



Industrial Carbon Neutral

Action Plan of BROAD Air Conditioning

Low Carbon Technology

Low Temperature Waste Heat Recovery——Heat pump recovers low-temperature waste heat to reduce heating energy consumption

Medium Temperature Waste Heat Cooling——Middle temperature waste heat drives absorption chiller for zero carbon cooling

Combined Cooling Heating&Power(CCHP)——Residual pressure steam, high temperature exhaust gas, jacket water from power generation for zero carbon cooling

Super Efficient Energy Station(SEES)——Energy saving technologies and control system to realize the high efficient and low cost operation of energy station





BROAD TOWN
HQ & Manufacture Base
Area Coverage:1 km²



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BROAD Low Carbon Solutions

Since the beginning of the Industrial Revolution, human activities have shaken the natural balance of the planet like never before. The carbon cycle system bears the brunt, and the balance between carbon sources and carbon sinks is no longer, triggering the world to think about the consequences of global warming and sea level rise. According to the IPCC's Special Report "Global Warming of 1.5°C", human activities have caused the global temperature rise by 1°C relative to that before the Industrial Revolution. If the 1.5°C temperature rise is to be controlled, 45% carbon emission should be reduced by 2030 compared to 2010, and net zero emission should be achieved by 2050. This will lead to a "rapid and far-reaching" transformation of systems such as energy, industry, building, transportation, agriculture, etc., which will be unprecedented in history.

It is imperative for the world to reach carbon peaks and become carbon neutral, and everyone is happy to see this great cause as an opportunity, and we see it as a glorious mission. Many people are eager to achieve carbon neutrality through new technologies and new methods, and focus on new energy technologies, carbon sink technologies, carbon capture and storage technologies, but fundamentally ignore the simplest way to reduce carbon - energy conservation and efficiency.

Industrial waste heat is a huge energy reservoir, and only 40% waste heat is utilized. If the discharged waste heat can be recycled and utilized, not only the enterprise will gain economic benefits from energy saving, but more importantly, industrial carbon reduction will take a big step forward.

Since its establishment, BROAD has firmly adhered to the road of green and low-carbon development, and has successively developed low-temperature waste heat recovery technology, medium-temperature waste heat cooling technology, CCHP technology, and SEES technology. And put forward the energy use principle of "Priority for renewable energy and waste heat, Balance well for gas and electricity utilization". We hope to apply these low-carbon technologies and concepts to industry and help the world achieve carbon neutrality soonest.

North Pole is in sight, where is the future of the earth?

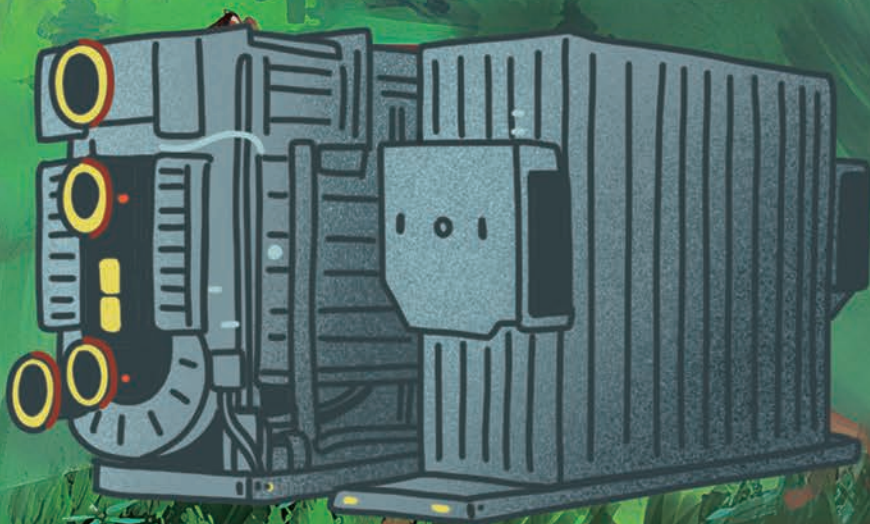
Zhang Yue, 2009.05.28

Every BROAD absorption
chiller(1,163kW)

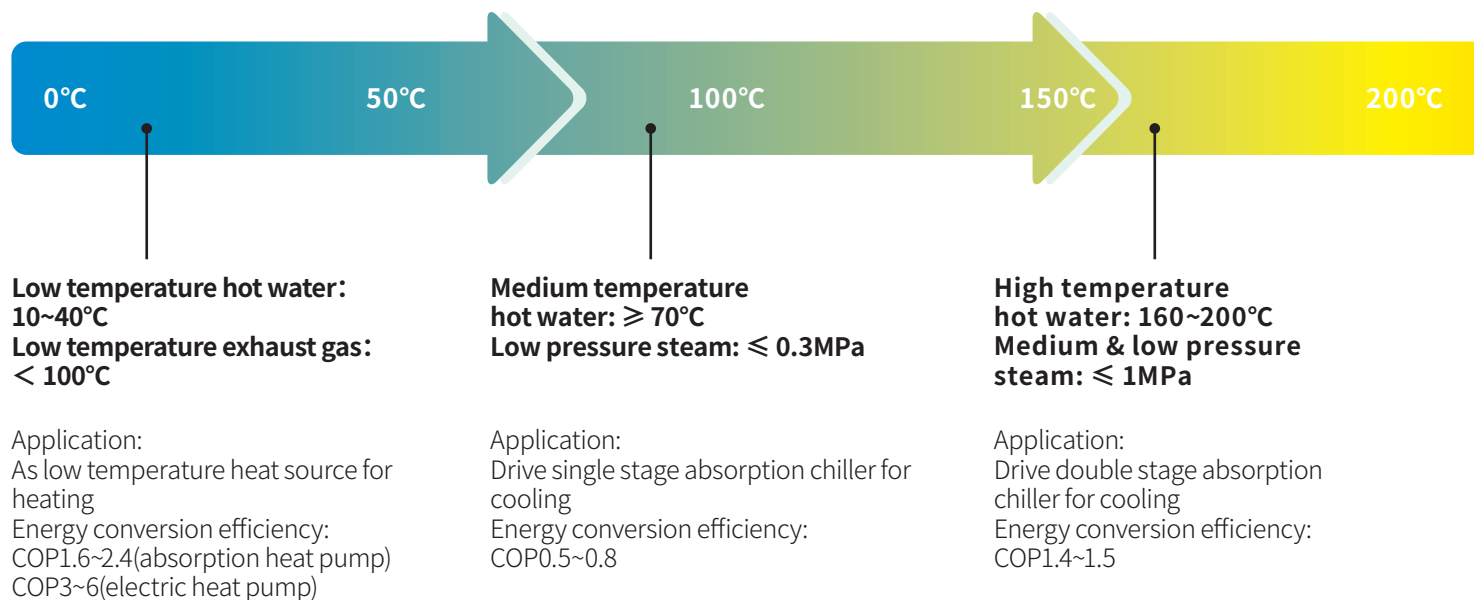
**Standard coal
saving:
652t/Y**

**CO₂ emission
reduction:
1,695t/Y**

**Equivalent
to tree
planting:
92,600trees/Y**



Waste Heat Utilization Methods



Note: COP refers to the ratio of the output cooling or heating capacity/the input driving heat source, and is the most important indicator to measure the performance of the unit

Low Temperature Waste Heat Recovery Technology

—— Heat pump

Absorption heat pump:

Use high-temperature heat sources (such as steam, high-temperature hot water, natural gas, etc.) to drive absorption heat pumps to recover low-grade waste heat, and produce hot water for central heating, process heating, etc.

Electric heat pump:

Use electricity to drive heat pump to recover low-grade waste heat and produce hot water for building, process, etc.

Medium Temperature Waste Heat Recovery Technology

—— Absorption chiller

Single stage chiller:

Use medium-temperature waste heat (such as medium-temperature hot water ≥70°C, medium-temperature exhaust gas ≥250°C, low-pressure steam >0MPa, etc.) to drive single stage absorption chiller, and produce chilled water for building, process, etc.

Double stage chiller:

Use high-temperature waste heat (such as steam ≥0.3MPa, high temperature hot water ≥160°C, natural gas, etc.) to drive double stage absorption chiller, and produce chilled water for building, process, etc.





300°C

400°C

600°C

**High temperature exhaust
gas: 250~600°C**

Application:
Drive absorption chiller for cooling
Energy conversion efficiency:
COP1.5 (500°C)
COP0.8 (300°C)

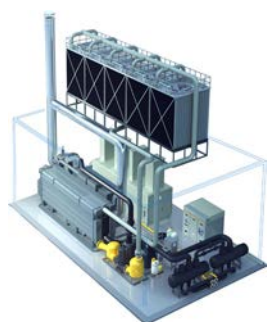
**Ultra high temperature
exhaust gas: >600°C**

Application:
Use for power generation as priority, electricity and
waste heat to be used for cooling
Energy conversion efficiency:
COP1.5 (absorption chiller)
COP6.4 (power efficient chiller)

Power Generation Waste Heat Recovery Technology

—— Combined Cooling Heating and Power(CCHP)

The waste heat after power generation drives absorption chiller for cooling and heating, and realizes the "temperature counterpart, cascade utilization" of energy, and the primary energy utilization efficiency can exceed 90%.



Super Efficient Energy Station(SEES)

—— Multi-energy complementary system

The model of factory manufacturing and on-site assembly is adopted, and its core includes four key parts: the selection of energy saving products, the application of energy-saving technologies, system optimization design, and energy-saving operation and maintenance, the most economical system operation in a complete cycle and each equipment is better than the national maximum energy efficiency.





Use Heat to Produce Cooling, Magical Refrigeration Technology

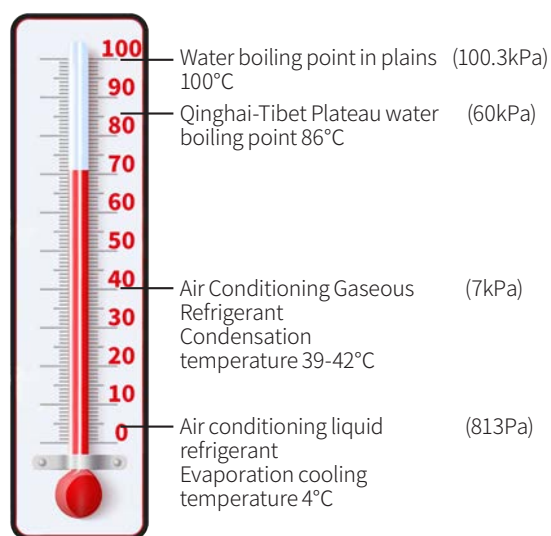
— Understanding the cooling principle of absorption chiller from the common sense of life

The liquid absorbs the surrounding heat as it evaporates. For example, if you sprinkle alcohol on your hands, you will feel cool; in autumn, it will be particularly cold just out of the water, because the liquid absorbs heat from the skin surface during the evaporation process.

Hot and cold, seemingly contradictory opposites unify in absorption chiller

Absorption chiller uses the principle of water evaporation to absorb heat. The biggest problem faced by water as a refrigerant is that the boiling (ie, violent evaporation) temperature of water is 100°C, and it is impossible to produce 7 °C chilled water. However, the boiling point of water will decrease with the decrease of atmospheric pressure. For example, on the Qinghai-Tibet Plateau, the atmospheric pressure is only 60kPa, and the boiling point of water drops to 86°C. Therefore, a pressure cooker must be used to cook on the plateau.

If an extreme vacuum is created, the boiling point of water will drop below 5°C, thus producing 7°C chilled water.



