Co-Generation and the New Era of Absorption Chiller

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ABSTRACT

This paper provides an overview of modern Power Plant with Co-generation system that recover waste exhaust heat to run absorption chiller and produce chilled water. The energy market transformation provides new opportunity for privately owned Power Plant, which could be as small as 75 kW up to 10 MW. ***By Co-generation, the industry will have more than 35% lower electricity cost as well as plenty of free cooling and/or heating****.*

INTRODUCTION

In Thailand, privately owned Power Plant of less than 10 MW does not have to prepare environmental impact study or the Environmental Impact Assessment-EIA. EIA is normally required on IPP and SPP power producer, and could lead to controversy and delay, especially when the project is in the community, coastal, or outside industrial estate. Therefore, individual industry or group of industries could invest on its own Power Plant easily when natural gas pipeline is available.

It is also an opportunity for private to invest on Co-generation plant, and the government should support the business by considering supply of natural gas as part of utility infrastructure and allow Co-gen operator to use right of way for the supply of chilled water and/ steam in certain district.

Modern gas turbine technology for electricity generation allows cheaper cost of producing electricity by natural gas and the cost of electricity could be only $ 0.35/kW-hr instead of $ 0.6/ kW-hr from the utility net work. That is a tremendous production cost saving. The amount of waste exhaust heat from gas turbine is huge and can be recovered to produce chilled water and/or steam. Exhaust heat from 1000 kW gas turbine could produce approx. 750 RT 7C chilled water or 2.2 ton/hr 8 bar steam. With such benefit, it could be clearly seen that **the modern Power Plant and Co-generation would become a new key of success factor for the industry and provide the industry with a new competitive edge in the world market.** Cost savings from the modern Power Plant has highest impact when compared to all other variable costs.

Steam absorption chiller is presently the most familiar type of absorption chiller. But that is not the only choice, and direct fired absorption chiller or even direct exhaust absorption chiller is also available. Why bother with heat recovery steam generator and steam plant if there is no steam requirement.

Modern absorption chiller can be designed to be **direct fired** by natural gas, bio-gas, and fuel oil or even run by **direct exhaust** air from gas turbine. Therefore, the whole steam plant can be eliminated and the investment will be much less. Besides, **modern absorption chiller can provide both chilled water and hot water.**

BACK TO BASIC

Absorption refrigeration was the pioneer technology used for refrigeration as could be traced back to the old time oil fired home refrigerator. At present, Electrolux is still supplying silent electric absorption refrigerator for 5 stars hotel.

Using water as refrigerant, absorption refrigeration is environmental friendly.

Blamed on its low COP of 1 compared to the compression type refrigeration with COP higher than 2. Previous development on refrigeration and air-conditioning has been dominated by compression refrigeration technology.

All the effort has been contributed to the development of refrigeration compressor and CFC refrigerant. The North America has become the world leader as the manufacturer of refrigeration and air-conditioner. No one could compete with USA on sophisticate manufacturing technology of compressor and refrigerant. Until, the mother earth yells back that high consumption of energy, green house effect,

CFC has been destroying the earth. After that, the best that the world leader can do to protect the world environment is to develop the new compressor and using better environmental friendly refrigerant. Water as refrigerant is coming back. Ammonia system is rising but with safety precaution.

No one knows why absorption refrigeration has not really been further developed since the early days. **Is it because the technology is too simple and allow anyone to compete?**

To rethink about the whole story, if we could go back and we have been using absorption refrigeration, there would have been more manufacturers and not limited to a few major brands that supplying refrigeration and air-conditioning all over the world. Asia could have been the world leader in this field, since we are in tropical climate.

We have been using electricity as prime source of retail energy. Our Power Plant and electricity distribution net work has been throwing more than 60% of energy resource into the air and river. We have tried to save some of the energy by developing higher electrical equipment efficiency such as lighting, high EER refrigerator and air-conditioner. I would like to ask you, are these measures compatible with the 60% lost at the power plant? **Why don't we tackle the problem at its root**. *Why do we still allow inefficiently use of energy resource and not capture most of it.*

CAPTURING WASTE ENERGY

Japan is a good example for the country that knows the value of energy resource, since Japan has to totally import energy and has huge demand of energy for industries and cities. There are hundreds of District Heating and Cooling systems (DHC) in Japan, where 85% of the import energy has been converted to consumable energy. Certainly, this system has been contributed as an important key of success for Japan.

DHC Co-generation plant in Japan supplies steam for heating and chilled water for cooling as part of town utility.

Absorption chiller has no development during past decades and only major market in Japan. Japan has become the leader for absorption chiller manufacturer, especially for steam absorption chiller. **Korea** follows Japan and also manufacturing absorption chiller.

