stock	Baht	577,760	654,998	742,572	841,866	954,447	1,082,096
5.	Total Assets	Baht	6,099,441	6,200,122	7,543,667	9,294,754	12,299,516	15,424,414
6.	Preliminary Assets	Baht	44,000,000	46,725,000	46,725,000	46,725,000	46,725,000	46,725,000
7.	Accumulative Depreciation	Baht	18,128,000	19,437,250	20,746,500	22,055,750	23,325,000	24,594,250
8.	Net Assets	Baht	25,872,000	27,287,750	25,978,500	24,669,250	23,400,000	22,130,750
9.	Total Assets	Baht	31,971,441	33,487,872	33,522,167	33,964,004	35,699,526	37,554,750
	Debt and Investment Cost	Unit	2013	2014	2015	2016	2017	2018
10.	Creditor	Baht	1,013,681	1,135,645	1,171,295	1,314,577	1,473,548	1,651,993
11.	Long-Term Loan	Baht	4,500,000	5,000,000	3,000,000	1,000,000	5,000,000	
	Equity	Baht						
12.	Registered Cost	Baht	17,000,000	17,000,000	17,000,000	17,000,000	17,000,000	17,000,000
13.	Collective Profits	Baht	9,457,759	10,352,227	12,350,872	14,649,427	16,725,968	18,902,898
14.	Total Debts And Cost	Baht	31,971,441	33,487,872	33,522,167	33,964,004	35,699,516	37,554,891

Table 6.8 Projected cash flow (post new compressor replacement)

List	Unit	2013	2014	2015	2016	2017	2018
1. Cash From Selling	Baht	30,721,364	33,510,864	36,553,650	39,872,722	43,493,165	47,442,344
2. Cash Paid For Production	Baht	20,911,949	23,517,943	24,797,979	27,266,214	30,691,863	33,862,365
3. Cash Paid For Services	Baht	6,779,645	7,299,492	7864137	8,477,580	9,144,176	9,868,673
4. Cash For Tax Payment	Baht	331,867	223,617	499,661	574,630	519,135	544,233
5. Net Cash In On Operation	Baht	2,697,902	2,469,814	3,391,873	3,554,289	3,137,991	3,167,074
6. Loan Interest	Baht	525,000	475,000	400,000	200,000	75,000	23,000
7. Net Cash In 2	Baht	2,172,902	1,994,814	2,991,873	3,354,289	3,062,991	3,142,074
8. Total Investment	Baht	0	2,725,000	0	0	0	0
9. Net Cash In 3	Baht	2,172,902	-730,186	2,991,873	354,289	3,062,991	3,142,074
Source of financial investment	Baht						
10. Cost of registered investment	Baht						
11. Long-Term Loan: Deposit-Withdrawal	Baht		2,500,000				
12. Long-Term Loan: Repaymentl	Baht	1,500,000	2,000,000	2,000,000	2,000,000	500,000	500,000
13. Net Cash In 4	Baht	672,902	-230,186	991,873	1,354,289	256,991	2,642,074
14. Remaining Cash-Beginning Period	Baht	2,115,886	1,788,789	2,558,602	3,550,433	4,904,764	7,467,755
15. Remaining Cash-End Period	Baht	2,788,789	2,558,602	3,550,475	4,904,764	7,467,755	10,109,829

DEBT SERVICE COVERAGE		1.33	1.00	1.41	1.62	5.46	6.03

Note: Meaning of finaical list in Table 6.3 to 6.8 can be explained as follow:

List of terms and meanings in the financial statement and explanation

	List	Meaning
1	Income	Value of product selling
2	Selling cost	Cost of product manufacturing
3	Depreciation	Cost due to the use of investment in assets
4	Preliminary profit	= Income – Selling Cost - Depreciation
5	Cost of selling and service	Indirect cost of manufacturing
6	Profit prior to interest and tax	= Preliminary profit - Cost of selling and service
7	Debt interest	Cost due to the credit
8	Profit prior to tax	= Profit prior to interest and tax – Debt interest
9	Tax	Income tax (juristic person)
10	Net profit	= Profit before tax – tax

List of terms and meanings in the projected financial status

	List	Meaning
1	Assets	Cash at hands (not include cash in A/C)
2	Debtor	Value from unpaid selling of the product
3	Products in stock	Value of the product stored for selling
4	Raw materials in stock	Value of manufacturing facturing waiting for use
5	Total assets	= Cash at hands + debtor + products in stock + raw materials in stock
6	Preliminary assets	Value of investment in collective assets
7	Depreciation	Cost of investment in collective assets
8	Net assets	= Preliminary assets + collective depreciation
9	Total asset	= Rotated assets + net assets
10	Creditor	Value of unpaid manufacturing factors
11	Long term loan	Remaining debt at the end of the year
12	Registered cost	Investment from shareholders for use in the

List of terms and meanings in the projected cash flow

	List	Meaning
1	Cash from selling	Value of paid product
2	Cash paid for production	Value of manufacturing factor which is paid
3	Cash paid for services	Paid cash non related to manufacturing
4	Cash for tax payment	Income tax (juristic person
5	Net cash in on operation	= Cash received – cash paid for manufacturing - cash paid for selling – cash for tax payment
6	Loan interest	Paid cash due to credit cost
7	Net cash in 2	= Net cash from operation – loan debt
8	Total investment	Investment value in the assets
9	Net cash in 3	= Net cash in 2 – total investment cost
Financial source		Source of financial investment
10	Cost of registered investment	Shareholder cost used in the business
11	Long-term loan: deposit-withdrawal	Value of long term loan withdrawal

	List	Meaning
12	Long term loan: repayment	Value of long term debt payment
13	Net cash in 4	= Net cash in 3 + Registered cost + Long term debt : withdrawal – long term debt : repayment
14	Remaining cash-beginning period	Cash at the end of the year
15	Remaining cash-end period	Remaining cash at the end of the year

6.2 Financial suitability assessement of the project

Entrepreneurs can assess financial suitability of their projects by following these two dimensions.

1) Investment worthiness assessment

Comparison of value of net cash flow displayed in the financial projection by using the following three types of evaluation tool.

- Net Present Value : NPV used as tool for identifying investment worthiness by using discount rate to show the present value and the present cash value. If the future cash value is more than the investment cost, the project will be seen as worth for investment. The key to use this mechanism is the identification of discount rate considered from loss of opportunities in other forms of asset investment i.e. cash deposit, asset management and investment in other businesses etc.
- Internal Rate of Return : IRR

This tool shows the comparison in %, which is easy to understand and can be compared with other projects. IRR is proportion of return from the project calculated from cost of investment in the present year and net cash flow in the future. IRR is closely related to NPV, making the discount rate equal to zero.

- Payback Period

Comparison of cash value in the present year with the net cash flow in the future. The result will be shown in duration period

Table 6.9 Minimum standard for financial ratio

Assement Criteria	Financial Ratio	Rate and duration
Financial worthiness	Internal Rate of Return	>10%
	Net Present Value	>0
	Pay Back Period	5 Years

Table 6.10 Financial worthiness of the energy efficiency project

1. NPV (10%)	8,010,669
2. IRR	49.69%
3. Simple Payback Period	2

2) Financial ratio analysis

Financial ratio can be categorized into four groups: profitability ratio, liquidity ratio, efficiency ratio, and debt ratio, for explaining reasons whether or not it is worthy to invest in the project. Business operators can use financial ratio i.e. debt service coverage ratio (DSCR) and debt equity ratio (DE ratio) to compare total debt burden as shown in Table 6.11

Table 6.11 Financial Ratio

Profitability Ratio	Meaning	Formula	Unit	Result
Growth Rate	Increasing income	=(Income from the present year – Income from the previous year)/ Income of the previous year	%	High: Good
Gross Profit Margin	Preliminary profit rate	=Preliminary profit/income	%	High: Good
Net Profit margin	Net profit rate	Net profit/income	%	High: Good
Liquidity Ratio	**Meaning**	**Formula**	**Unit**	**Result**
Current Ratio	An indication of a company's ability to meet debt obligations	Current assets/current debt	Times	High: Good

Liquidity Ratio	Meaning	Formula	Unit	Result
Quick Ratio	A measure of how well a company can meet its short-term financial liabilities	(Current assets-inventory control/current debt	Times	High: Good
Efficiency Ratio	**Meaning**	**Formula**	**Unit**	**Result**
Assets Turnover	Efficiency in asset use and management	=income/assets	Times	High: Good
Stock Turnover	A ratio showing how many times a company's **inventory** is sold and replaced over a period.	=Production/value of inventory control	Times	High: Good
Account Receivable Turnover	Account Receivable Turnover	= Income/value of debtor	Times	High: Good
Account Payable Turnover	Account Payable Turnover	= Production cost/value of creditor	Times	High: Good
Debt Ratio	**Meaning**	**Formula**	**Unit**	**Result**
Debt to Equity	A measure of a company's financial leverage calculated by dividing its total liabilities by stockholders' equity. It indicates what proportion of equity and debt the company is using to finance its assets.	=Debt/capital accumulation	Times	Low: Good
Loan to Value	A key risk factor that lenders assess when qualifying borrowers for a mortgage	=Project debt/project value	Times	Low: Good
Debt to Income	The percentage of a consumer's monthly gross **income** that goes toward paying **debts**	=Debt/income	Times	Low: Good