Boiling and condensation temperatures of water at different pressures

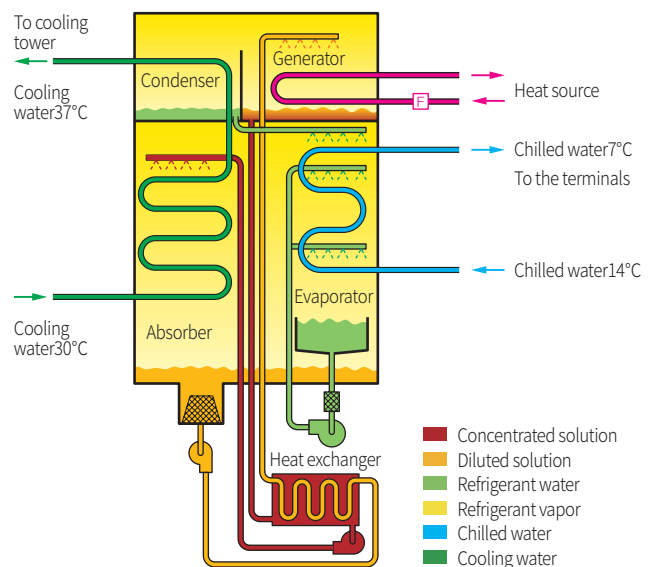
Absorption Chiller Cooling Principle

Evaporation cooling: In an evacuated airtight container (evaporator), when the air pressure drops to 813Pa, the boiling point of water drops to 4°C. The refrigerant water is sprayed on the evaporator tube to boil and evaporate, absorb the heat of the chilled water in the tube and cool down the chilled water to 7°C, and deliver it to the terminals.

Water vapor absorption: The water vapor produced by boiling evaporation causes the pressure in the evaporator to rise. In the absorber (in the same airtight container as the evaporator), spray a highly absorbent substance-concentrated lithium bromide solution, continuously absorb water vapor, and maintain the vacuum in the container below 813Pa. The heat released in the process of absorbing water vapor is taken away by the cooling water.

Solution regeneration: The diluted lithium bromide solution is sent to the generator by the canned pump (in the same evacuated airtight container as the condenser, the pressure is about 7kPa) and heated & boiled by the heat source (waste steam, waste hot water, waste exhaust gas or natural gas, etc.), producing concentrated lithium bromide solution and refrigeration vapor. The concentrated lithium bromide solution enters the absorber and absorbs water vapor again to complete the solution cycle.

Water vapor condensation: The refrigeration vapor generated in the generator enters the condenser and is condensed into water by the cooling water, and finally enters the evaporator for cooling to complete the refrigerant cycle. The cooling water enters the cooling tower to cool down and returns to the absorber.



Absorption chiller cooling process

Heat Pump, a Core Equipment for Low Temperature Waste Heat Recovery

— Knowing heat pump from chiller

Water flows to lower position as heat transfers to object with low temperature, these natural phenomenon are well-known. People invent water pump which can transfer water from low position to high position through power. Like water pump, heat pump transfers heat from low temperature to high temperature through energy (heat source or electric energy).

Chiller makes cooling while heat pump makes heating, literally it is like two equipment with opposite functions, on the contrary, it is same equipment with two different applications.

Both chiller and heat pump are driven by heat source (Q1) which drop temperature by releasing heat (Q2, chilled water of chiller and low temperature water of heat pump) and raise temperature by absorbing heat (Q3, cooling water of chiller and medium temperature water of heat pump). Both have same heat balance: Heat from temperature raising (Q3) = Heat source (Q1) + Heat from temperature dropping (Q2).

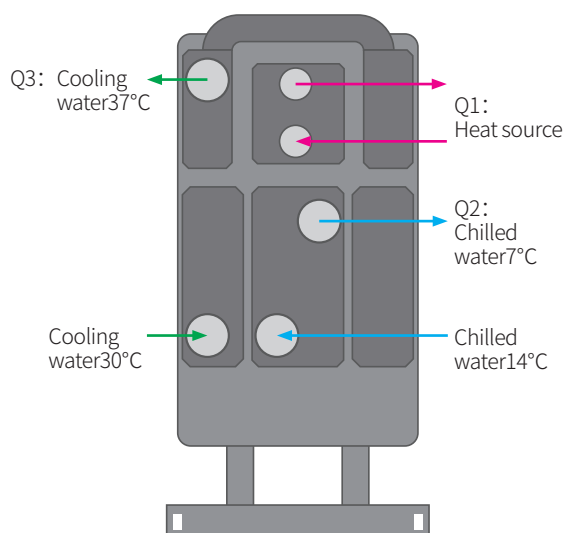
From the look of structure, they are like twins or one equipment only different from their working purpose and working condition. When the user is received chilled water after temperature dropping, it is a chiller. If the user is received medium temperature water after temperature rising, it is a heat pump. Heat pump can be simply known as a chiller using cooling water for heating, they can be switched under certain conditions.

Additionally, chiller has its own rated working condition, however, performance condition of heat pump is required to be decided together according to temperature of low temperature waste heat, supply heat temperature and heat source.

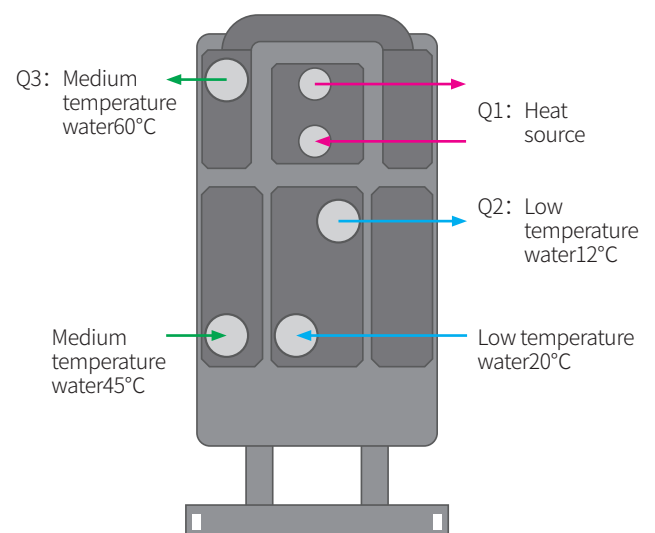
A Promising Future for Heat Pump

Supply heat of heat pump comes from heat source and low temperature waste heat which has multiple times of supply heat efficiency of boiler, in addition, low temperature waste heat is widely existed in industrial production (e.g. process cooling water, exhaust discharge of boiler) and nature (e.g. air, earth, ground water, underground water and etc.) which are easily to acquire. Due to characteristic of energy saving and low carbon during heating, heat pump will be one of important heating technologies to fulfill carbon neutrality in the future.

Comparison between Chiller and Heat Pump



Absorption chiller heat balance: $Q_3 = Q_1 + Q_2$



Absorption heat pump heat balance: $Q_3 = Q_1 + Q_2$

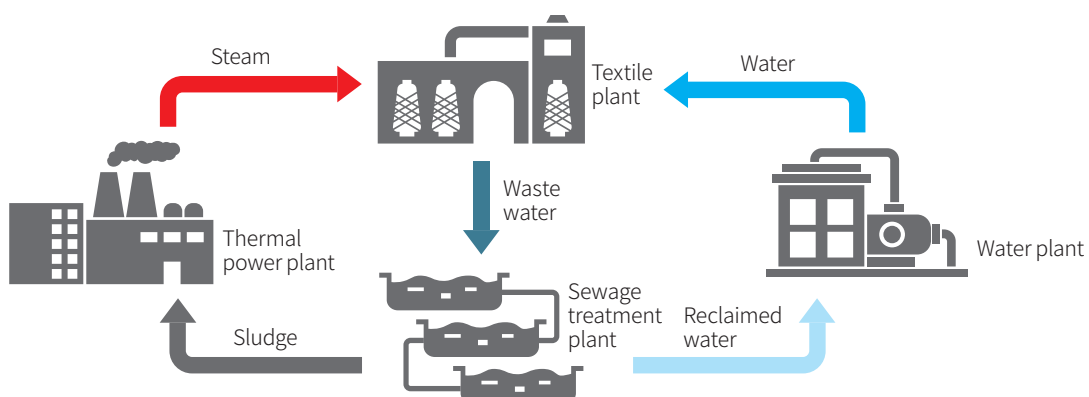


It's a Chiller also a Heat Pump —An inside look from case

Jialida Environmental Technology Co.,Ltd, is located in Datang Industrial Park, Foshan, at the junction among Guangzhou, Foshan and Qingyuan, it has a thermal power plant, a water plant and a sewage and sludge treatment plant. Boilers(950t capacity), 1 unit of suction and condensing steam turbine generator(6MW) and 4 units of back pressure steam turbine generators(33MW), they supply medium and high pressure steam(800t/h) for manufacture process. Waste water(4,375t/h) from printing and dyeing process is centralized and flowed into sewage treatment plant, after filtration and purification, reclaimed water is sent to water plant for manufacture and daily life use. Sludge that settles in sewage contains large amounts of flammable substances like organic matter and fuel, these substances will be desiccated and sent to thermal power plant as additional fuel. The whole area is a closed loop of ecological development includes steam supply+sewage treatment+sludge recycle.

Demands of Cooling and Heating

During the process of sludge activation, temperature of waste water is one of technique indexes that requires to be controlled, as well as one of the most direct factors that affects waste water treatment. Whether the waste water temperature is too high or too low, it will have great influence on treatment process of active sludge waste water, mainly impact flocculation of active sludge, types of indigenous bacteria, sludge settlement, etc. Due to the waste water in sewage treatment plant is discharged from printing and dyeing plant, this type of process heat water has temperature of 48°C. The higher the temperature of waste heat water is, the lower the dissolved oxygen content will be, it leads to insufficient oxygen supply and hypoxia of active sludge, especially during aerobic reaction, active sludge is easily to be broke down and floated. Thus the temperature of waste water is required to be decreased from 48°C to 38°C or even lower. On the other hand, during operation of steam boiler, preheated desalted water (20~35°C) under normal temperature is sent to oxygen extractor for deoxygenation by increasing temperature to 103°C. Heat is mainly from steam generated by boiler with 11% of steam consumption. The total amount of make-up water in boiler is 830t that equivalents to around 100t of steam for preheating, USD 3,000 is lost per hour based on USD 30/t of single price of steam.





Sewerage treatment plant



Chiller room

Transform "Cold" to "Heat"

During sludge activation, 48°C of waste water is cooled down by cooling tower in conventional way, this way of cooling increases equipment investment and operation cost while discharge great amount of low temperature waste heat. On the other hand, make-up water in boiler shall be preheated to above 100°C. Heat pump can meet the demand cooling and heating simultaneously and greatly decrease operation cost of boiler.

This project uses small amount of steam (0.6MPa, 36t) from power plant as driving heat source for a set of composite absorption heat pump with heating capacity of 53.1MW (BDS2600-R1), the heat pump recovers 29.5MW from reclaimed water (1,460t, 48°C/30.6°C). Heat from steam and reclaimed water increases 35°C of desalted water (830t) in boiler to 90°C through heat pump, then the temperature is increased to 103°C in oxygen extractor by steam (19t) and sent to the boiler. When using steam heat pump, steam consumption of make-up water preheating is reduced by 45t per hour.

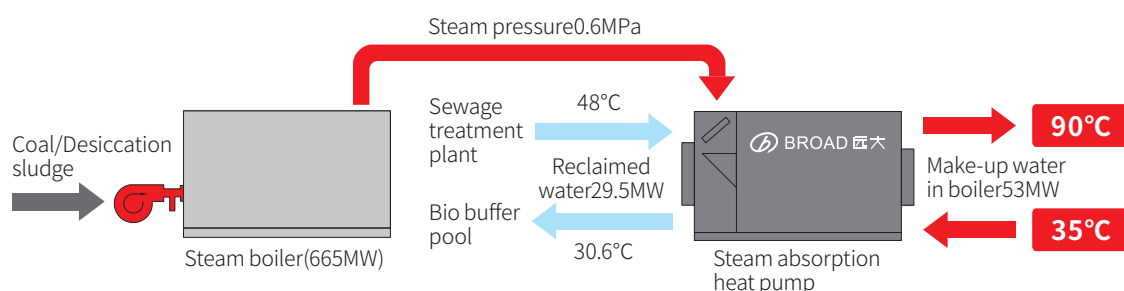
Application Value

This project explains relationship between heat pump and chiller: temperature of reclaimed water is decreased from 48°C to 30.6°C which plays role of chilled water. Temperature of make-up water in boiler is increased from 35°C to 90°C which plays role of cooling water. Heat from chilled water and cooling water is well used for cooling and heating simultaneously, energy in the whole system is utilized in the maximum way.