DHC Co-generation plant in Tokyo.

India has used absorption chiller for industries and textile factory. These absorption chiller are mostly steam absorption chiller.

Absorption chiller is rising against electric chiller with the quest for better world and environment. Major electric chiller manufacturers are now realized that the era of electric chiller is

diminishing and next decade will be different. With high cost of production, the manufacturing facilities are moving to China, Mexico and South East Asia.

Besides steam absorption chiller, manufacturers are now also supplying direct-fired absorption chiller and running R&D on direct exhaust absorption chiller. Since, absorption chiller construction is simple. It is not difficult to develop other type of absorption chiller. Basic construction of absorption chiller is the same for every type with only the change in the part of heating chamber or heat exchanger for the solution generator.

COP for absorption chiller of 1.2-1.3 is now available and the machine has only a few moving parts and very low maintenance cost.

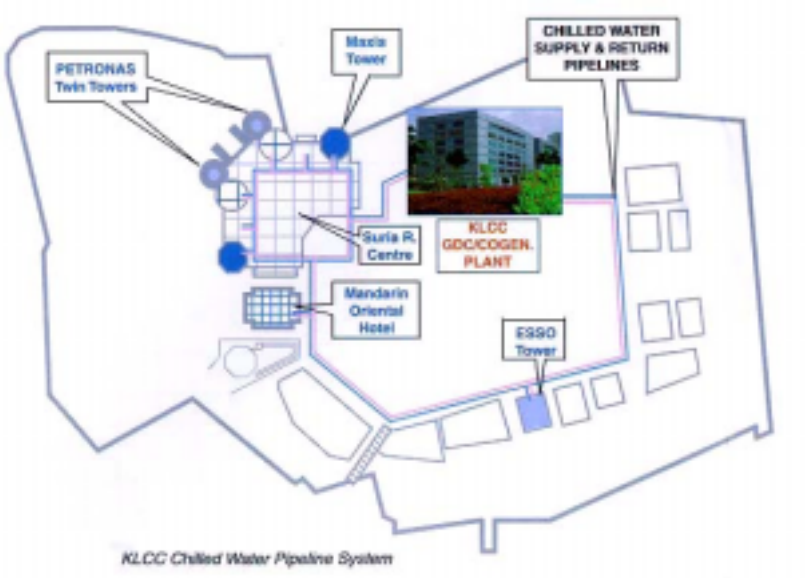
In the last decade, with the fast development of **China**, there has been great demand for chiller. Therefore, China becomes the market with very high prospect. Electric chiller manufacturers have high hope for China market, which could substitute down trend South East Asian market. However, life is not as planned. Electric chiller, especially centrifugal chiller is too complicate to operate and maintain. China is too big to have good service net work set up in a short time. A lot of electric chiller fails to operate properly. Poor electricity and water quality, China needs a simple air-conditioning machine, rugged and very reliable, since many places rely only on one machine.

Absorption chiller has debut as the solution to the trouble electric chiller. Electric chillers have been gradually replaced with direct-fired absorption chiller. At present, thousands of direct-fired absorption chiller have already been installed and a thousand more each year.

Therefore, **China becomes the largest market for absorption chiller and the world leader in absorption chiller manufacturing**. With high competition, ex-factory price of absorption chiller has recently drop from approx.$700/ RT to $400/ RT and with better improvement. Indian make absorption chiller is no doubt the cheapest. Korean, Japanese and Chinese made are competitive but US made are expensive.

Direct fired absorption chiller installation in China.

Malaysia has the lead on implementing Co-generation and District Cooling system (DC) at KLCC twin tower, KLIA- new international airport, Putrajaya-new government town, Ciber Jaya-new Silicon town, Petronas new university.



DC Co-generation plant in Malaysia.

Thailand has just started with DC Co-generation for the new Suwanapoom (Nong Ngu Hao) airport.

Capturing and make use of waste exhaust heat is becoming a new business and market in South East Asia.

Capturing solar, wind energy or recycle of waste is by no means comparable.

CONVENTIONAL CO-GENERATION PLANT

Conventional Co-generation with gas turbine and heat recovery steam generator (HRSG) at the exhaust stack to produce high steam pressure . The high pressure steam has been used to run steam turbine generator to produce electricity. Excess steam could be supplied to nearby industry. Most IPP and SPP operator are having this arrangement. However, there is more excess steam supply than demand, especially when the industry demand has been dropped because of economic recession. Therefore, this waste energy has not been captured and most of the IPP and SPP are still depend on producing and selling of electricity.