Table 6.12 Standard rate of debt ratio

Consideration	Financial ratio	Ratio
Debt burden	Debt to Equity	1.5:1 Times
Debt repayment capacity	Debt Service Coverage Ratio	1.5 Times

Meanwhile, financial ratio of the business operator prior to and after changing the compressor can be shown in Table 6.13 and 6.14

Table 6.13 Financial ratio (before changing Compressor)

Ratio	2013	2014	2015	2016	2017	2018
Growth Rate		9%	9%	9%	9%	9%
Gross Profit Margin	29%	27%	27%	26%	24%	23%
Net Profit Margin	4%	3%	4%	4%	3%	2%
Current Ratio	6.02	6.13	6.30	6.48	7.23	7.72
Quick Ratio	5.29	5.40	5.56	5.74	6.49	6.96
Assets Turnover	0.97	1.06	1.16	1.26	1.32	1.39
Stock Turnover	134.98	134.96	134.98	134.98	134.96	134.98
A/R Turnover	12.00	12.00	12.00	12.00	12.00	12.00
A/P Turnover	20.63	20.73	20.41	20.10	20.18	19.88
Debt to Equity	0.21	0.15	0.10	0.05	0.05	0.05
Debt to Income	0.18	0.12	0.08	0.04	0.04	0.04
Debt Service Coverage Ratio	1.33	1.28	1.40	1.53		

Table 6.14 Financial ratio (after changing compressor)

Ratio	2013	2014	2015	2016	2017	2018
Growth Rate		9%	9%	9%	9%	9%
Gross Profit Margin	29%	26%	29%	29%	27%	26%
Net Profit Margin	4%	3%	5%	6%	5%	5%
Current Ratio	6.02	5.14	6.44	7.07	8.35	9.34
Quick Ratio	5.29	4.73	5.65	6.28	7.54	8.53
Assets Turnover	0.97	1.01	1.10	1.18	1.23	1.27
Stock Turnover	134.98	134.96	135.03	134.98	134.96	134.98
A/R Turnover	12.00	12.00	12.00	12.00	12.00	12.00
A/P Turnover	20.63	20.73	21.12	20.76	20.84	20.51
Debt to Equity	0.21	0.22	0.14	0.07	0.06	0.05
Loan to Value		92%				
Debt to Income	0.18	0.18	0.11	0.06	0.05	0.03
Debt Service Coverage Ratio	1.33	1.00	1.41	1.62	5.46	6.03

The Business operators do care on their financial assessment while financial institutions do evaluate the risk, ability to repayment and financial ratio. Well and precisely prepare of the financial assessment results in chance of getting the credit approval.

Annex A.
Details of Energy Saving Technologies

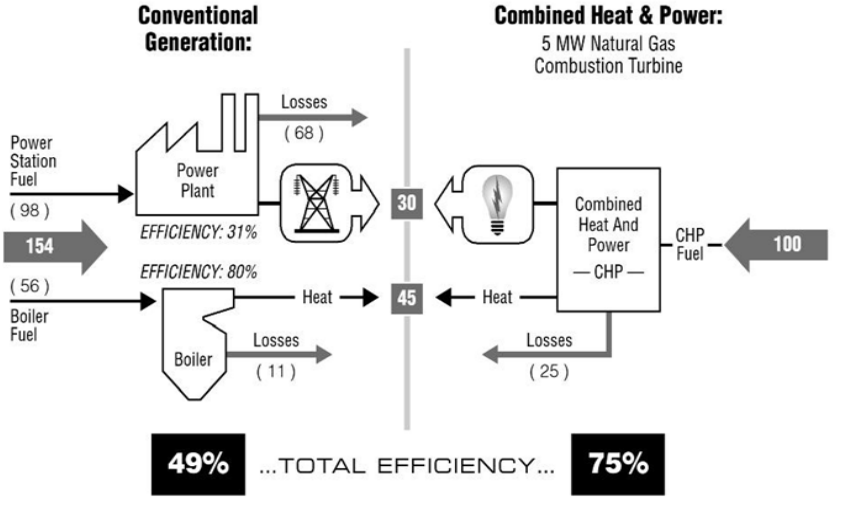
The energy conservation measures mentioned below are applicable for various types of industries and mostly identified based on the following utility machines and process machines:

- The cogeneration system for food, textile, cement, metal, glass and chemical industries.
- The boiler system mostly used among food, textile and non-metal industries.
- The air compressor system used among industries requiring high-pressured air consumption e.g. food, metal and non-metal industries.

1. Cogeneration

The cogeneration system is the electricity and heat generation process which utilizes energy input into a single system. The overall efficiency of the cogeneration system is as high as 75 - 80% compared to the efficiency of the isolate generation at 40-50%. This system is also known as “CHP” or “Combined Heat and Power”.

The cogeneration system and conventional system are shown in Figure 1.



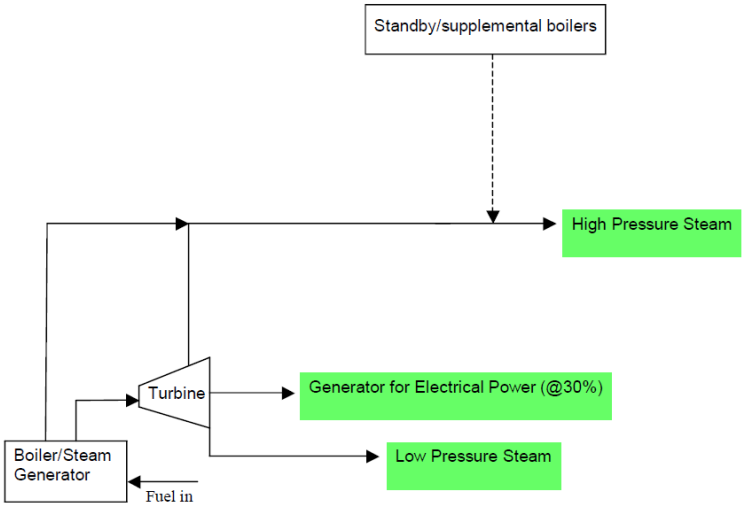
Source: U.S.EPA, Combined Heat and Power Partnership, "Efficiency Benefits"

Figure 1 The overall efficiency of the usual power generation system vs. the cogeneration system

1.1 Steam Turbine Cogeneration

The main component of this system comprises steam boiler and steam turbine using gas, liquid or solid fuel. In principle, fuel is injected into the combustion chamber. The heat generated from thermal reaction at high temperature and pressue is then transformed into hot water, steam and superheat steam. The steam at this high energy level will drive mechanical parts e.g. turbine compressor and eventually transform into electricity. The medium pressure steam after passing through turbine will be utilized for other process system.

The schematic diagram of steam turbine cogeneration is shown in Figure 2.



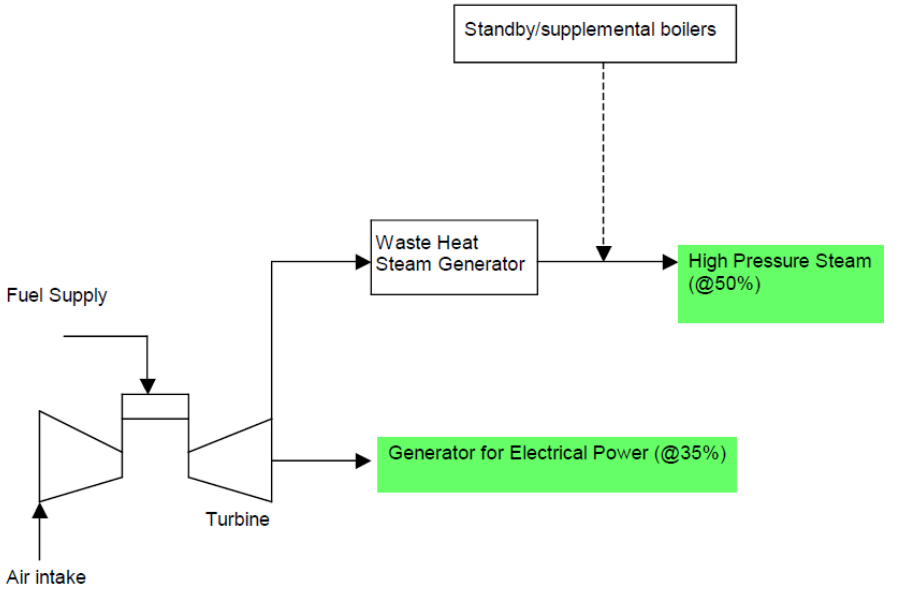
Source: Doanh Van, Union University, Co-generation-A Feasibility Screening Analysis Using Excel Spreadsheet

Figure 2 Steam Turbine Cogeneration

1.2 Gas Turbine Cogeneration

Compressed air and fuel will be feeded into the combustion chamber. The mixing between compressed air and fuel will ignite, leading to expansion of hot gas driving the turbine and the generator. Waste heat boiler will be used for generating hot flue gas with the temperature of 450-550 °C producing low-pressured steam.