Absorption heat pump technology recovers waste water heat which is supposed to be discharged to atmosphere and uses it to preheat make-up water in boiler, it saves 255,800t of steam per year, annual economic return is USD 7.4 million, period of return on investment is less than six months.

Use composite absorption heat pump technology, general COP is up to 2.24, and efficiency is increased by 31.7% compared to traditional heat increasing type heat pump. Yearly, it saves 22,000t of standard coals, reduces 64,100t of CO₂ emission which equivalents to 3.51 million trees planted.

■ System diagram



Low Temperature Water Waste Heat Recovery - Heat Pump

Low Temperature Water Waste Heat Recovery

Source of low temperature water: Low temperature water is widely found in the nature and manufacture process, e.g. river, lake, underground water and cooling water. They have same features: low temperature(Below 40°C) and great amount.

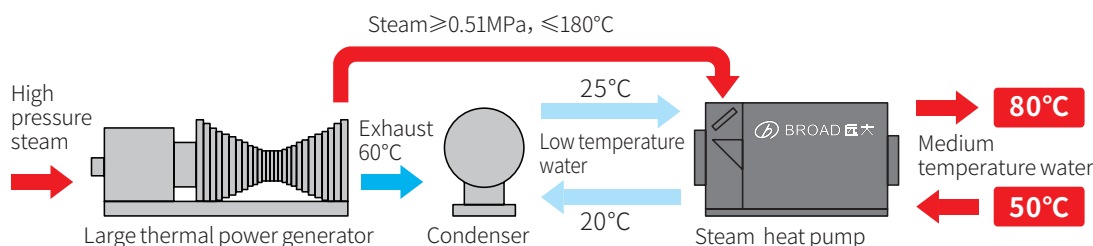
Low temperature water has lots of heat but it has no use because of low temperature.

Use of waste heat in low temperature water: Heat pump is driven by small amount of high level heat source to extract heat from low temperature water and increase to suitable temperature for heating. Absorption heat pump can make medium temperature water that 30~60°C higher than low temperature water outlet, oil free heat pump(maglev) can make medium temperature water no higher than 55°C.

Energy saving: 0.7~1.4 unit of low temperature waste heat can be recovered through absorption heat pump for every single unit of high temperature heat source, eventually it generates 1.7~2.4 units of medium temperature heat for heating, 40~60% of supply heat comes from low temperature waste heat. 2~ 5kW low temperature heat can be recovered through electric heat pump(Maglev) for every kWh of electric power.

Typical Application of Low Temperature Waste Water Heat

■ Typical application

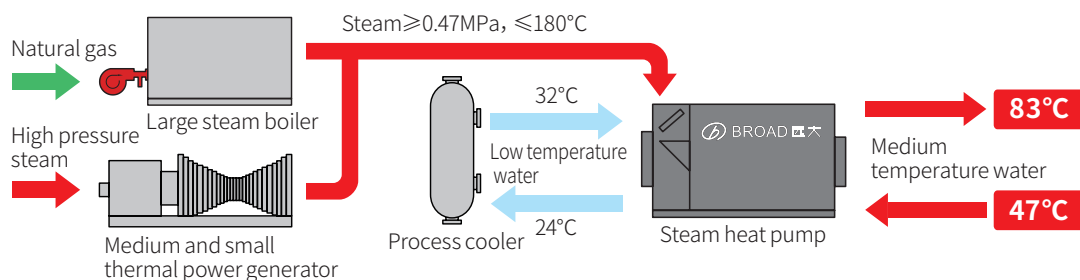


Low temperature waste heat: cooling water of thermal power generator(15~30°C)

Driving heat source: steam of large thermal power generator or high temperature hot water of heat supply network.

Application result: 15~20% efficiency is increased for power plant with reduction of cooling water consumption.

■ Waste heat recovery from cooling water of industrial process



Low temperature waste heat: Discharge water of printing & dyeing mill(approx.30°C), cooling water of chiller(approx.37°C), cooling water of steel mill(approx.40°C), discharge water of oil field(approx.50°C), cooling water of coking plant(approx.40°C,23°C)

Driving heat source: Steam,natural gas, high temperature water of large steam boiler or medium and small thermal power generator.

Application result: 40~60% of energy consumption for heating is decreased



BROAD absorption heat pump
model selection and design
manual

Low Temperature Exhaust Gas Waste Heat Recovery

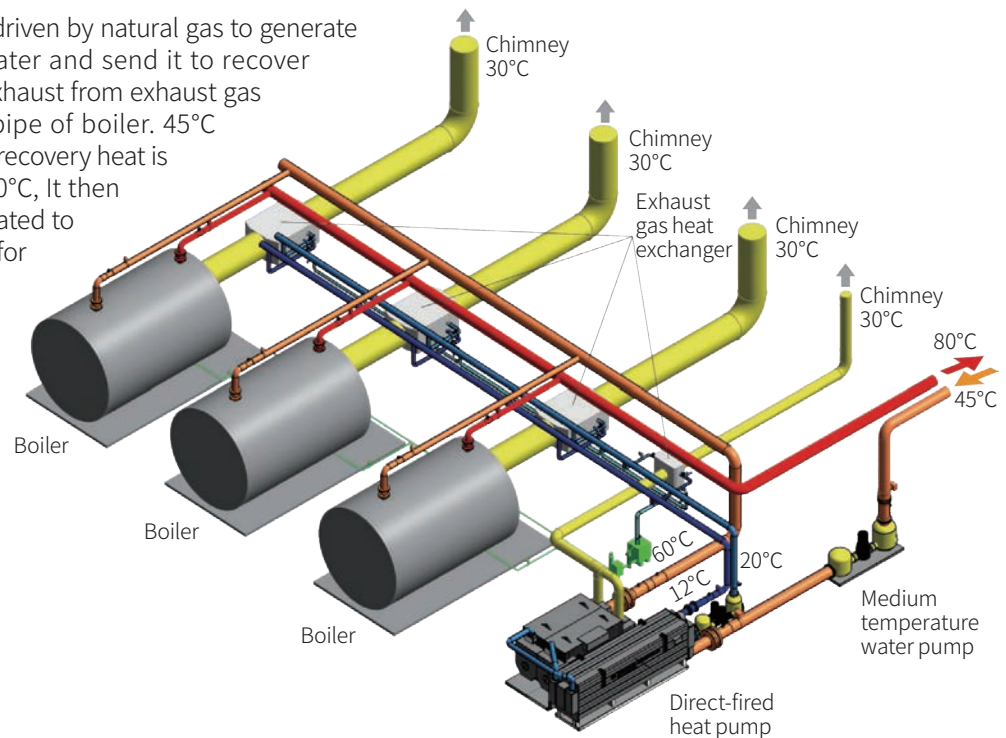
Source of low temperature exhaust gas: Low temperature exhaust gas (Below 100°C) is mainly from heat energy or hydrogen material burnt by power unit or desulfurization wet exhaust gas burnt by coal and bio mass. These exhaust gas can be discharged directly for its low temperature and little heat.

Use of low temperature exhaust gas: Heat pump is driven by small amount of high level heat source to extract latent heat from exhaust gas and increase to suitable temperature for heating.

Energy saving: While exhaust gas temperature is decreased to under 30°C by heat pump, energy efficiency of heating system is increased by 8~15%, 80% of water vapour is erased to fulfill white smoke removal.

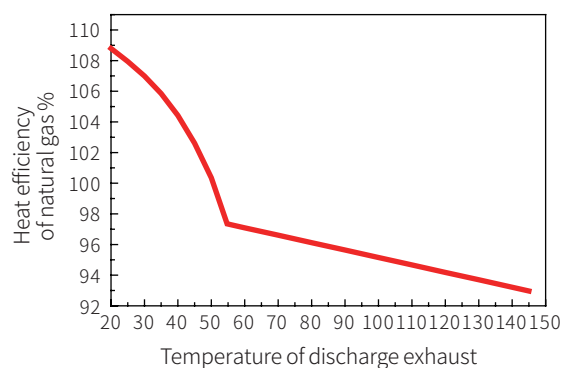
Recovery Procedure of Exhaust Gas Waste Heat

Absorption heat pump is driven by natural gas to generate 12°C low temperature water and send it to recover waste heat of discharge exhaust from exhaust gas heat exchanger on flue pipe of boiler. 45°C heating return water from recovery heat is raised by heat pump to 60°C. It then enters the boiler and is heated to the temperature required for heating.



Why Using Heat Pump for Recovery of Exhaust Gas Waste Heat

Heat efficiency of natural gas is determined by the temperature of discharge exhaust. Heat in exhaust gas comprises sensible and latent type (water vapour burnt from natural gas). As shown in the picture at right side. At sensible heat section ($>55^{\circ}\text{C}$), heat efficiency of natural gas is increased by around 1% for every 20°C of exhaust gas that decreases. At latent section ($\leq 55^{\circ}\text{C}$), heat efficiency of natural gas is increased by 8.5% for every 20°C of exhaust gas that decreases. It shows heat of exhaust gas is mainly concentrated at latent section.



Coking Circulating Cooling Water Waste Heat Recovery

—Shanxi Everbright Coking Gas Source Co., Ltd.

Application Analysis of Waste Heat in Coking Industry

- The waste heat of the Coke Dry Quenching (CDQ) process is recovered, and the high-pressure steam is generated by the waste heat boiler to drive the steam turbine to generate electricity. The low pressure steam after power generation drives the steam type absorption chiller to produce 16°C chilled water for cooling to purify the waste gas.
- The hot water in the initial cooling section of the waste gas is about 70°C, and the circulating ammonia water is about 80°C, which can be used to drive the hot water type absorption chiller to produce 16°C chilled water for cooling to purify the waste gas.
- A large amount of circulating cooling water (23~40°C) is produced in the process section of waste gas purification and ammonia distillation, which can be used as a low-temperature heat source for the heat pump to produce hot water for process production or central heating, etc.

Project Overview

Shanxi Everbright Coking Gas Source Co., Ltd. is a chinese private joint-stock enterprise integrating coal washing, coking, chemical production, power generation, gas supply, urban heating, water treatment and railway transportation. Everbright Coking has always been committed to comprehensive utilization of resources and clean production. In recent years, it has invested a lot of money in energy-saving renovations. It is the first local company to use CDQ to generate electricity, and it is also the first company to use process waste heat for central heating which greatly improved energy efficiency.

System Introduction

Everbright Coking is responsible for the central heating in Hexi District of Xiangfen City. In the early stage, the high-pressure waste steam recovered by the CDQ process during the coking process was used to drive the back-pressure steam turbine generator to generate electricity. With the development of urbanization, the heating area will further increase to more than 2 million m² in the future. The residual pressure steam of power generation can no longer meet the heating demand, and it is urgent to find new heat sources.

In the coke oven gas purification and ammonia distillation process section of coking, a large amount of circulating water (flow rate of 4,360t/h, temperature of 28/38°C) is required for cooling. This part of the low-temperature waste heat cannot be used because the temperature is too low, and is dissipated in vain by the cooling tower. In this project, the low-pressure steam (0.27~0.6MPa) of the back-pressure steam turbine generator is used as the driving heat source of 4 absorption heat pumps of model BDS2000-R1 (the maximum heat supply per unit is 31MW), and the heat of the process circulating cooling water is recovered and distributed to the heat network for central heating in surrounding towns.