CO-GENERATION PLANT AND DISTRICT COOLING SYSTEM (DC)

This Co-generation plant use gas turbine and heat recovery steam generator (HRSG) that produce high pressure steam to run steam turbine generator and steam turbine chiller. At KLCC twin tower in Malasia, The Co-generation plant supplies electricity and chilled water for KLCC District Cooling system. Electric chiller and auxiliary boiler supplement the system.

Previous Malaysian projects had not used steam turbine chiller but only steam absorption chiller, which is more simple and straight- forward design. Recent projects are heading toward direct-fired and direct exhaust absorption chiller.

DC Co-generation Plant is rising and Thailand is going along with Malaysia. Prime source of energy will be natural gas, which is clean and will have greater supply after completion of the Trans-Malaysian natural gas pipeline.

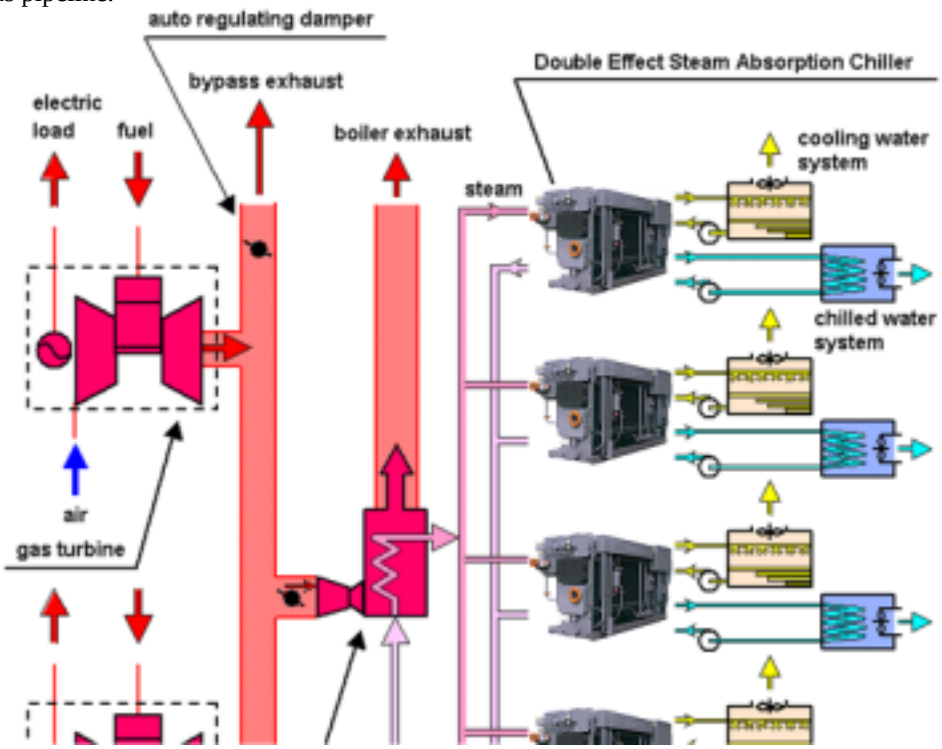


Diagram of conventional DC Co-generation system using HRSG and steam absorption chiller.