Figure 3 illustrates the gas turbine cogeneration system.



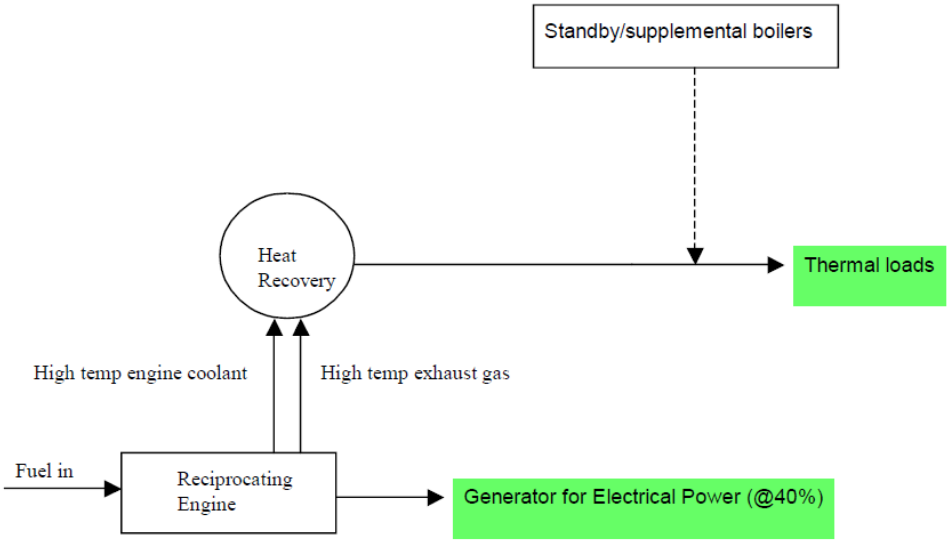
Source: Doanh Van, Union University, Co-generation-A Feasibility Screening Analysis Using Excel Spreadsheet

Figure 3 Gas Turbine Cogeneration

1.3 Reciprocating Engine Cogeneration

There are two types of engines: spark-ignition engine (liquid or NG as fuel) and compression-ignition engines (diesel or bunker oil as fuel). Electricity generated is between 100 kW to 10 MW. Waste heat in a form of flue gas, cooling water and lubricant could be recovered from the waste heat boiler to produce steam and/or hot water.

The reciprocating engine cogeneration is shown in Figure 4.



Source: Doanh Van, Union University, Co-generation-A Feasibility Screening Analysis Using Excel Spreadsheet

Figure 4 Reciprocating Engine Cogeneration

Pros and cons of the cogeneration system

Pros:

- Up 10-30% of energy consumption can be saved, thanks to the efficiency of the cogeneration system approximately at 80% compared with 50% of the isolated heat and 35% of the electricity generation
- Initital investement cost of cogeneration sytem is much less than large scale power plant.
- The cogeneration system could reduce peak load of the utility agencies Provincial Electricity Authorities and Metropolitan Electricity Authorities and consequently reduce the demand of large scale power plant.

Cons:

- Design, construction and operation of the cogeneration system are complicated and that experts in each task are required.
- High capital cost and operation and maintenance (O&M) cost.
- If installing overcapacity of heat and power in the cogeneration system, it will be difficult to manage exceeding energy and steam existing in the system.

Energy efficiency evaluation and performance and cost of each cogeneration systems are shown in Table 1 and Table 2 respectively.

Table 1 Example of energy efficiency evaluation

ECMs	Implement	Saving	Unit	Investment	Unit	Payback	Unit	Remark
Gas turbine + HRSG Boiler (Co-generation)	☑ Yes	8,188,288.45	[B/y]	31,000,000.00	[B]	3.79	[y]	
Gas turbine + HRSG Boiler +Absorption Chiller (Tri-generation)	☐ Yes	27,872,752.45	[B/y]	56,000,000.00	[B]	2.01	[y]	
Total (All ECMs selected)		36,061,040.90	Baht/yr	87,000,000.00	Baht	2.41	Years	
Total (some ECMs selected)		8,188,288.45	Baht/yr	31,000,000.00	Baht	3.79	Years	

Table 2 Example of evaluating performance and cost of different cogeneration systems

Energy Conservation Measures	*Size range (MWe)	*H/P Ratio	*Electrical conversion Eff.	*Thermal conversion Eff.	Total Eff.	Estimated Investment Cost	Unit	*Estimated O&M Cost	Unit	Remark
Open Cycle-Gas Turbine	0.25 - 50+	1.5:1 - 5:1	42%	45%	87%	25M - 90M	[Baht/MW]	0.53	[Baht/kWh]	25 MBaht/MW for large scale , 90MBaht/MW for Small scale
Combined Cycle - Gas/Steam Turbine	3 - 300+	1:1 - 3:1	55%	35%	90%	25M - 90M	[Baht/MW]	0.53	[Baht/kWh]	25 MBaht/MW for large scale , 90MBaht/MW for Small scale
Reciprocating Engine	0.2 - 20	0.5:1 - 3:1	45%	45%	90%	25M - 90M	[Baht/MW]	0.75	[Baht/kWh]	25 MBaht/MW for large scale , 90MBaht/MW for Small scale
Steam Turbine	0.5 - 500	3:1 - 10:1	20%	60%	80%	25M - 90M	[Baht/MW]	0.15	[Baht/kWh]	25 MBaht/MW for large scale , 90MBaht/MW for Small scale

*Source : Cogeneration Guide, The European Association for the Promotion of Cogeneration (www.cogeneration.org)

Financial Consideration

- Electricity cost per selling unit (Baht/kWh)
- Fuel cost per selling unit
- Cost of produced steam per selling (Baht/ton of steam)
- Investment cost in the project

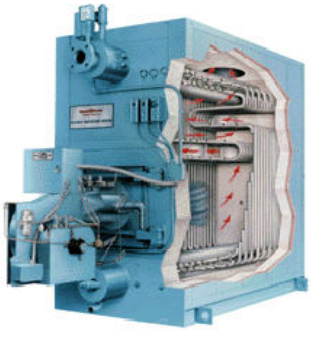
- Heat to Power Ratio
- Financial conditions of commercial banks/ESCO

2. Boilers

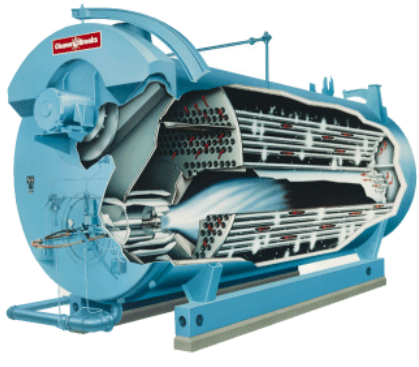
Boiler is the main equipment to generate steam. Steam system is commonly used among the industries, hotels and hospitals. Steam cost is relatively high due to energy and fuel consumption. Operation and maintenance of the system will not increase the efficiency but also help reduce energy cost and green house gas effect.

There are two categories: water-tube boiler and fire-tube boiler as illustrated in Figure 5.

- **Water-tube boiler**: Water inside the tube is heated by flame outside the tube.
- **Fire-tube or shell boiler**: Flame inside the tube will transfer the heat to water surrounding the boiler.



(a) Water-tube boiler



(b) Fire-tube boile

Figure 5 Types of boilers

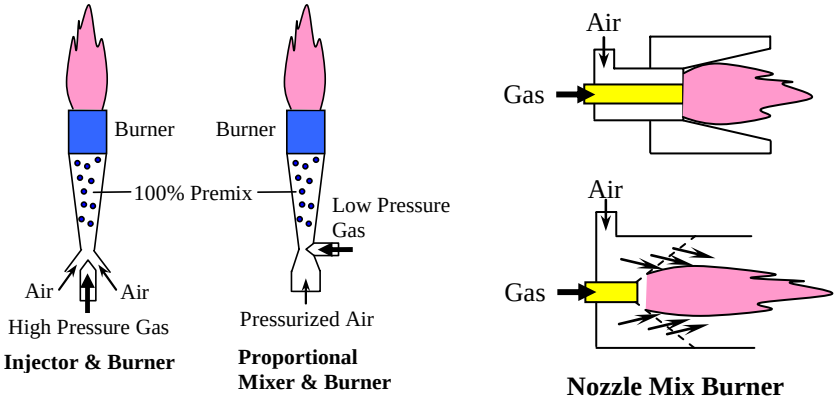
It will take longer time for the fire-tube boiler to produce water steam than the water-tube boiler. Water-tube boiler is more efficient in responding to the change in steam demand.

For fire-tube boiler, the more tubes it is equipped, the better its capacity and efficiency will be due to the longer duration that hot gas will flow into the boiler. Small-sized fire tube-boiler may be equipped with 2 passes of fire tubes going back and forth while the large size boiler could have up to 3-4 passes or more.