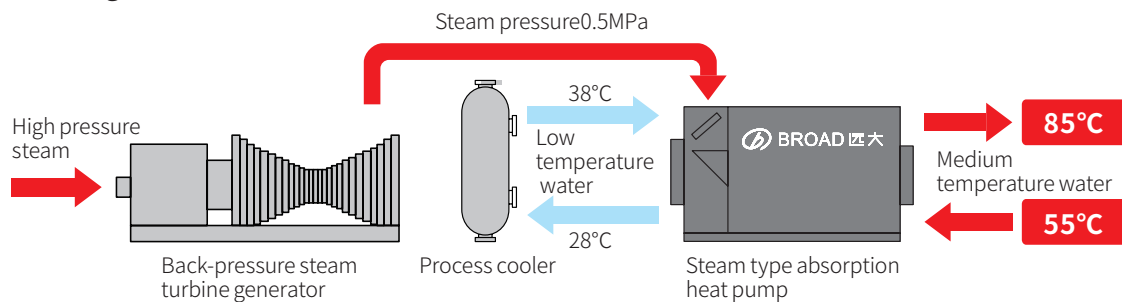


Application Value

- The absorption heat pump is used to recover 50.7MW circulating cooling water heat in the coking process, and the heating area is increased by 940,000 m², which fully meets the heating gap of the heat source plant. The annual increase in heating income is about USD 2.26 million, and the investment payback period is about 2 years.
- The use of absorption heat pumps has achieved clean heating, saving 18,200 tons of standard coal annually, reducing circulating cooling water consumption by 117,000 tons, and reducing CO₂ emissions by 48,000 tons, equivalent to planting 2.64 million trees.

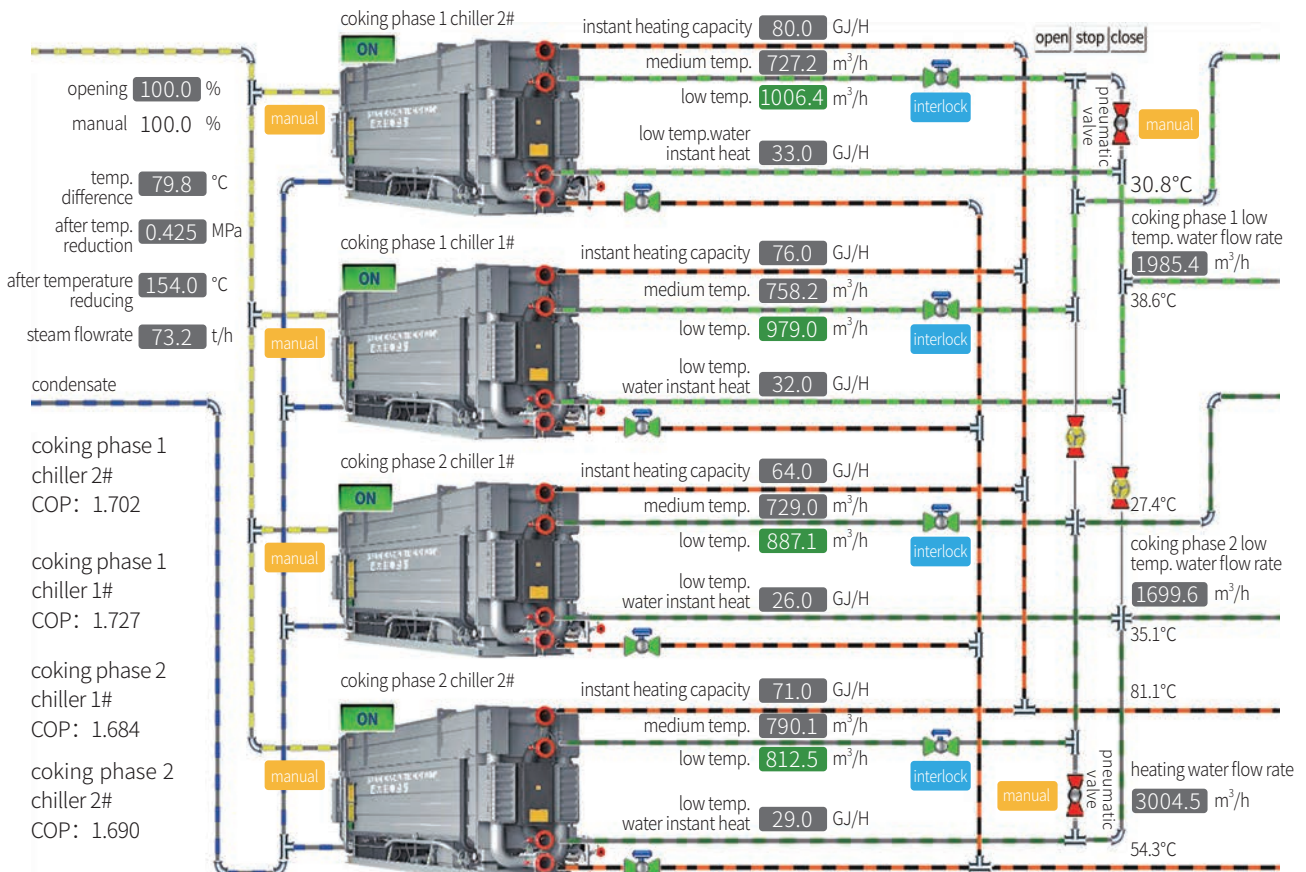


■ System diagram



■ System operation interface diagram

For many heat pumps that actual operating COP is only about 1.5, the heat pumps in this project is basically at 1.7, which fully reflects the technical strength and product quality of BROAD. The level of COP reflects the waste heat recovery capability of the heat pump unit. Higher COP will bring more energy saving.



Note: The calculation method of COP is instant heating capacity/(instant heating capacity-low temperature water instant heat) The COP of coking phase 2 chiller #1 and coking phase 1 chiller #2 are relatively low due to the actual low temperature water flow rate and temperature are lower than the designed specifications.

Low Temperature Exhaust Gas Heat Recovery of Gas Boiler

—Beijing Fengtai Jiayuan Heating Center

Why do You Want to Recover the Heat of Exhaust Gas from Gas Boiler ?

- **Energy saving:** the heat recovered from low temperature exhaust gas by absorption heat pump can reduce the heating energy consumption by 8 ~ 15%. During single heating season(2,900h), each ton(i.e. 0.7MW) boiler can save around 21,000m³ natural gas consumption
- **Eliminating white smoke:** the absorption heat pump will lower the temperature of the exhaust gas to 30°C, and the water vapor removal rate in the exhaust gas can reach 80%. During single heating season(2,900h), each ton boiler can reduce water vapor emission by about 25.2t
- **Purifying exhaust gas:** SO₂ and NO_x are absorbed by condensate, SO₂ decreases by 30% and NO_x decreases by 15%. During single heating season(2,900h), each ton boiler can reduce 945g of SO₂ emission and 1,985g of NO_x emission

Project Overview

Beijing Fengtai Jiayuan Heating Center is a "coal to gas" project. A reconstructed heat source plant is mainly responsible for the heating of 1.56km² of buildings. The heating center is equipped with 4 units of gas-fired hot water boilers with heating capacity of 29MW, with a total heating capacity of 116MW. According to the statistics of previous heating center, the heating load in the early and late cold season is 25MW, and 45MW in the severe cold season. The return water temperature of the heating network is 45 ~ 50°C, and the water supply temperature is 75 ~ 100°C. The gas boiler has been installed with economizers, the final exhaust temperature of the boiler is related to the boiler load and the heating water return temperature, with a range of 50 ~ 60°C. The selection of direct-fired heat pump is based on the previous base heating load of 30MW from heating station. A direct-fired heat pump with a waste heat recovery capacity of 3,489kW is used to recover the waste heat of exhaust gas

■ Direct-fired heat pump design parameters:

Item	Value	Unit
Rated waste heat recovery	3,489	kW
Rated heating capacity	8,478	kW
LTW inlet / outlet Temp.	20/12	°C
Low Temp. W. flowrate	375	m ³ /h
Heating W.inlet / outlet Temp.	45/60	°C
Heating W. flowrate	486	m ³ /h



Energy Management Contract(EMC) to Achieve Win-Win

Another major feature of the project is that the energy-saving renovation is jointly invested by BROAD and Fengtai Heating Institute by EMC form, and the energy-saving benefits obtained are shared by the investors. Cooperation mode: BROAD provides a BDZ600-R1 heat pump and is responsible for the operation and maintenance of the unit; Fengtai Heating Institute is responsible for the necessary energy conditions for project construction and operation.

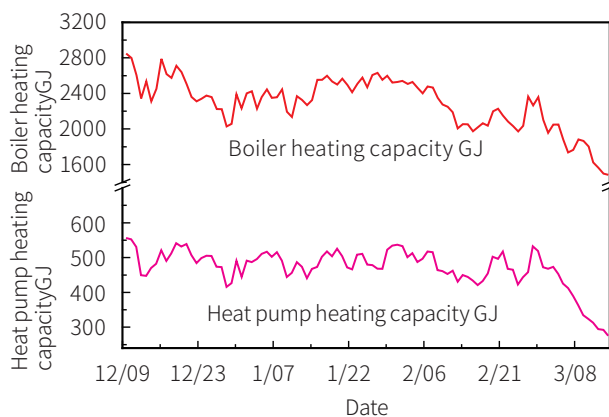
Energy saving benefit sharing mode: the heat recovered by the heat pump from the low temperature exhaust gas is measured by heat meter on the low temperature water, then the recovered heat is converted into natural gas according to the calorific value of natural gas, and the energy saving benefit is calculated according to the unit price of natural gas. All parties shall share the energy-saving income according to the proportion agreed in the contract. After the end of the contract, the equipment shall be handed over to Fengtai Heating Institute.

Why Boiler Heating Efficiency can Exceed 100%?

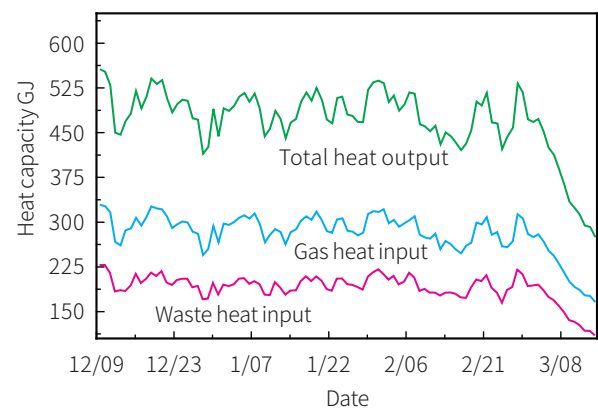
- The boiler heating efficiency exceeds 100%, which is caused by the difference between the low calorific value and the high calorific value of natural gas
- The high calorific value refers to all the heat released when 1 m³ natural gas is completely burned, including the latent heat of vaporization released when water vapor in exhaust gas condenses into water. When the latent heat in the exhaust gas is subtracted from the high calorific value of the fuel, it is called the low calorific value. The high calorific value is generally about 11% higher than the low calorific value.
- The calculation formula of boiler heating efficiency is: boiler heating capacity / (natural gas volume × low calorific value) × 100%
- If all the heat of natural gas (including the condensation heat of water vapor) is converted into the boiler heating supply, then the boiler heating efficiency is equal to: high calorific value / low calorific value = 111%
- In actual operation, when the condensation heat of water vapor is greater than the sum of the exhaust loss and heat dissipation loss of the boiler, it is inevitable that the heating efficiency of the boiler will exceed 100%. For natural gas boilers, when the exhaust gas temperature is reduced to 50°C, the heating efficiency can be 100%.

Project Benefit Analysis

From the statistical analysis of various data, in the 97 days of operation in the first heating season, the total heating capacity of the direct-fired heat pump was 45,700GJ which is 17.1% of the total heating capacity. The direct-fired heat pump recovers an average heat of 190GJ from exhaust gas every day, with a total energy saving rate of 8.3%. If calculated by operating a complete heating season, the recovered heat will reach 22,800GJ, which is equivalent to 656,000m³ of natural gas. The local natural gas price is USD0.42/m³, saving USD273,400 in annual operating cost.