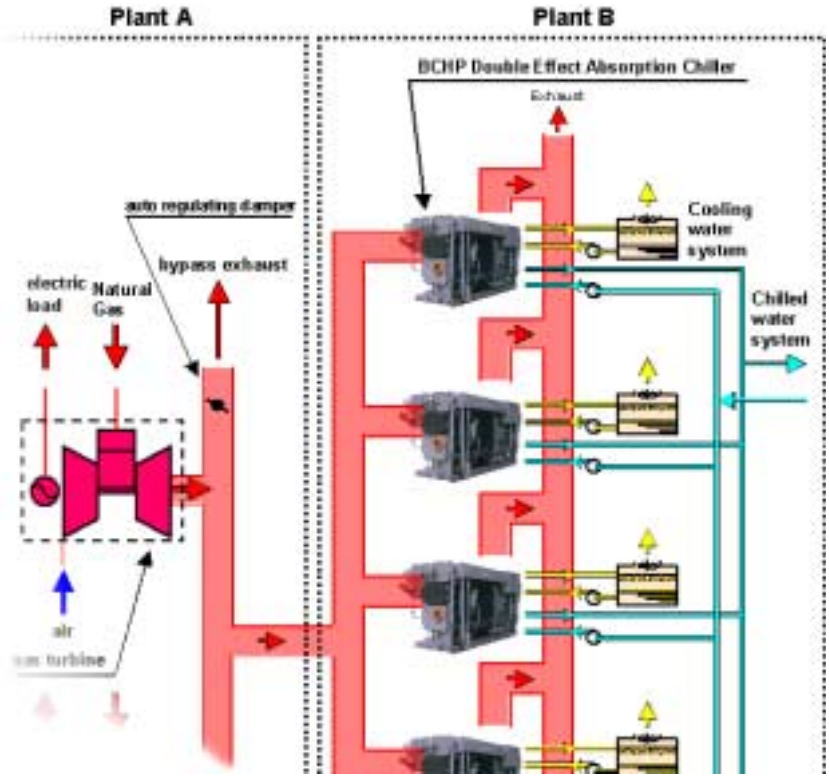


Diagram of DC Co-generation system using direct exhaust absorption chiller.

MODERN CO-GENERATION WITH DIRECT EXHAUST ABSORPTION CHILLER

Small to medium size gas turbine manufacturers such as Parallon and Solar Turbine are running R&D with prominent absorption chiller manufacturer to couple gas turbine with direct exhaust absorption chiller. **The package will supply both electricity as well as FREE chilled water.**

Standard size of Parallon is 75 kW. Solar Turbine could supply from approx. 1000 kW to 10 MW. Cooling capacity start from approx.50 to 5000 RT.

The direct-fired absorption chiller could also be equipped with auxiliary burner.

In tropical climate, the chilled water could be used to pre-cool inlet air to the gas turbine to improve its efficiency.

Small gas turbine coupled with Direct exhaust absorption chiller.

WHAT HAS BEEN IMPROVED ON ABSORPTION CHILLER

Each manufacturer has been developing a better version of absorption chiller, especially towards a larger unit. Previous absorption chiller is normally less than 1000 RT and a larger unit has been assembled from several smaller units. With the larger requirement in District Cooling system, which could be more than 10000 RT, a larger absorption chiller has been manufactured up to 3000 RT. Larger absorption chiller is more competitive and easy to operate.

Development of absorption chiller has been aimed at having higher efficiency and quality. Though, absorption chiller has simple construction but there are also a few things that could cause problems such as corrosion and crystallization. Therefore, not all absorption chillers are reliable and the good unit could last 20 years while a bad unit could last only a few years. The unit should also be tested and certified according to international standard such as ARI, JIS, UL listed.

COP

It is no surprise for COP of 1.3 for double stage absorption chiller with the improvement of heat exchangers and heat recovery in the solution cycle process. With single stage absorption chiller, COP is normally half and therefore only use in low pressure steam application or hot water.