2.1 Burner

Burner is the equipment for fuel injection mixed with combustion air in the appropriate ratio. There are two types of gas burner (Figure 6)

1. Pre-mix Burner
2. Nozzle-mix Burner

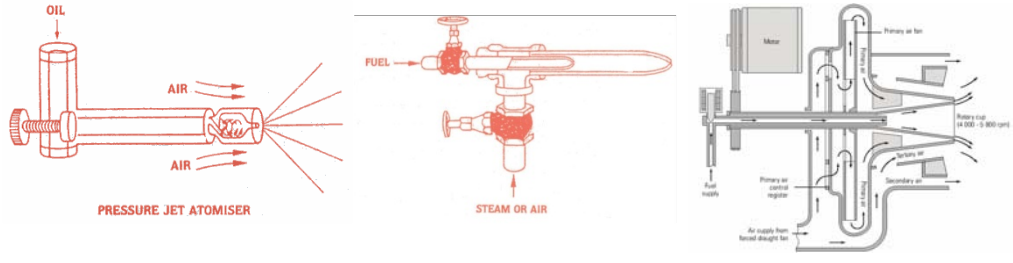


(a) Pre-mix Burner (b) Nozzle-mix Burner

Figure 6 Types of gas burner

There are three types of oil burner (Figure 7)

a) Pressure Atomized
b) Steam or Air Atomized
c) Rotary Cup



(a) Pressure Atomized (b) Steam or Air Atomized (c) Rotary Cup

Figure 7 Types of oil burner

Burner can also be classified based on operation characteristic. Selecting different types of burner to meet the need will maximize energy efficiency.

a) Modulating Burner: Fuel consumption of the modulating burner depends on the amount of heat required for steam production and maintaining air pressure. When steam pressure is reduced, fuel rate in the burner will be increased accordingly. On the other hand, fuel rate in the burner will be decreased when the steam pressure exceeds the setpoint.

b) High/Low-Fire Burner: This type of burner could supply fuel at high and low levels. Suitable for steam load that does not change much.

c) Constant-Fire or ON-OFF Burner: This type of burner is suitable for the constant steam load. The burner will be automatically ON when steam pressure is lower than the setpoint and be automatically OFF when steam pressure is higher than the setpoint. The fuel is then supplied to the boiler according to the ON-OFF status.

The turn down ratio, reflecting proportion between the maximum and the minimum firing rate which doesn't affect the burning capacity, is one of the selection criterias. If there is much change in the steam load, user should select the burner with the high rate of the turn down ratio, leading to the high capacity of steam production. Variation of the turn down ratio also depends on the steam load. It is worth to say that the the high-fire/low-fire burner has the turn down ratio of 3:1 whereas the modulating burner has the turn down ratio of 10:1. Hence the modulating burner is better than the turn down ratio 3:1 of High-fire/Low-fire burner or ON-OFF burner.

2.2 Steam Generation

For many years, heat recovery of steam boiler has been implemented for use during heating process. The average payback is 2-3 years. The efficiency of waste heat recovery boiler is as high as 80%. However installation and maintenance cost are the main issues needed to be taken int consideration at the beginning design step.

The followings are typical questions regarding waste heat recovery boiler.

- Any continuous waste heat available?
- Any continuous demand on steam in the process?
- Any suitable water treatment system available for operation?
- Any area to install a large boiler near the source of waste heat?
- Capable of implementing operation and maintenance to ensure the system will be at the best condition?

In summary, the demand on the amount of steam in process and/or waste heat for cooling equipment such as absorption chillers are important factors needed to be taken into consideration.

2.3 Power Generation

In chemical and petrochemical industry, waste heat is always utilized for electricity plant for cost-effectiveness purpose. Ethylene cracking, ammonia production, petrochemical refining are among the industries demanding electricty and low pressure steam from waste heat recovery. The electricity or power generation using waste heat must contain:

- Source of continued waste heat
- Pre-treatment water plant
- Regular maintenance
- High pressure steam boiler and condensing steam turbine

The last equipment mentioned above results high investment cost. The average payback is then around 3-6 years.

2.4 Available Heat Recovery Technology

The waste heat recovery technology has been developed over 30 years. The technology is now adopted for use with high temperature waste heat to better energy efficiency, return on investement and environmental solutions.

The relationship between preheat air temperature and percentage of fuel saving at various flue gas temperature, i.e. high flue gas temperature, high preheat temperature, high fuel saved, is illustrated in Figure 8.

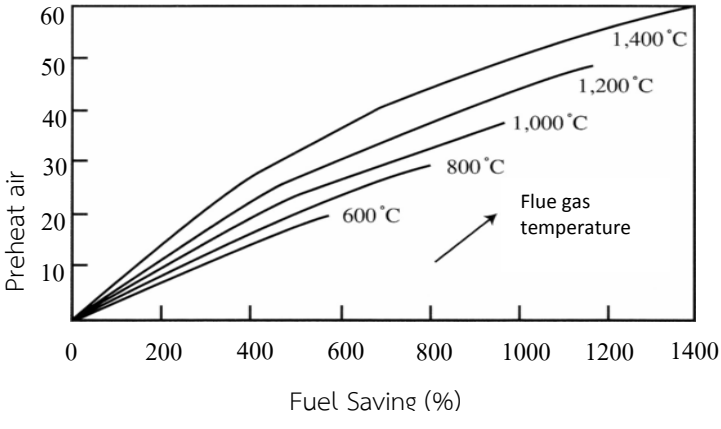


Figure 8 Fuel saving of waste heat recovery for air preheater

Generally, the waste heat recovery unit is equipped with most of the furnace system. The estblished technolgy described below will explain more details about the process, how to put into practice and its benefits.

Table 3 shows alternative in energy saving evaluation of boiler by economizer installation or change to waste heat recovery boiler, high efficiency boiler while Table 4 suggests the efficiency and investment cost of each alternative.

Table 3 Example of energy efficiency evaluation for boiler modification

ECMs	Implement	Saving	Unit	Investment	Unit	Payback	Unit	Remark
1. Install Economizer	☑ Yes	266,611.61	[B/y]	266,611.61	[B]	1.00	[y]	
2. Waste heat recovery boiler	☐ Yes	3,506,713.99	[B/y]	5,260,070.99	[B]	1.50	[y]	
3.Use High Eff. Boiler	☑ Yes	1,441,096.05	[B/y]	2,593,972.88	[B]	1.80	[y]	
Total (All ECMs selected)		5,214,421.65	Baht/yr	8,120,655.48	Baht	1.56	Years	
Total (some ECMs selected)		1,707,707.66	Baht/yr	2,860,584.49	Baht	1.68	Years	

Table 4 Example of evaluating factors concerning performance and cost of boiler modification

Energy Conservation Measures	Size (kg/hr)	Efficiency	Estimated Investment Cost	Unit	*Estimated O&M Cost	Unit	Remark
Economizer [1]	3,000	increase boiler eff +4%	80	[Baht/kg/hr]	N/A		
Waste Heat Recovery Boiler [2]	1,500	91%	1,767	[Baht/kg/hr]	480,000.00	[Baht/yr]	Boiler eff = 80% Overall eff = 91%
High Eff. Boiler [3]	47,000	94%	798	[Baht/kg/hr]	N/A		

*Source : USDOE, Energy Tips :

1. Steam
2. Switch Asia Program
3. MIT

3. Air Compressors

An electrical appliance widely-used in buildings and factories for producing compressed air with 2-8 times higher pressure than atmosphere to proceed machines and pneumatic tools. Typically, the oversized air compressor is chosen to handle air consumption at various pressure levels. Therefore several types of air compressor have to be carefully selected to meet the need because of its energy- intensive machine which could cause air leakage feasibility in the system.

3.1 Types of compressor

3.1.1 Compressor characteristics

a. Turbo

(1) Axial flow compressor

Gas is compressed while passing between moving blades on the impeller and stationary blades on the casing (Figure 9).

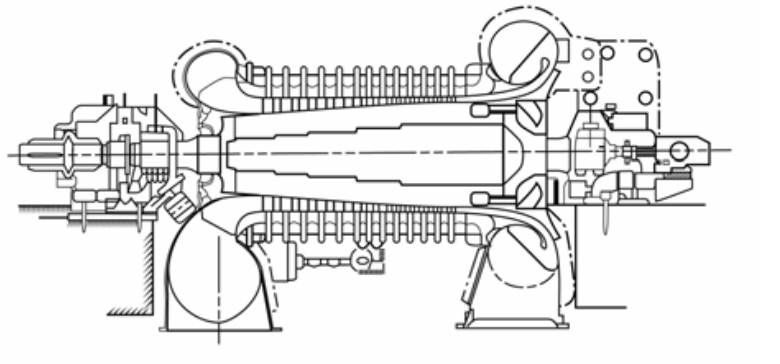


Figure 9 Axial air compressor

(2) Centrifugal compressor

For this type of compressor, the air is sucked through the centre of the impeller by the centrifugal force of the rapidly rotating impeller, which creates an air passage discharged to the periphery. The centrifugal compressor is suitable for the work that highly demands air quantity, oil free and less corroded blade. The illustration of centrifugal compressor is displayed in Figure 10. It should be noted that the centrifugal air compressor is not often found in general factory due to its design for a high air quantity with less pressure.