Heat pump /bioler heating capacity



Heat pump operation data

Through the comparison of boiler exhaust before and after the renovation, it can be seen that the effect of eliminating "white smoke" after using the heat pump is very obvious. Most of the water vapor in the exhaust gas is removed from the exhaust gas after being condensed by low temperature water cooling. According to the actual test data, when the exhaust gas is cooled to 30°C, 1.24kg of water can be condensed per 1 m³ of natural gas, and the water vapor removal rate is 80%, so as to eliminate "white smoke". 813t water vapor emission can be eliminated in the whole heating season



Before



After

Waste Heat Recovery from Low Temperature Exhaust Gas of Biomass Boiler

—Hjorring District Heating, Denmark



Project Overview

Denmark is located in Northern Europe, with low temperature and long time in winter. The energy used for heating has a large proportion of the total energy in the country. As one of the most energy-efficient countries in the world, Denmark has the world's leading district heating technology. The Danish energy agency believes that the widespread use of district heating and CHP is the main reason for the country to improve energy efficiency and reduce carbon emissions in the past decades, a cornerstone of Denmark's green and efficient energy system

Due to the scattered population, district heating centers of all sizes are very common in Denmark. Hjorring is a typical silhouette. In order to improve the energy efficiency of the whole heating system, Hjorring district heating center uses sawdust biomass boilers for heating. It is required to fully recover the waste heat of boiler exhaust gas at about 40°C for heating. The center has pioneered the development of a double lift heat pump, which provides 10°C chilled water to recover 40°C boiler exhaust gas waste heat and 85°C high temperature hot water for district heating, so as to fully recover waste heat and maximize the energy efficiency of the heating system for customers

The Hjorring district heating center provides cooling, heating and power services for the commercial, industrial and residential areas around Hjorring town. In April 2014, BROAD absorption heat pump unit was successfully

commissioned and put into operation, achieving high reliability and low-cost district heating service. It is one of the heating centers with the lowest operating cost in Denmark

BROAD absorption heat pump recovers the waste heat of biomass boiler exhaust gas as the low temperature heat source (10 / 20°C) of the heat pump, and raises the low-level waste heat to 85°C by the heat pump and supplies it to the district heating network, with a total heating capacity of 13MW. The feature of this project is that the chilled water below 10°C produced by the absorption heat pump is directly used to recover the waste heat of the boiler exhaust gas while clean the exhaust gas to 9 ~ 12°C, recover the latent heat in the exhaust gas, while clean the exuhaust gas to ensure that the emission is at the lowest level. This project overcomes the large temperature difference (75°C) between low temperature chilled water and high temperature heating water, and meets the high requirements of customers on low temperature heat source water side and medium temperature water side

This is a typical case of absorption heat pump which recovers the condensed waste heat of boiler exhaust gas and improve the energy efficiency of the whole heating center



What is Double Lift?

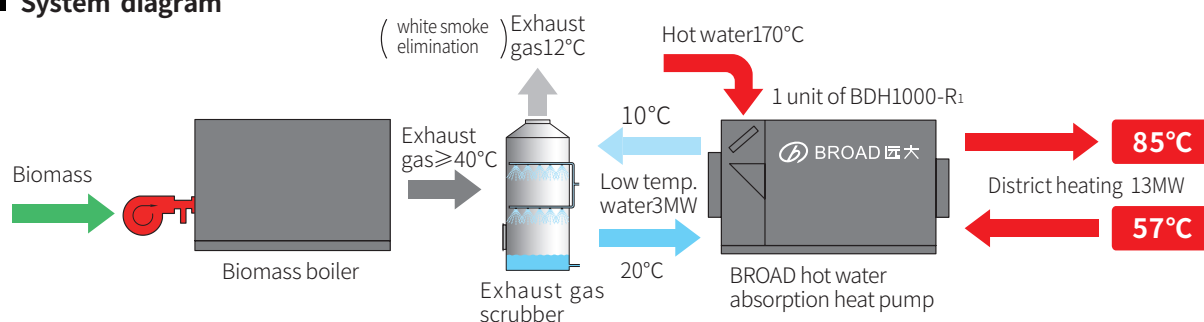
- The ordinary heat pump does not have double section mode when the temperature difference between the outlet temperature of low heat source and middle heat source is large. BROAD has developed a new type of heat pump to meet this demand: through the special design of evaporator and absorber structures and the innovative design process, low heat source water is transferred and lifted to middle heat source water by two times. We call it double lift.
- Through this innovation, the temperature difference between the outlet temperature of low heat source water and middle heat source water can exceed 70°C, and 75°C in the Hjorring project, many customers have visited this project for its long term and stable operation.

Application Value

40°C boiler exhaust is decreased to 9 ~ 12°C with recovery of 3,000 kW waste heat. At the same time, the energy efficiency in heating center will be improved to 120%, which is a world-class energy efficiency. The equipment can reduce carbon emissions by 1,800t per year as well as operating costs by about USD450,000 per year with three years of investment payback.

The emission level of boiler exhaust is extremely low. The gas and particulate emissions have been at the lowest level in the current allowable range, and some parameters have reached the allowable emission level of 2022 in Denmark

■ System diagram



Direct Contact or Indirect Contact - How to Choose the Exhaust Gas Heat Exchanger?

Indirect contact type (indirect contact between exhaust gas and low temperature water)

- It is installed on the flue in series, with small exhaust gas resistance ($\leq 250\text{Pa}$), and small volume, easy installation and maintenance, no need to add smoke exhaust fan
- Low temperature water does not contact with exhaust gas, and the water quality is not affected. long service life heat pump(30+ years)
- The heat exchange temperature difference between exhaust gas and low temperature water is large, and the heating temperature of heat pump is relatively low, higher requirements for heat pump technology



Indirect contact type
(Suitable for 100t
gas boiler)
(2.8m*3.6m*3.45m)

Direct contact type (direct contact between exhaust gas and low temperature water)

- It is installed on the flue in parallel, with large exhaust gas resistance (450 ~ 500Pa), large volume, difficult installation and maintenance, need to add smoke exhaust fan
- Low temperature water is in direct contact with exhaust gas, very high requirements of corrosion prevention to heat exchanger and heat pump, short service life of heat pump (5-8 years)
- The heat exchange temperature difference between exhaust gas and low temperature water is small, the heating temperature of heat pump is relatively high, and the technical requirements for heat pump are low



Direct contact type
(suitable for 70t gas
boiler)(Φ4m*14m)

Data Center Waste Heat Recovery for Heating

—Tencent Tianjin Binhai Data Center

- Under the national strategy of "channel computing resources from the east to the west", the data center will usher in rapid development, but its large power consumption and annual cooling energy consumption will undoubtedly become an important challenge for China to achieve carbon peaking and carbon neutrality
- The Data Center has obtained the platinum level certification of the first LEED V4 O+M data center system in North Asia and China, which is also the largest data center in the global LEED platinum certification. Among many energy-saving technologies, use heat pumps to recover waste heat from data centers for heating undoubtedly provides a very good idea and engineering practice for low-energy heating in the north. In the chapter of CCHP, we will introduce the methods and cases of reducing PUE by using waste heat of power generation to get cooling for data centers

Project Overview

Tencent Tianjin Data Center is located in Binhai New District . It was put into operation in November 2010. It is Tencent's first self-built super large-scale data center with a total construction area of 92,777m², 4,800 designed racks and 25MW power consumption. The data center includes three computer room buildings and an office building. The computer room building is mainly responsible for Tencent's Wechat, instant messaging and other services, providing comprehensive cloud platform services for internet users and third-party enterprises across the country

System Introduction

The IT equipment in the data center operates 24/7. Most of the electric energy entering the server is emitted in the form of heat, and more energy will be consumed for cooling. In the transition season and winter, Tencent Tianjin Data Center uses cooling tower to provide 15°C chilled water for the heat dissipation of the machine room. The heat dissipation is up to 20MW. The office building supporting the data center uses municipal heat supply network for heating

Low temperature waste heat on one side, needed heating supply on the other side. How to combine both to achieve low-cost cooling and heating? Energy saving heat pump is the solution. Tencent Tianjin Data Center uses a large power saving (magnetic levitation) heat pump with the model of C35 (heating capacity of 600kW) to cool the 20°C chilled water in the data center machine room to 15°C to recover low temperature waste heat, which is heated to 55°C by the energy-saving electric pump to meet the heating needs of nearly 10,000 m² of office buildings

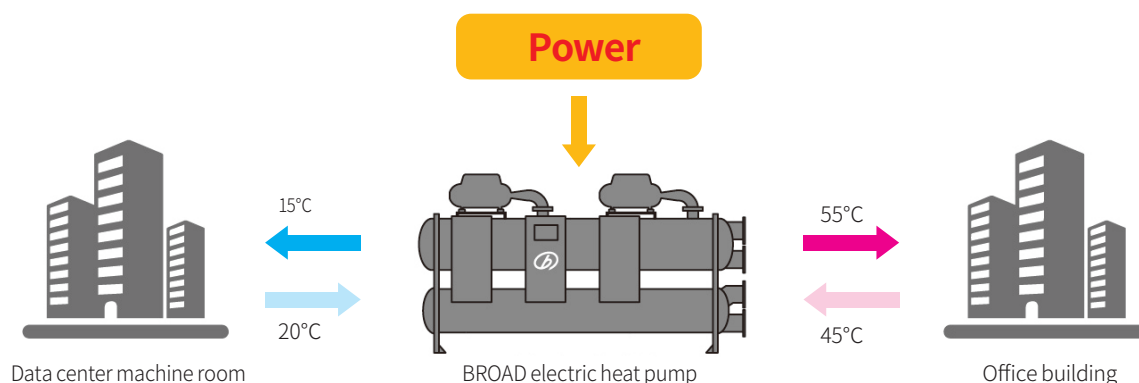
Application Value

- The application of heat pump meets both cooling and heating demand for the project. It turns waste into treasure and realizes the comprehensive utilization of energy. The system adopts BROAD maglev and energy-saving electric heat pump technology, This non friction heat pump is running without fuel, low power and noise utilization, 90% of maintenance cost saving, 30~50% of volume reduction, 30% of weight reduction and 30 years service life.
- Due to the small heating demand of the project, only 1 / 40 of the heat of the machine room is recovered, and 3,249t standard coal is saved in the heating season, which is equivalent to 8,447t CO₂ emission reduction. If all the waste heat of the data center is recovered, the green low-carbon heating of 2 million m² residential buildings can be realized, and the benefits of energy conservation and environmental protection will be more considerable





■ Schematic diagram of waste heat recovery



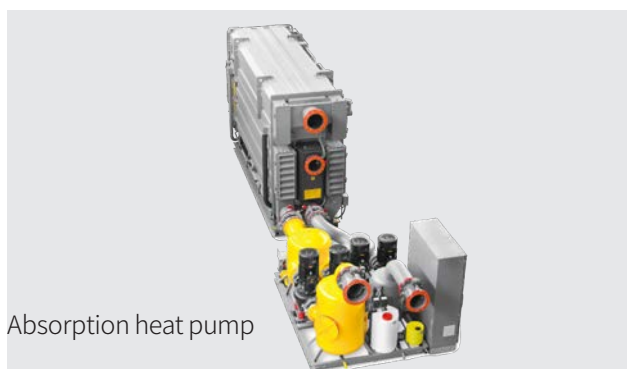
Electricity or Heat? How to Select the Driving Heat Source of the Heat Pump?