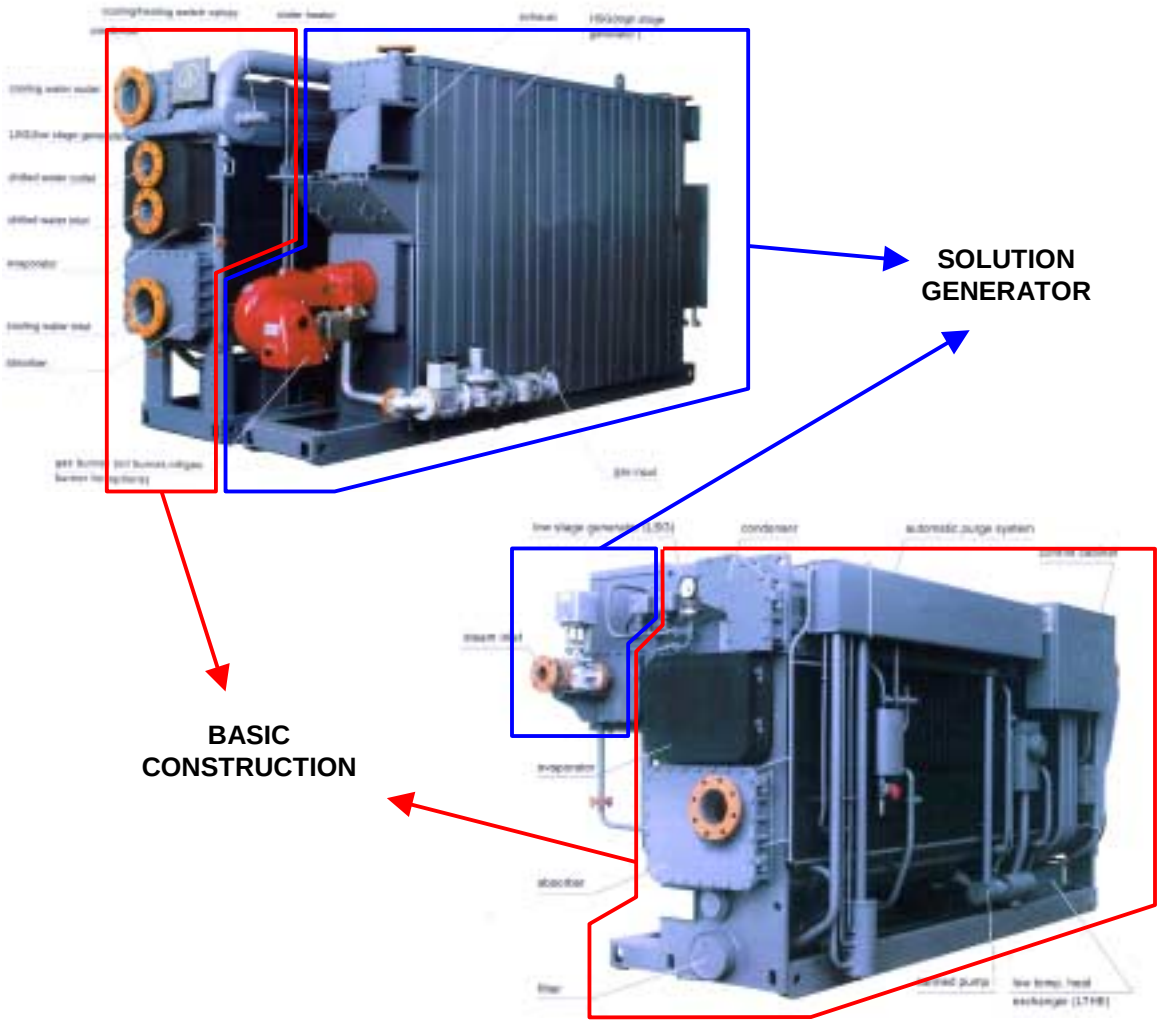
CONSTRUCTION

Modern absorption chiller is more compact and a large unit could be put into an existing building that has space and height limitation.

Better manufacturing equipment such as robotic welding, metal surface treatment, testing and better quality of steel, stainless steel and copper make them trouble free and very long life.

SOLUTION GENERATOR

As mentioned earlier, the basic construction of absorption chiller is the same for all type of absorption chiller. Types of absorption chillers are differentiated by the different in solution generator.



Basic construction of absorption chiller could be divided into 2 parts. The 2nd part, which is the generator, determines type of absorption chiller.

Steam Absorption Chiller

Using steam coil to generate the solution. Steam pressure for double stage absorption chiller is between 4 -8 bar and with a lower steam pressure, the single stage will be applied. Steam has been a prime source of heat since steam supply is available in general Co-generation plant. Several industries still using steam since they could use waste wood, sugar cane, husk, lignite as their energy source, which is very low cost. With increasing air pollution awareness, these industries will be decreased.

Direct Fired Absorption Chiller

Using burner with natural gas or oil. The unit is not a pressure vessel as boiler and could produce both chilled water and hot water, which is a very nice set up for hotel application as well as projects that has limited electricity supply.

Direct Exhaust Absorption Chiller

With the availability of gas turbine for electricity generation from small to larger unit, direct exhaust absorption has been develop as a package to the gas turbine that supply both electricity and cooling. Previous package has been designed to pre-cool the entering air to the gas turbine, and improve its efficiency. The unit has similar construction to the direct- fired unit and could also be equipped with auxiliary burner.

Exhaust gas entering temperature is in the range of 400-500 C and the outlet temperature is 200 C to avoid condensation in the flue stack.

LiBr

Since LiBr is very important component in the absorption chiller and condition of LiBr could trouble shoot the condition of the unit. Therefore, only high quality of LiBr should be used.

Modern absorption chiller will be designed to be automatically de-crystallized and avoid problem of crystallization.

CONTROLS

Modern controls allow better part load control and alarm monitoring. It could also allow unmanned operation of the unit by remote monitoring and control.

SUMMARY AND DISCUSSION

It is evident that Co-generation and District Cooling system will become the prominent technology for further development of South East Asia, when the price of energy is high and increasing. Air-conditioning demand will increase further, since air-conditioning has become a key factor for the productivity efficiency in most industry.

When looking at the cooling capacity that could be produced by waste exhaust heat from gas turbine, say 500 –800 RT for 1000 kW gas turbine, it is astonishing figure and it is really a figure that everyone should look into.

District Cooling system should become the concept of town development and part of utility. The system could reduce power demand for air-conditioning tremendously and reduce build up of heat island in the city.

National Energy Policy should clearly state the Co-generation and District Cooling Policy. Malaysia should be admired as the country that has long sighted vision and a good example for other South East Asian countries.