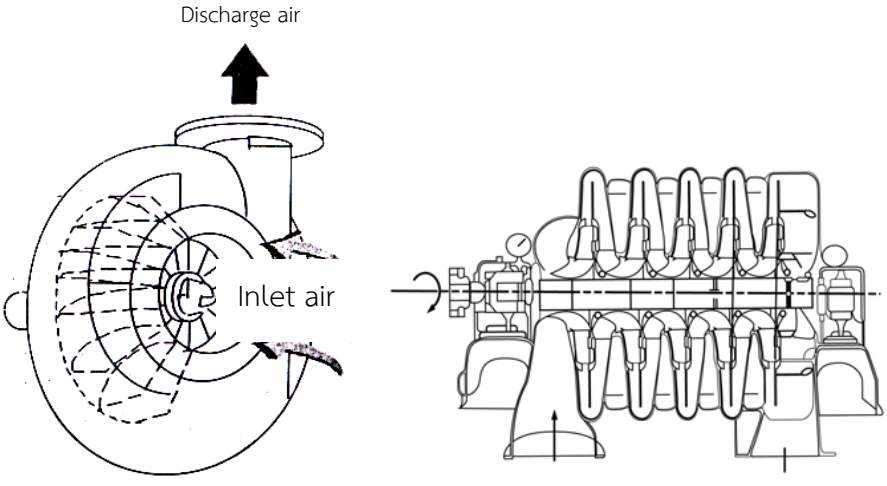


Figure 10 Centrifugal compressor

b. Positive displacement

(1) Reciprocating Compressor

Air is sucked and compressed by the reciprocating motion of a piston. This compressor type has been used before the development of rotary compressor or centrifugal compressor. Nevertheless, the reciprocating has high maintenance cost and vibration issue. The illustration of reciprocating compressor is displayed in Figure 11.

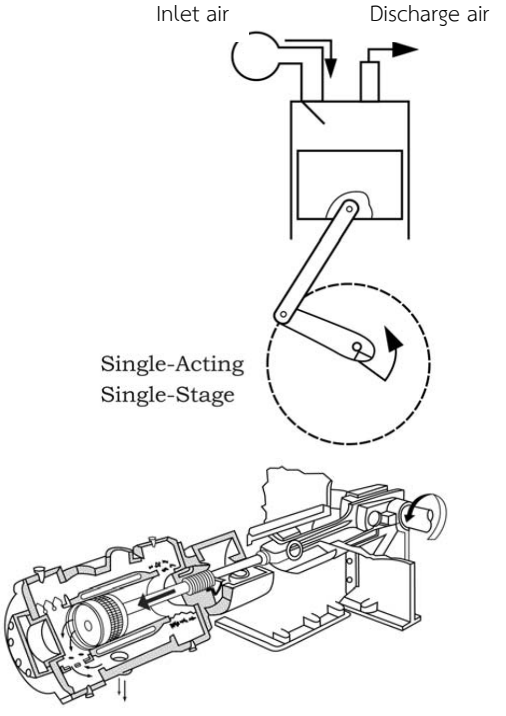


Figure 11 Reciprocating compressor

(2) Screw Compressor

The air is sucked and discharged by the volume changes between the gap and the casing generated by rotation of the male and female rotors. The illustration of screw compressor is displayed in Figure 12.

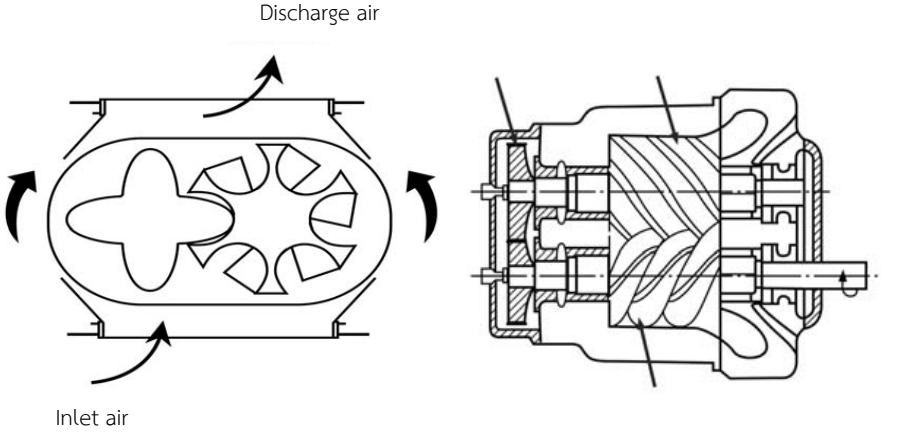


Figure 12 Screw compressor

(3) Rotary Vane Compressor

Rotating shaft fixed with sliding vanes will be used. The rotor is mounted offset in a larger housing. As the rotor turns, blades will slide in and out of the slots, thus the air is sucked and compressed. Figure 13 shows the roratory vane compressor.

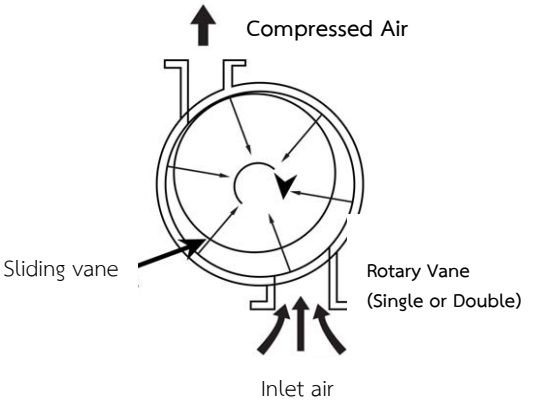


Figure 13 Rotary Vane Compressor

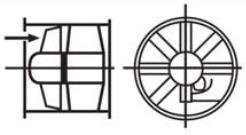
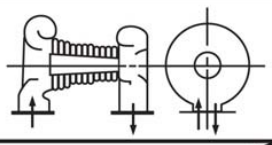
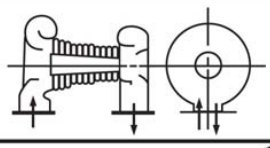
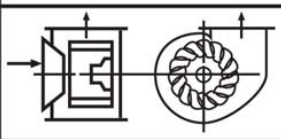
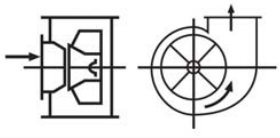
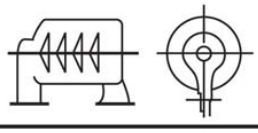
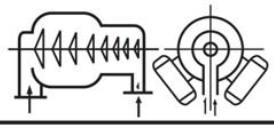
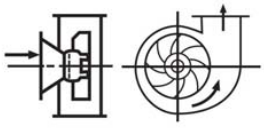
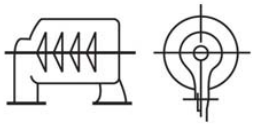
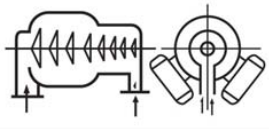
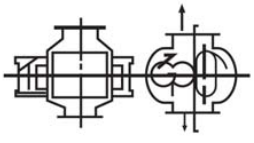
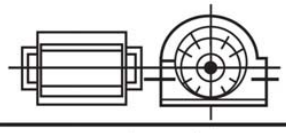
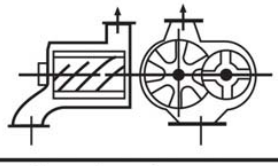
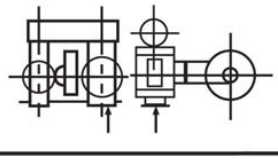
3.1.2 Classification of air compressors

There are various types of air compressors. The selection of air compressor depends on air quantity and pressure demand. Table 5 illustrates the classification of air compressor. Generally, it can be distinguished into 3 pressure ranges: low pressure (fan), medium pressure (blower), and high pressure (compressor).

In addition, the air compressor can be classified by turbo and positive-displacement types. Turbo type uses centrifugal force by blades to increase the velocity and the gas pressure, while the positive-displacement type increases the pressure by adjusting the volume using piston or movable vane.

The positive-displacement type is classified into rotary and piston types. The rotary type is divided into two-lobe, movable vane, and screw types.

Table 5 Types of blower and compressor

Name			Blower		Compressor
			Fan	Blower	
Type \ Press			Balow 1000mmaq	Aboue 1000mmaq and balow 10maq	Aboue 1kg/cm2
Turbo	Axial Flow	Axial Flow			
	Centrifugal	Multiblade			
		Radial			
		Turbo			
Positive displacement type	Rotary	Root's			
		Moriable varne			
		Screw			
	Raciproceting	Raciproceting			

3.1.3 Application range of blowers and compressors

The application of compressors is depended on the condition of usage such as the gas type, pressure and volume. Figure 14 shows the general application range of each blower and compressor.