Absorption heat pump is preferred in the following cases (mainly industrial projects)

- Recover the waste heat generated by the main heat source or the main heat source can be used as a driven heat source. For example, direct-fired heat pumps (driven by natural gas) should be preferred for recovering waste heat from exhaust gas of gas-fired boilers
- Heating temperature $\geq 55^{\circ}\text{C}$, or heating temperature difference $\geq 15^{\circ}\text{C}$, or single machine heating capacity is more than 2.5MW, absorption heat pump is preferred

In the following cases, electric heat pump is preferred (mainly for civil projects)

- When heat pump is used as the main heat source, such as buildings with water source heat pump and ground source heat pump as the main heating forms
- Small heating projects with low temperature heat source $\leq 12^{\circ}\text{C}$ or heating temperature lower than 55°C



Typical Cases of Low Temperature Waste Hot Water



Thermal power plant: Ilsan & Bundang Power Plant, Korea

The waste steam generated by the thermal power unit is used to drive two sets of absorption heat pumps with 11MW single unit heating capacity and two sets of 14MW single unit heating capacity to recover the low temperature cooling water heat of the thermal power unit, and the 400,000m² building realizes zero energy consumption heating

Recover heat of waste hot water: 20MW
Heating temperature: 55/89°C
Waste hot water temperature: 46/40°C

Yearly CO₂ cutting: 29,000t
Yearly standard coal saving: 10,000t
Equivalent to yearly tree planting: 1.6 million



Paper plant: Thai Kraft Paper Industry Co.,Ltd. (SCG), Thailand

The waste steam generated by the thermal power unit is used to drive two sets of absorption heat pumps with 1.9MW single unit heating capacity to recover the low temperature cooling water heat of the thermal power unit, and the 32,000m² building realizes zero energy consumption heating

Recover heat of waste hot water: 1.6MW
Heating temperature: 55/85°C
Waste hot water temperature: 43/30°C

Yearly CO₂ cutting: 2,300t
Yearly standard coal saving: 786t
Equivalent to yearly tree planting: 0.13 million



Printing and dyeing factory: Ansan Banwol ECO Park, Korea

The waste steam of the thermal power plant is used to drive four sets of absorption heat pumps with a single unit heating capacity of 14MW to recover the low temperature waste hot water heat of the printing and dyeing plant for district heating, and the heating area of 480,000m² realizes zero energy consumption heating

Recover heat of waste hot water: 24MW
Heating temperature: 47/83°C
Waste hot water temperature: 35/27°C

Yearly CO₂ cutting: 35,000t
Yearly standard coal saving: 12,000t
Equivalent to yearly tree planting: 1.93 million



Geothermal water: Tianjin Technology University, China

Natural gas is used to drive a absorption heat pump with a single heating capacity of 4.2MW to recover the heat of geothermal tail water, cool the geothermal tail water to 14°C and then recharge it. The utilization rate of geothermal water is more than doubled, and the 34,000m² building realizes zero carbon heating

Recover heat of waste hot water: 1.7MW Heating temperature: 47/83°C
Geothermal water temperature: 35/27°C

Yearly CO₂ cutting: 1,800t
Yearly standard coal saving: 620t
Equivalent to yearly tree planting: 0.1 million

Typical Cases of Low Temperature Exhaust Gas Waste Heat



Gas boiler: Beijing Daxing Kangzhuang Heating Center

Natural gas is used to drive two absorption heat pumps with a single heating capacity of 14.6MW, recover the low temperature exhaust gas waste heat of four 100t gas boilers, and achieve zero energy consumption heating for 240,000m² buildings

Recover heat of waste exhaust gas: 12MW
Heating temperature: 50/65°C
Exhaust gas temperature: 66/30°C

Yearly CO₂ cutting: 7,535t
Yearly natural gas saving: 3.77 million m³
Equivalent to yearly tree planting: 0.41 million



Garbage incinerator:Waste To Energy District Heating, Bordeaux, France

The waste steam generated by the waste-to-energy plant is used to drive 2 units of absorption heat pumps with a heating capacity of 5.56MW per unit, recover the low grade heat of the incineration system, and realize zero energy consumption heating for 91,600m² buildings

Recover heat of waste exhaust gas: 4.58MW
Heating temperature: 70/84°C
Exhaust gas temperature: 40/35°C

Yearly CO₂ cutting: 6,725t
Yearly natural gas saving: 2 million m³
Equivalent to yearly tree planting: 0.37 million



Gas turbine: Incheon Total Energy, Korea

The high temperature hot water (108°C) generated by the waste heat boiler is used to drive four absorption heat pumps with a single unit heating capacity of 14MW, recover the waste heat of low temperature exhaust gas of the gas steam combined cycle, and achieve zero energy consumption heating for 460,000 m² buildings

Recover heat of waste exhaust gas: 23MW
Heating temperature: 48/61°C
Exhaust gas temperature: 90/53°C

Yearly CO₂ cutting: 25,000t
Yearly natural gas saving: 12.7 million m³
Equivalent to yearly tree planting: 1.4 million



Biomass boiler: Grenaa District Heating, Denmark

The high temperature hot water (140°C) generated by the biomass boiler is used to drive two absorption heat pumps with a heating capacity of 4.9MW per unit, recover the low temperature exhaust gas waste heat generated by the biomass boiler, and realize zero energy consumption heating for 80,000m² buildings

Recover heat of waste exhaust gas: 4MW
Heating temperature: 57/85°C
Exhaust gas temperature: 120/30°C

Yearly CO₂ cutting: 3,456t
Yearly natural gas saving: 1.73 million m³
Equivalent to yearly tree planting: 0.19 million

Medium Temperature Waste Heat Recovery Technology

Utilization

Source: Medium temperature water can be widely found in nature and in industrial processes, such as thermal drainage (e.g. steam condensate, chemical reaction drainage), power plant (e.g. generator jacket water), geothermal water, etc. Medium temperature water already has a certain temperature and can be used directly for cooling, heating or steam production.

Utilization Modes

■ Cooling:

Hot water above 70°C can drive a hot water absorption chiller for cooling. If the temperature of the hot water is higher, then the chiller will be more efficient and the investment will be lower. The chiller model and cooling capacity can be determined based on the following table.

Hot W.Chiller Model	Outlet/Inlet Temp.	Unit Cooling Capacity	COP
Standard	Inlet $\geq$ 90°C, Outlet $\geq$ 80°C	0.9kW/(t*°C)	0.7-0.82
Double Section	Inlet $\geq$ 90°C, Outlet $\geq$ 70°C	0.8kW/(t*°C)	0.7-0.75
Triple Generation	Inlet $\geq$ 90°C, Outlet $\geq$ 55°C	0.7kW/(t*°C)	0.5-0.6
Double Generation	Inlet $\geq$ 70°C, Outlet $\geq$ 55°C	0.6kW/(t*°C)	0.4-0.5

Note: Rated chilled W. outlet/inlet temp.: 7/14°C, cooling W. inlet/outlet temp: 30/37°C. The cooling efficiency decreases with increasing of cooling water temperature.

Unit hot water cooling capacity can be produced when each ton of medium temperature water is cooled down by 1°C. For example, when 100 tons of 100 °C medium temperature water are cooled down to 55 °C, we can choose a triple generation hot water chiller, cooling capacity = 100 * (100 -55) * 0.7 = 3,150kW; It can also be estimated by COP, such as 100 * (100-55) * 1.163 * 0.6 = 3,140kW (the heat output of 1 ton water with temperature drop of 1 °C is 1.163kW)

Double Generation Hot Water Chiller (DG hot water chiller)

The auxiliary absorber is used as the generating pressure for the medium temperature generator, as the pressure is lower and the heat source temperature is higher (originally designed for the heat source is 90°C), It makes the solution of the medium temperature generator more concentrated, and to be used as the absorber for the chiller; the diluted solution from the low temperature generator comes from the auxiliary absorber which absorbs more water vapour and is therefore more diluted and can evaporate more water vapour as the refrigerant.

Double Generation Hot Water Chiller (Heat source water 70/55°C ,cooling water 37/30°C ,chilled water 7/14°C)															
Main shell	20	30	50	75	100	125	150	200	250	300	400	500	600	800	1000
Cooling capacity kW	105	157	262	393	523	654	785	1,047	1,308	1,570	2,093	2,617	3,140	4,187	5,234
Chilled w. flowrate m ³ /h	13	19	32	48	64	80	96	129	161	193	257	321	386	514	643
Pressure drop kPa	30	30	40	40	50	70	70	70	90	90	50	50	70	70	120
Cooling w. flowrate m ³ /h	39	58	97	145	193	241	289	386	482	579	771	964	1,157	1,543	1,929
Pressure drop kPa	70	80	80	80	60	120	90	90	100	100	70	70	100	100	100
Heat source w. temp.°C	70/55	70/55	70/55	70/55	70/55	70/55	70/55	70/55	70/55	70/55	70/55	70/55	70/55	70/55	70/55
Flowrate m ³ /h	12	18	30	45	60	75	90	120	150	180	240	300	360	480	600
Power demand kW	4	4	5	11	11	13	15	20	20	24	26	30	38	42	42
Solution weight t	2	2	2	2	2	2	3	4	5	6	8	10	13	17	21
Unit ship weight t	4	5	7	8	10	13	16	20	28						
Separate ship weight t										15	20	25	30	45	53
Operation weight t	5	7	9	10	12	15	19	24	32	35	45	60	70	80	95
Cooling capacity 10*4kcal/h	9	13	23	34	45	56	67	90	112	135	180	225	270	360	450
COP	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50



Performance data for
big temp. difference heat
exchange application

Triple Generation Hot Water Chiller (TG hot water chiller)

On the basis of the Double Generation, a high temperature generator is added. The steam produced by both the high temperature generator and the low temperature generator enters the condenser to be condensed as refrigerant water; the concentrated solution from the high temperature generator enters the medium temperature generator to be evaporated again to produce a more concentrated solution for the absorber.

Note: Both models have only one evaporator and one main absorber.

Triple Generation Hot Water Chiller (Heat source water 90/55°C ,cooling water 37/30°C ,chilled water 7/14°C)															
Main shell	20	30	50	75	100	125	150	200	250	300	400	500	600	800	1000
Cooling capacity kW	140	209	349	523	698	872	1,047	1,396	1,745	2,093	2,791	3,489	4,187	5,582	6,978
Chilled w. flowrate m ³ /h	17	26	43	64	86	107	129	171	214	257	343	429	514	686	857
Pressure drop kPa	45	45	60	60	65	110	110	110	130	130	30	60	110	110	60
Cooling w. flowrate m ³ /h	46	68	114	171	229	286	343	457	572	686	914	1,143	1,371	1,828	2,286
Pressure drop kPa	90	100	100	100	60	150	110	110	130	130	70	70	130	130	130
Heat source w. temp. °C	90/55	90/55	90/55	90/55	90/55	90/55	90/55	90/55	90/55	90/55	90/55	90/55	90/55	90/55	90/55
Flowrate m ³ /h	6	9	14	21	29	36	43	57	71	86	114	143	171	229	286
Power demand kW	4	4	5	11	11	13	15	20	20	24	26	30	38	42	42
Solution weight t	2	2	2	2	3	3	4	5	6	7	9	13	16	21	26
Unit ship weight t	4	6	8	10	12	15	18	23	32						
Separate ship weight t										17	23	28	34	48	55
Operation weight t	6	8	10	12	14	18	22	28	38	40	48	65	76	85	99
Cooling capacity 10*4kcal/h	12	18	30	45	60	75	90	120	150	180	240	300	360	480	600
COP	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60

Double Section Hot Water Chiller (DS hot water chiller, equivalent to two units operated in series)

Heat source - heat in series, entering from the primary unit and exiting from the secondary unit

Chilled water - entering from the evaporator of the secondary unit and exiting from the evaporator of the primary unit

Cooling water - in two ways, one in series with two condensers and the other in series with two absorbers, both entering from the secondary unit and exiting from the primary unit, because the heat source of the secondary unit is at a lower temperature, the effect is worse and the cooling water is needed at a lower temperature.