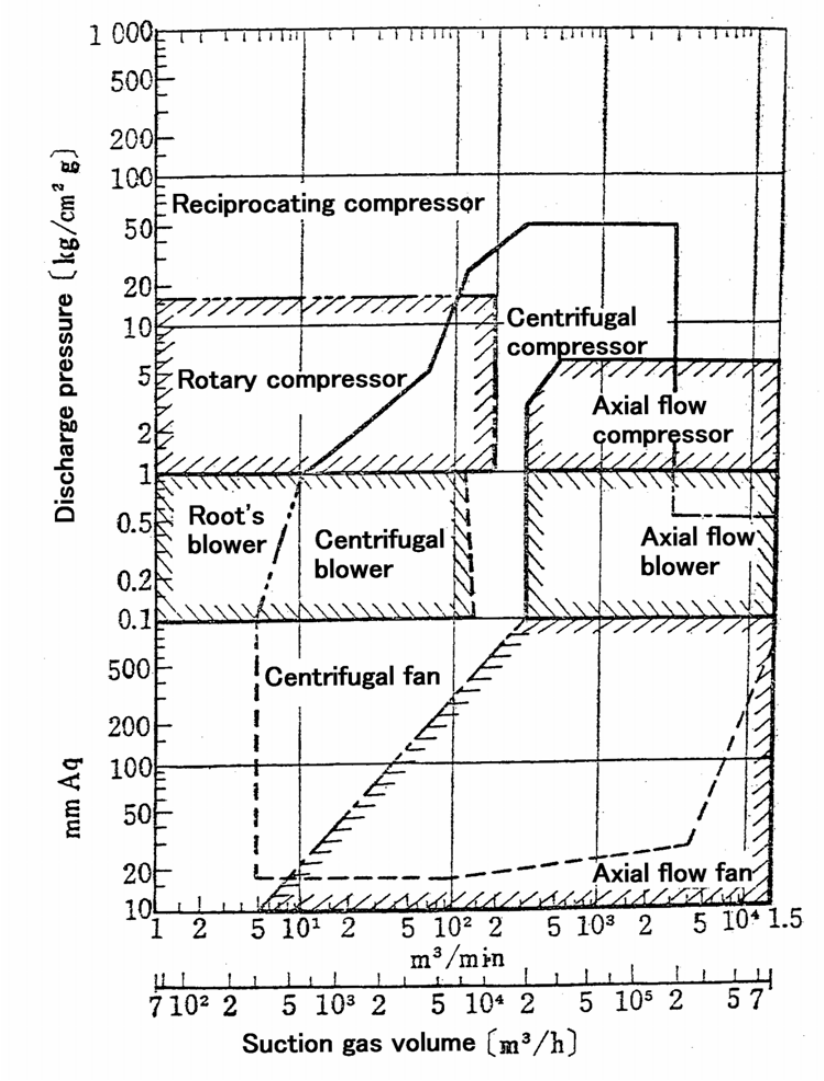


Figure 14 Application range of blowers and compressors

1 mmAq	=	1	kgf/m^2	=	9.8 Pa
1 mAq	=	0.1	kgf/cm^2	=	9.8 kPa
10 mAq	=	1	kgf/cm^2	=	0.098 MPa

3.2 Energy saving efficiency measure of air compressor

The energy saving efficiency measure of the air compressor consists of the good design of the system, the selection of appropriate compressor type and capacity, the tank size that provides enough air quantity to work on, and the diameter of the main pipe that helps create suitable air velocity and separate the condensate.

In addition, the pressure system should be properly designed. Reducing the air pressure from one point to another could unstabilize the pressure system while setting very high pressure will cause high-energy consumption. Selection of good equipment suitable for the function will help. Operation and maintenance should also be put in place. The energy conservation in air compressor can be operated as following.

3.2.1. The use of high efficiency air compressors

(1) Reciprocating air compressor

The more compression stages, the higher efficiency the reciprocating air compressor will be. Generally, the two-stage compression will be used. The air compressor with water-cooling system is better because it helps reduce air temperature during the compression. It can also be said that its isothermal process is of high efficiency.

Using double acting compressor will increase the efficiency, reduce wearing down, and help compress much air volume compared to the same size. The reciprocating type is suitable for unstable loads since it has good un-load equipment. The energy consumption in un-load period is small compared to other types. The control can be used multi-step in the part load operation, leading to higher efficiency. The reciprocating air compressor is shown in Figure 15.

Figure 15 Reciprocating air compressor

(2) Rotary Screw air compressor

The two untouched screws function this type of air compressor having low wear down. Rotary screw type has moderate efficiency due to the screw type structure which is determined constant pressure ratio, if being operated in low load and low rated pressure, its energy efficiency will be reduced. Therefore, the rotary screw air compressor is suitable for full and stable load. This will make higher efficiency. The rotary screw air compressor is shown in Figure 16.

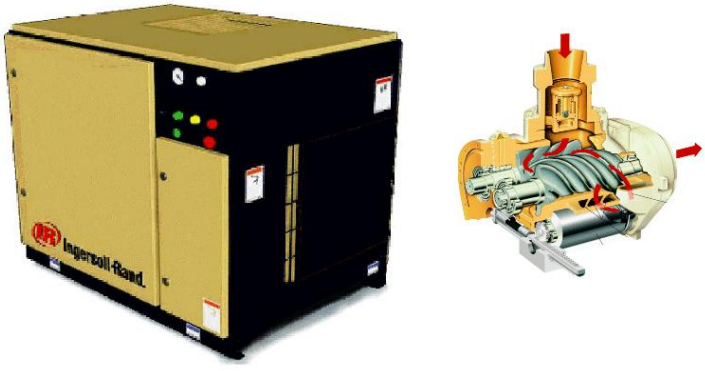


Figure 16 Rotary Screw Air Compressor

(3) Centrifugal Air Compressor

This type of Air Compressor, as shown in Figure 17, is of high efficiency and suitable for the amounts of large air quantity.

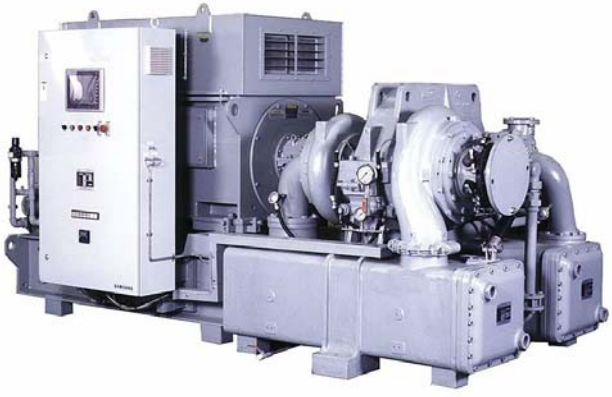


Figure 17 Centrifugal Air Compressor

(4) Variable Speed Air Compressor

Equipped with variable speed drive (VSD), this type of air compressor is suitable for the wide range of operation especially in the part load operation. It could help reduce air speed by 20% of full capacity. The machine can produce compressed air to meet the demand on consumption. Therefore this technology is appropriate for replacing reciprocating, rotary vane and screw air compressor.

The VSD cost is high but it could reduce losses of existing compressors in transmission e.g. gear or belt. However, it is necessary to ensure that this machine will operate on the low speed with oil coolant system to avoid resonant frequency.

The rule of thumb for air compressor is every 0.5 of pressure reduction it will save energy consumption of the air compressor by 3%.

The VSD air compressor is feasible for a variety of operation e.g. replacement of screw air compressor with load fluctuated by half of the time or more (see standard measure of DEDE). Figure 18 represents power consumption vs compressed air consumption. Table 6 and Table 7 represent example of energy efficiency evaluation and performance and cost effectiveness of different types of air compressors needed for improvement respectively

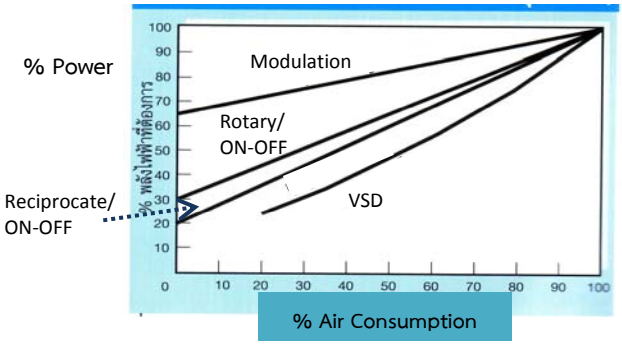


Figure 18 VSD compressor characteristic

Table 6 Example of energy efficiency evaluation

ECMs	Implement	Saving	Unit	Investment	Unit	Payback	Unit	Remark
1. VSD air compressor	☑ yes	483,361.57	[B/y]	1,480,000.00	[B]	3.06	[y]	Viable for load<50%>
2. High eff. Motor*	☐ yes	14,695.05	[B/y]	185,000.00	[B]	12.59	[y]	Viable for load<75%>
3. Multi Stage compressor	☐ yes	137,398.70	[B/y]	740,000.00	[B]	5.39	[y]	Less power consumed as same amount of air produced by 1-stage
Total (All ECMs seleted)		635,455.31	Baht/yr	2,405,000.00	Baht	3.78	Years	
Total (some ECMs seleted)		483,361.57	Baht/yr	1,480,000.00	Baht	3.06	Years	

Table 7 Example for considering performance and cost effectiveness of different types of air compressors needed for improvement

Energy Conservation Measures	Size range (kW)	Performance	Eff.	Estimated Investment Cost	Unit	*Estimated O&M Cost	Unit	*Remark
VSD Compressor	37 - 200	vary depends on load demanded	upto -35% less energy than fix speed compressor	40,000.00	[Baht/kW]	10.00%	of TLCC	Capital cost = 20%, Energy Cost = 50%, Maintenance cost = 10%, Saving =20% of Total Life Cycle Cost (TLCC)
Multi-Stage Compressor	75 - 450	16-18 kW/100CFM	2-stage eff > 1 stage eff =6% (reciprocate) , =13% (rotary screw)	20,000.00	[Baht/kW]	5.00%	of TLCC	Capital cost = 5%, Energy Cost = 80%, Maintenance cost = 5%, Saving =10% of Total Life Cycle Cost (TLCC)
High Efficiency Motors	0.75 - 300	N/A	82-95%	5,000.00	[Baht/kW]	1.00%	of TLCC	Capital cost = 5%, Energy Cost = 89%, Maintenance cost = 1%, Saving =5% of Total Life Cycle Cost (TLCC)

*Source :

1. Compressed air best practice, Sustainable Energy Authority of lreland (SEAI) Improving Compressed Air System Performance,

2. Improving Compressed Air System Performance, Compressed air challenge, USDOE

3. Motor Energy Management : Opportunities & Cost Savings, www.motormatters.org

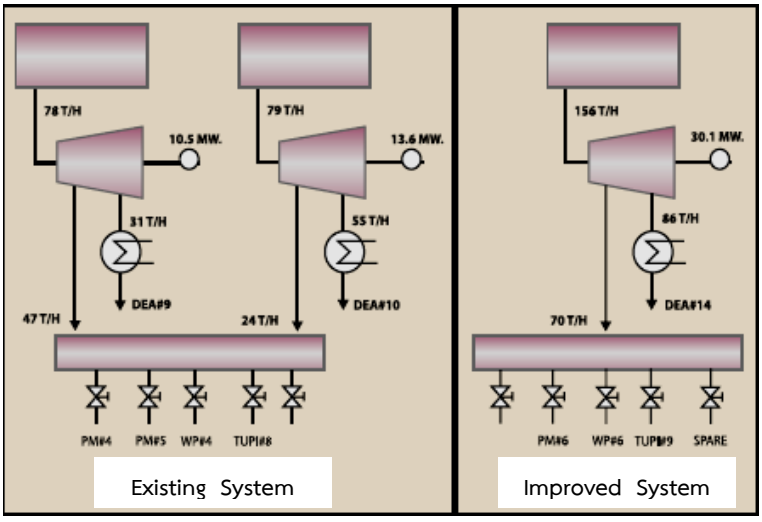
4. Energy Saving Potential and Opportunities for High-Efficiency Electric Motor, USDOE 2013

Annex B.

Case Study on Energy Conservation Measures

(Source: Department of Alternative Energy Development and Efficiency)

<u>Case Study 1</u> : Cogeneration System

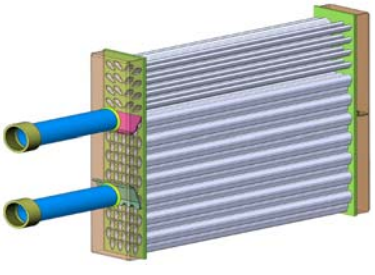


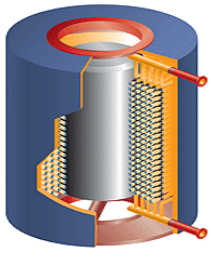
Factory	:	Siam Kraft Industry Co.,Ltd.	
Province	:	Kanchanaburi	
Type of Industry	:	Paper	
Details of measure	:	More energy source is required for factory expansion. CFB boiler woodchip and sludge with fuel-production capacity of 45 ton/day and 60 ton/day respectively have been installed to replace the existing boiler, leading to an increase in energy saving efficiency compared to the previous high-pressure steam which needs up to 156 ton/hr fuel for its 30MW power generation.	
Investment cost	:	650	Million Baht
Energy Cost Saving	:	7.6	Million Baht/year (coal reduction)
Payback Period	:	N/A	Year (No information of other cost saving)

Case Study 2 : Cogeneration System

Factory	:	Thai Union Paper PCL.
Province	:	Samutprakarn
Type of industry	:	Paper
Detail of measures	:	Twin screws press-type of water pressing machine aimed at reducing humidity of fiber used as fuel together with coal fire. The boiler could produce up 34.5 tons of steam with 65-barpressure within an hour to feed into the steam turbine for generating 3.56MW electricity.
Investment Cost	:	2.9 Million Baht (Twin Screws Press)
Energy Cost Saving	:	3 Million Baht/year (Coal reduction 6.67 ton/day and sludge disposal cost 864,000 Baht/year)
Payback Period	:	1 year

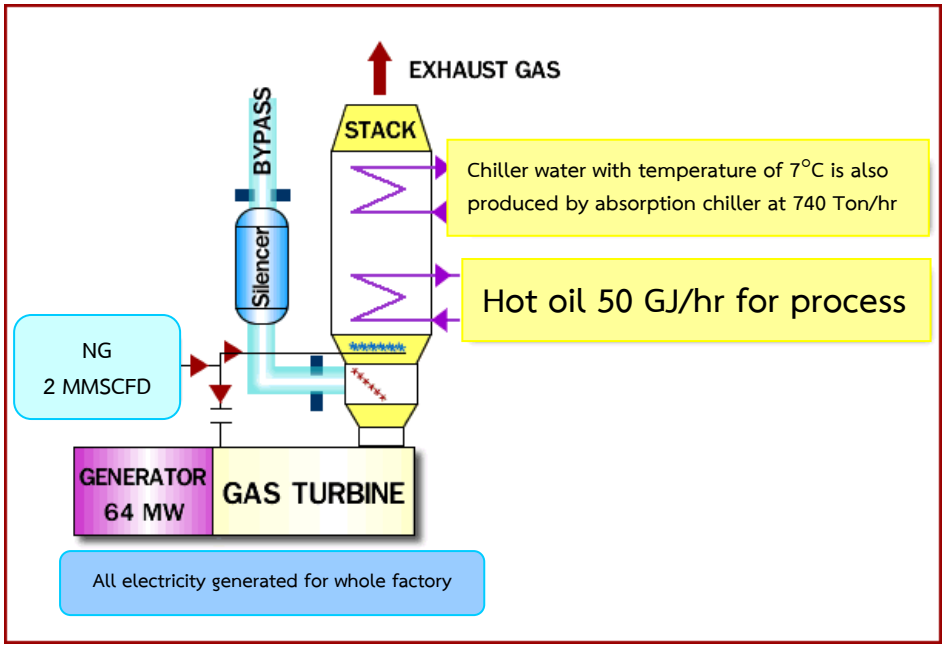
Case Study 3 : Waste heat recovery by the economizer





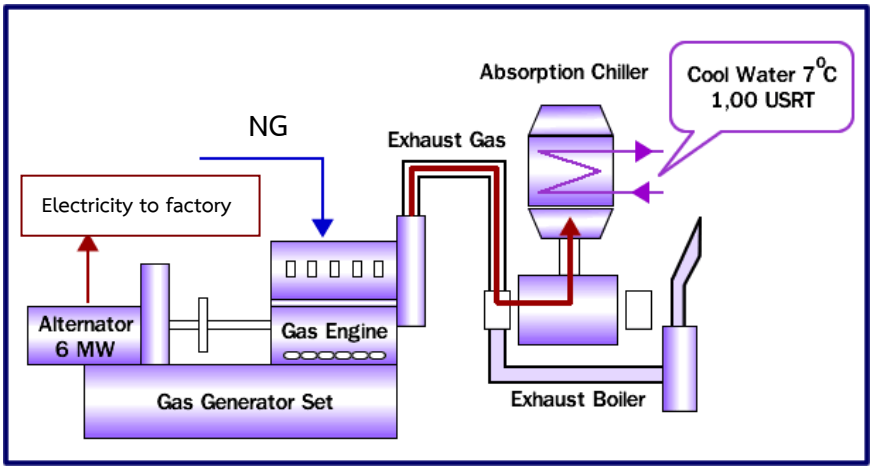
Factory	:	Green Spot (Thailand) Co., Ltd.
Province	:	Pathumthani
Type of industry	:	Food & Beverage
Details of measure	:	Install economizer to exchange heat recovery from 240°C flue gas totaling 14 tons/hour for preheating feed water in the boiler from 88°C to 130°C. The economizer help reduce natural gas consumption by 5%
Investment Cost	:	1.7 Million Baht
Energy Cost Saving	:	2.2 Million Baht/year
Payback Period	:	0.7 Year