Double Section Hot Water Chiller (Heat source water 90/70°C ,cooling water 37/30°C ,chilled water 7/14°C)															
Main shell	20	30	50	75	100	125	150	200	250	300	400	500	600	800	1000
Cooling capacity kW	116	174	291	436	582	727	872	1,163	1,454	1,745	2,326	2,908	3,489	4,652	5,815
Chilled w. flowrate m ³ /h	14	21	36	54	71	89	107	143	179	214	286	357	429	571	714
Pressure drop kPa	40	70	50	50	50	75	75	75	100	100	110	75	75	75	130
Cooling w. flowrate m ³ /h	34	51	85	128	171	213	256	341	427	512	683	853	1,024	1,365	1,706
Pressure drop kPa	50	50	50	70	70	90	90	90	120	120	120	100	100	120	120
Heat source w. temp. °C	90/70	90/70	90/70	90/70	90/70	90/70	90/70	90/70	90/70	90/70	90/70	90/70	90/70	90/70	90/70
Flowrate m ³ /h	7	10	17	26	35	43	52	69	87	104	139	174	208	278	347
Power demand kW	4	4	5	10	10	10	10	11	14	14	18	21	25	33	33
Solution weight t	1	1	1	2	2	2	4	5	6	6	7	11	11	14	17
Unit ship weight t	5	7	9	12	15	16	19	20	24	26	27				
Separate ship weight t												28	42	50	55
Operation weight t	6	8	11	14	17	19	22	24	30	35	42	50	65	85	100
Cooling capacity 10*4kcal/h	10	15	25	37	50	63	75	100	125	150	200	250	300	400	500
COP	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72



Triple Generation Hot Water Chiller

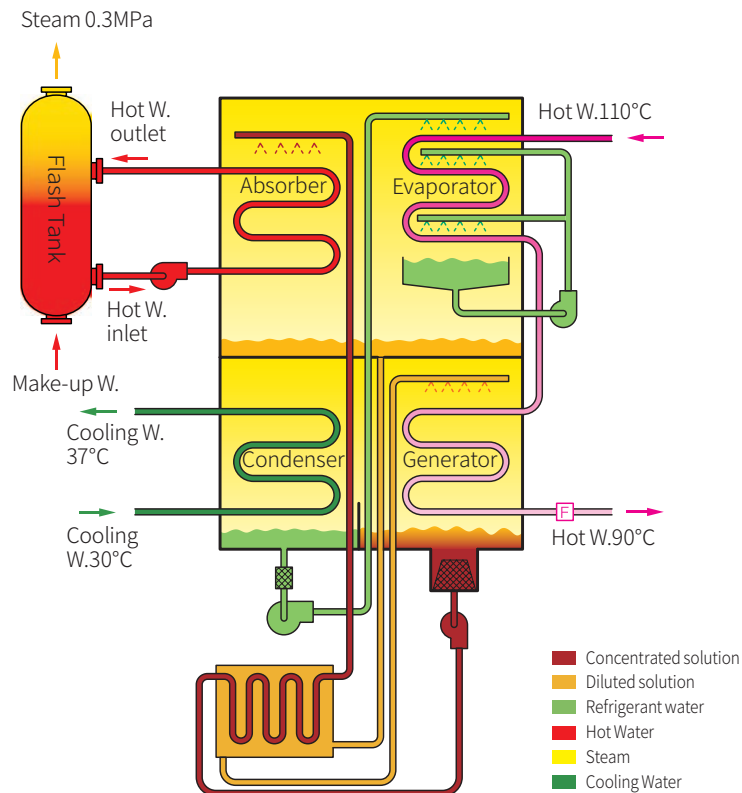
■ Steam production:

Type II absorption heat pumps, also known as stepup heat pumps, operated by inputting a large amount of medium-temperature hot water to drive it and produce hot water at a higher temperature than the medium-temperature heat under the condition of cooling water or by flashing out steam under reduced pressure to achieve medium-temperature heat transfer to high-temperature heat

Energy saving: every 1kW of medium temperature heat input can get 0.4~0.5kW of high temperature heat, the conversion efficiency is only 40~50%, so only if the medium temperature heat is completely waste heat, energy will be saved .

Usable waste heat: Hot water, exhaust, steam or other air, liquid that above 80°C.

Output: high temperature hot water or steam is 30~40°C higher than medium temperature heat

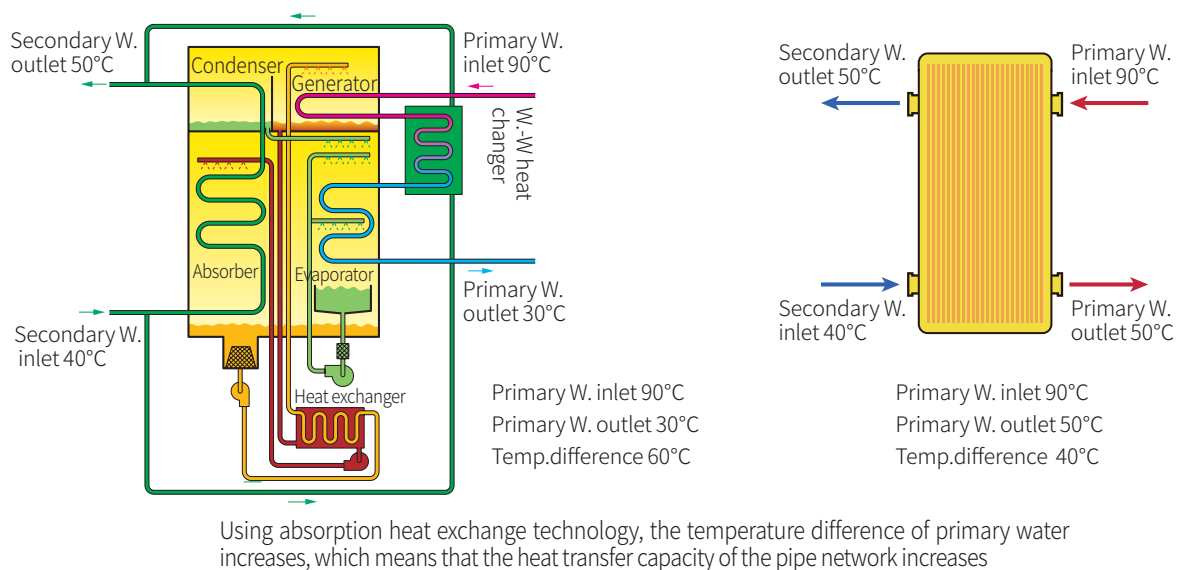


■ Heat exchange:

The conventional method of water-water heat exchange is to use a heat exchanger, which is limited by the first law of thermodynamics, the primary water outlet temperature (50 °C) can only be infinitely close to the secondary water inlet temperature (40 °C), and the closer temperature difference brings the larger exchange area, which also means the larger investment.

Principle: Absorption heat exchange is a new technology combining hot water absorption chiller and water-water heat exchanger. High temperature primary water first enters the generator of hot water absorption chiller to drive the chiller, then enters the water-water heat exchanger to exchange heat with the secondary water, and then enters the hot water absorption chiller evaporator for the third time to cool down. Finally, all the heat from the primary water is transferred to the secondary water through the hot water absorption chiller and heat exchanger, and the outlet temperature of the primary water is much lower than the inlet temperature of the secondary water to achieve a large temperature difference in heat exchange.

Energy saving: absorption unit is used as a heat exchanger, and does not function for providing cooling or recovering waste heat. This technology is mainly used in projects such as central heating renovation, geothermal water heating with large temperature difference and distillation self cooling process for brewing



Heat Recovery

Source: Medium-temperature exhaust gas mainly refers to gas below 300°C (mainly exhaust gas or hot air), from industrial kilns, micro-turbines, air compressors and other thermal or power equipment after combustion (or compression), or after recovery of high-temperature exhaust gas. This part of exhaust gas (hot air) has a certain value of utilization if the temperature is applicable and the volume is large.

Utilization

- If the exhaust gas pressure is low, it is recommended to use exhaust gas/water heat exchanger to produce medium temperature hot water, and then drive hot water absorption chiller for cooling.
- If the exhaust gas pressure $\geq 2,500\text{Pa}$ can overcome the resistance of chiller, then the exhaust absorption chiller can be directly used, such as the exhaust from micro-turbine.

Energy saving: By cooling down the exhaust gas with a volume flow rate of $10,000 \text{ Nm}^3/\text{h}$ (about $12,853 \text{ kg/h}$) by 10°C , the heat recovered is about 42kW , and then the cooling capacity is calculated based on the efficiency of the chiller. The chiller is driven entirely by waste heat, achieving zero carbon cooling.

For example: $100,000 \text{ Nm}^3/\text{h}$ of exhaust gas from 180°C cooling down to 90°C , the heat is about $10 * (180-90)/10 * 42 = 3,780\text{kW}$, then use the exhaust gas / water heat exchanger to produce $90/70^\circ\text{C}$ medium temperature water, chiller COP is 0.7, cooling capacity: $3,780 * 0.7 = 2,646\text{kW}$.

Triple Generation Hot Water Chiller Application

—Hankook Tires Factory , Tennessee

Founded in 1941, Hankook Tire has developed a global presence through continuous innovation and development over the past 80 years. In addition to its global headquarters in Korea, Hankook Tire has three regional headquarters (China, Europe and the USA) around the world. It invests 5% of its annual revenue in research and development and has established five R&D centres around the world to develop advanced technologies. This project is located in Tennessee, USA, and the client has planned to build the second phase of the plant.



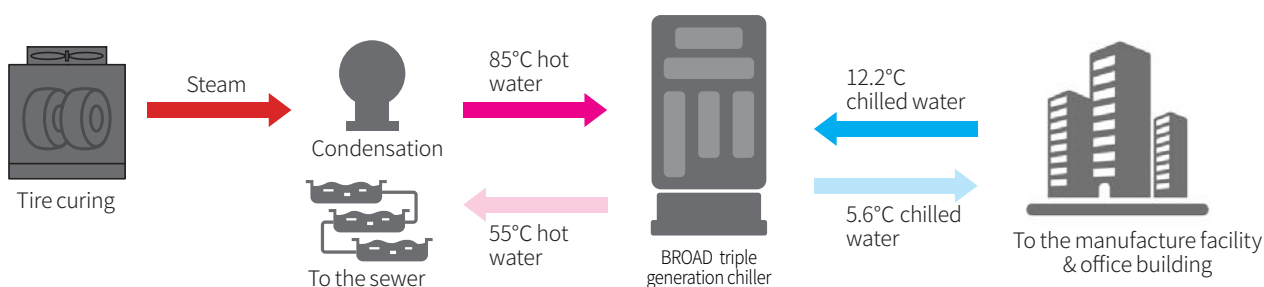
System Introduction

The plant uses waste steam from the cured tires process to recover condensate for heat exchange to 185°F (85°C) and a BROAD BDH250 Double Section chiller to recover 185°F (85°C) hot water to supply cooling for the factory and offices, the chilled water temperature is 43°F (5.6°C) . And it cools down the heat source to 131°F (55°C), making full use of the waste heat.

Application Value

Recovered residual heat from steam condensate for process cooling, solving the waste heat treatment challenge. Using BROAD Triple Generation chiller technology to provide cooling services for process and office buildings, reducing the plant's power consumption. The stable operation of the chiller throughout the year is equivalent to an annual saving of 1,060 tons of standard coal, reducing carbon emissions by 2,642 tons and equal to planting 144,000 trees.

■ System Schematic



Double Section Hot Water Absorption Chiller Application

—Medtronic, Inc. Factory , Puerto Rico

Founded in 1949 and headquartered in Minneapolis, Minnesota. Medtronic, Inc. is one of the world's largest medical technology companies, providing lifelong treatment solutions for patients with chronic diseases. In 2019, Medtronic invested \$50 million into its operations in Puerto Rico to upgrade equipment and expand capacity. 2G Energy signed a 15-year energy management contract to sell electricity and chilled water to Medtronic by installing packaged CCHP systems at each of its four facilities on the island. Each system uses one 338Rt BROAD double section hot water chiller to provide inexpensive chilled water to the plants.