Case Study 4 : Gas Turbine Cogeneration & Absorption Chiller Installation



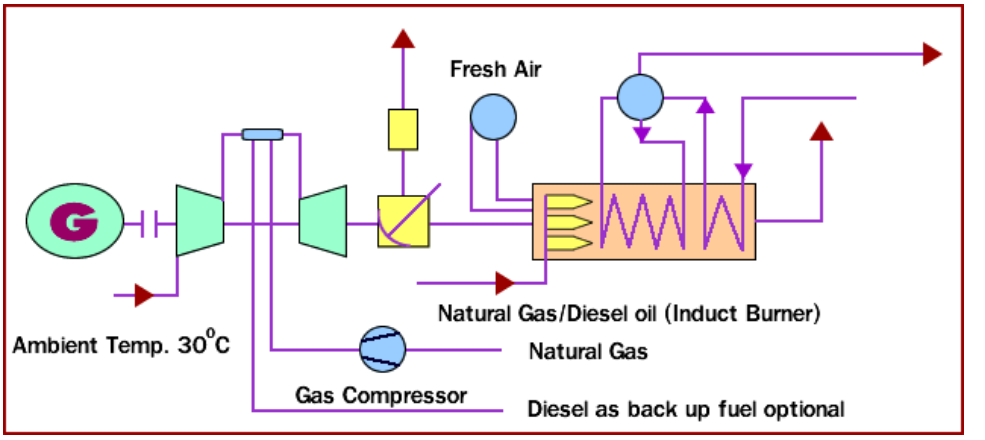
Factory	:	Bangkok Polyester Co.,Ltd.
Province	:	Rayong
Type of industry	:	Chemical (Plastic Pellets)
Details of measure	:	Gas Turbine Cogeneration with electricity generation capacity of 6.4 MW is installed. The waste heat from absorption chiller is recovered to exchange with hot oil at 50GJ/hr. Cooling water with temperature of 7°C is also produced by absorption chiller at 740 Ton/hr
Investment Cost	:	N/A Million Baht
Energy Cost Saving	:	N/A Million Baht/year
Payback Period	:	N/A Year

Case Study 5 : Gas Turbine Cogeneration & Absorption Chiller Installation



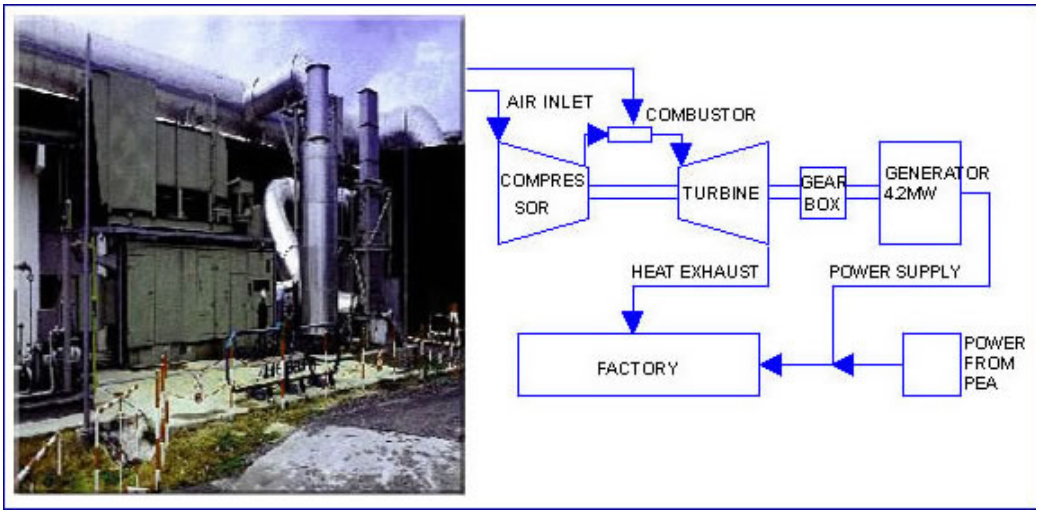
Factory	:	Crown Seal PCL.
Province	:	Bangkok
Type of industry	:	Metal products (Caps of can/bottle)
Details of measure	:	Install Gas Turbine Cogeneration 6 MW, waste heat recovered for absorption chiller at 1,080 tons/hr. Cool water with the temperature of 7°C is produced.
Investment Cost	:	N/A Million Baht
Energy Cost Saving	:	N/A Million Baht/year
Payback Period	:	N/A Year

Case Study 6 : Gas Turbine Cogeneration Installation



Factory	:	Central Paper Industry PCL.
Province	:	Samutprakarn
Type of industry	:	Paper
Details of measure	:	Install Gas Turbine Cogeneration 4.4 MW electricity, Waste heat producing steam at 30 tons/hr, 170°C, 7Bar for process.
Investment Cost	:	N/A Million Baht
Energy Cost Saving	:	N/A Million Baht/year
Payback Period	:	N/A Year

Case Study 7 : Gas Turbine Cogeneration Installation



Factory	:	Thai Gypsum Co.,Ltd.
Province	:	Chonburi
Type of industry	:	Non Metallic (Gypsum)
Details of measure	:	Install Gas Turbine Cogeneration 4.2 MW electricity, waste heat 71.1 tons/hr at 30°C utilized in process.
Investment Cost	:	N/A Million Baht
Energy Cost Saving	:	N/A Million Baht/year
Payback Period	:	N/A Year

Case Study 8 : Gas Turbine Cogeneration & Absorption Chiller Installation

Factory	:	Thai Taffeta Co.,Ltd.
Rayong	:	Rayong
Type of industry	:	Textile (Export)
Details of measure	:	Install Gas Turbine Cogeneration 10 MW electricity, waste heat producing steam 24 ton/hr for absorption chiller to produce chilled water
Investment Cost	:	N/A Million Baht
Energy Cost Saving	:	N/A Million Baht/year
Payback Period	:	N/A Year

Case Study 9 : An installation of recuperator utilizing waste heat from the furnace to preheat combustion air

Factory	:	PPG-Siam Silica Co.,Ltd.
Province	:	Rayong
Type of industry	:	Chemical (Silica Powder)
Details of measure	:	Install recuperator recover waste heat from flue gas with temperature of 1,100°C for preheating combustion air from 35°C to 550°C. The rest of the waste heat will be used for producing 70-80°C hot totalling 6,000 litre/hr for cleaning during the process.
Investment Cost	:	10 Million Baht
Energy Cost Saving	:	3 Million Baht/year
Payback Period	:	3.3 Years

Case Study 10 : An installation of the regenerator utilizing waste heat from melting furnace to preheat combustion air

Factory	:	Tha Glass Industry PCL.
Province	:	Bangkok
Type of industry	:	Container Glass
Details of measure	:	Install regenerator 2 units with the furnace using heat with the temperature of 1,500°C to preheat combustion air from 35°C to 1,200-1,300°C. Help save energy by 30%.
Investment Cost	:	20 Million Baht
Energy Cost Saving	:	12.2 Million Baht/year
Payback Period	:	1.6 Years

Case Study 11 : Waste Heat Boiler Installation

Factory	:	Thai Carbon Black PCL.
Province	:	Rayong
Type of industry	:	Petro-Chemical (Carbon Black Powder)
Details of measure	:	Install waste heat boiler utilizing waste gas from the process at 150,000 m^3/h to produce 400°C steam totalling 130 ton/hr at 42 Bar and drive steam turbine for generating electricity totalling 17.5 MW. The low pressure steam at 3.5 Bar can be sold to other factories. The energy efficiency rate is at 25-30%.
Investment Cost	:	300 Million Baht
Energy Cost Saving	:	300 Million Baht/year
Payback Period	:	1 Year

Case Study 12 : Waste Heat Boiler & Absorption Chiller Installation

Factory	:	Crown Seal PCL.
Province	:	Bangkok
Type of industry	:	Metal Products (end caps)
Details of measure	:	Install gas engine cogeneration + waste heat boiler+ absorption chiller using gas engine at 3x2MW. Waste flue gas with 500°C temperature at 150-210 m^3/h per unit, totalling 3 units provided to waste heat boiler totalling 3x1.56 tons/hr at 6 Bar. The steam generated could also provided to absorption chiller at 3x360 tons/hr producing chilled water for the process and space cooling.
Investment Cost	:	160 Million Baht
Energy Saving	:	25%
Payback Period	:	10 Years

Case Study 13 : Installing VSD for air compressor

Factory	:	Carpet Inter Thailand PCL.	
Province	:	Pathumthani	
Type of industry	:	Textile	
Detailsof measure	:	Install Variable Speed Drive (VSD) for Screw Air Compressor 250kW (Existing Unload time 40%)	
Investment Cost	:	550,000	Baht
Energy Cost Saving	:	423,000	Baht/year
Payback Period	:	1.3	Years

Case Study 14 : Installing High Efficiency Air Compressor

Factory	:	DEDE case study project.	
Details of measure	:	Install a unit of two-stage screw air compressor 150kW to replace a unit of 37kW air compressor and a unit of 112 kW.	
Investment Cost	:	2,600,000	Baht
Energy Cost Saving	:	553,429	Baht/year
Payback Period	:	4.7	Years

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