System Introduction

The project adopts four BDH200 double section hot water chillers to recycle hot water exchanged from generator exhaust and reduce the return water from 92°C to 75°C. The customer has strict requirements on cooling capacity and equipment quality, and the BROAD chiller can maximize the recycling of generator waste heat for cooling to meet the cooling demand. The project is BROAD's first project on the island of Puerto Rico. In addition to providing the absorption chillers, it also provided a stainless steel outdoor machine room and cooling tower, which expands BROAD's business territory and supply scope.

Application Value

The project is located in a tropical coastal area with harsh climatic conditions, as well as a tight energy supply. The customer attaches great importance to energy saving and emission reduction through contract energy management services for accurate metering of cooling capacity. The system gets hot water for process cooling by recovering exhaust from the generator. Using BROAD double section hot water absorption chiller technology, the heat is fully utilized and the economy is significantly improved, which is equivalent to saving 22,800 tons of standard coal, reducing carbon emission by 0.6 million tons and equal to planting 880,000 trees.



Making the Best Products with the Highest Standards

—Yangzi Petrochemical-BASF

Yangzi Petrochemical-BASF Co.Ltd. is a successful example of Sino-German joint venture cooperation between two Fortune 500 companies, Sinopec and BASF, in a 50:50 share ratio. The company is located in Nanjing, near Nanjing Chemical Industry Park, and mainly produces ethylene oxide and ethylene glycol (flammable and explosive). The safety and explosion-proof requirements of the site equipment are extremely demanding, and all personnel entering the area must be trained in chemical safety and wear safety suits before entering.

Yangzi Petrochemical-BASF Co.Ltd. conducted a strict screening of refrigeration equipment suppliers around the world. After six technical exchanges and site visits, the rigorous technical experts from BASF headquarters in Germany, through comprehensive comparison, were impressed by BROAD's R&D and manufacturing capabilities and excellent product performance: only BROAD was capable of undertaking this special order. Finally Yangzi-BASF decided to use a BROAD single stage hot water chiller to provide process cooling for the EOEG plant.

Project Features

This project uses 98°C steam condensate generated during the production process to drive a hot water absorption chiller to produce 7MW of 16°C chilled water for process cooling of the EOEG unit. The chiller is installed in an explosion-proof area: Exdeib II BT4 and IP55 for electrical protection. Due to the importance of safety, there are high requirements for the chiller in all aspects.

High reliability

The chiller is used for process cooling, and the plant runs continuously 24/365, and can only be shut down during plant-wide overhauls. The equipments on site are very compact and there is no dedicated room for the chiller, which can only be installed close to the production equipment. Due to the limited area of the site, only one chiller can be installed, which means that there is no possibility of a backup unit, and the only chiller must be guaranteed to run all year round. If the chiller failed and shut down the production process, the direct loss would exceed \$1 million per day.

High stability

The chiller is placed in the open air without a machine room and only a rain-proof shed is installed, it must be able to operate stably in ambient temperature -14~43°C.

The heat source temperature and cooling water temperature of the chiller are subject to process and weather variations: the driving heat source temperature ranges from 98°C to 105°C and the cooling water temperature from 26°C to 35°C. Temperature variations can have a significant impact on the performance, but the chiller is required to operate with a cooling capacity deviation of no more than 4%.

The cooling water comes from the plant's centralized circulating cooling water system has poor quality and corrosive property, with a fouling factor of 0.35m²K/kW, which is over four times of the national standard, and it is corrosive. The chiller is required to adopt anti-corrosion materials and the design life should reach more than 30 years.



Strict manufacturing standards

"Made in Germany" represents the highest level of manufacturing in the world, and its quality assurance is based on the pursuit of detail and excellence. To ensure that the chiller can meet the requirements of "Made in Germany", it must be manufactured in accordance with the standards and specifications provided by BASF, which are nearly 1,000 pages. They have much higher compared to the national standards, which put forward more stringent requirements on the manufacturing and process of BROAD.

All process documentation for the chiller must be reviewed by Fluor (China), the world's largest architectural and engineering firm hired by Yangzi-BASF, with internationally renowned designers and engineers involved in document approval.

During the manufacturing process, Yangzi-BASF hired Modi (Shanghai) Consulting Company, a world renowned consulting firm, to conduct third-party on-site monitoring and inspection.

The quality control points: welding, material composition (PMI), non-destructive testing, pipe expansion, leak detection, helium inspection, hydrostatic testing, shot blasting and performance testing are all done in the presence of the third-party supervisors. In addition, for one of the most critical unit electrical tests and performance tests, BASF-YPC organized more than a dozen experts to witness the tests on site.

Complete after-sales service system

Another important reason for Yangzi-BASF to choose BROAD is its excellent after-sales service. In particular, the BROAD global monitoring system plays an important role in the stable operation of the project. This system monitors and analyzes the chiller 24/365, and automatically connects to the terminal when a fault symptom or failure occurs, notifying service engineers to come to the site to solve the problem in a timely manner.

Project Operation

The chiller was put into operation in 2011 and has not had a single downtime due to failure for over 10 years. This is a milestone in the absorption chiller industry, as it only needs to be vacuumed by one time every 1.5 to 2 years (chiller with poor vacuum condition has to be pumped every 3 to 4 days).

The significance of this project is not only to save more than 1.6 million USD of energy cost for the customer every year, but also to be a big test for BROAD's manufacturing, process level and after-sales service level. Facing such a high standard of Yangzi-BASF, only BROAD has such ability to meet the demand. It is because the reliability and stability of the chiller exceeded the customer's expectation that Yangzi-BASF chose BROAD as the only choice.

Energy and Water Saving Renovation of Baijiu Distillation Cooling Process

Process Analysis

Baijiu brewing process is accompanied by high energy and water consumption, generally 1t of Baijiu production needs to consume 30~40t of water, water consumption can reach 100t with Maotai flavor. And in all water consumption, the distillation process cooling water consumption accounted for the largest proportion of 50%, reaching 50%. If we can recycle or reduce the consumption, the water saving benefit will be very significant

We conducted on-site research on several large Chinese baijiu producers and found that water waste in the cooling process has become a common phenomenon and is easily influenced by the local climate causes high cooling water temperatures, resulting in a series of problems such as decreased production and thermal pollution. For example, Beijing Niulanshan distillery uses tap water cooling, the drainage temperature is as high as 60 ~ 70 °C, because it is too high to meet the local environmental requirements, the distillery had to use normal temperature water mixed with 30 °C water before discharge, the water consumption has increased exponentially. The drainage temperature of the distillation cooling process at the Anhui Gujingong Distillery is 80°C, their cooling tower is used to cool down the water and recycle. In summer and autumn, when the weather is hot, the cooling water temperature cannot reach 30°C or less, and because the cooling water is an open system, there are many strains of bacteria in the distillery and the water temperature is suitable for their reproduction. This causes the cooling tower and condenser to build up soft scale, which seriously affects the cooling effect. Some distilleries also use air-cooled cooling, which causes the cooling effect to deteriorate due to the high air temperature, resulting in a decrease in the amount of liquor produced and affecting the production process. The high water consumption and thermal pollution of the distillation and cooling process of liquor has become an important reason to restrict the development of the liquor industry, and even the survival of some distilleries due to environmental issues.

Self-cooling of Medium-temperature Distillation Cooling Water

— Niulanshan Distillery, Gujingong Distillery

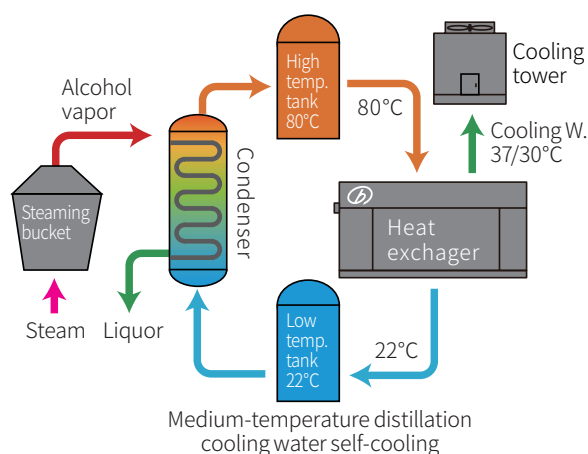
For the brewing workshop without cooling demand, or the cooling can not be supplied through a long distance, then lithium bromide absorption heat exchanger can achieve self-cooling cycle.

The system flow is shown in the figure below. The 80°C medium-temperature cooling water from each condenser is collected in the buffer tank together. The medium temperature cooling water is pumped to the BROAD heat exchanger unit and cooled down to 22°C and collected in the low temperature water buffer tank. The final 22 °C low-temperature water is then pumped back to the original distillation cooling process, so as a cycle.

In this system, rely on 80°C medium temperature water to drive the BROAD heat exchanger without additional power input, the heat of the medium temperature water cooling (80/22°C) is finally discharged to the environment by the cooling water at 37°C through the cooling tower.

This system was first used in Beijing Niulanshan Erguotou Distillery. The original cooling system produced 63t of medium temperature cooling water at 70°C per hour, which could not be discharged directly due to environmental requirements, and it had to be cooled down to below 30°C by using cool water blending. The daily water consumption of the workshop reached 1,500t, which caused water wastage and also increased the load of the waste water treatment plant. After the system is upgraded to powerless self-cooling with 70/22°C, and the water saving is 1,350t per day by using evaporative cooling instead of blending cooling, the water saving rate is more than 90%.

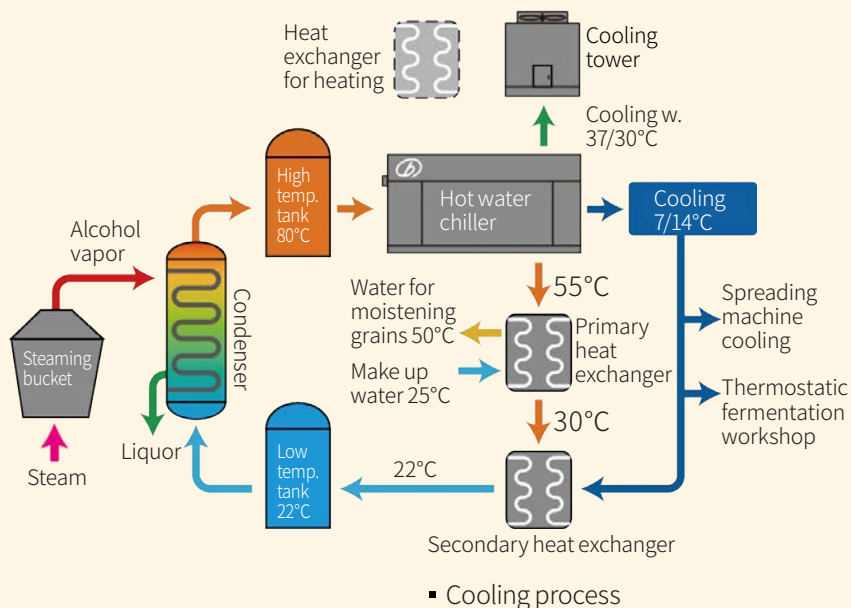
This system is also used at the Gujingong distillery to save cooling water consumption during the distillation cooling process. The distillery can produce 65°C cooling water per hour, and the original system uses cooling towers for cooling, but in actual operation, when the temperature is high, it cannot be cooled down to below 23°C, especially from May to October, which seriously affects the production process and has to use electric chillers to assist in cooling. After the innovation, the 65 °C water directly cooled to 23 °C, the process is no longer affected by the temperature, in addition, the system is driven by 65 °C distillation cooling water, saving energy consumption of auxiliary electric chillers.



Cooling of Medium Temperature Distillation Cooling Water — Liuchixiang Distillery, Shiwan Distillery

The medium-temperature cooling water ($\geq 70^{\circ}\text{C}$) produced by the high temperature condenser can drive the hot water absorption chiller for cooling, higher temperature brings higher chiller efficiency and more capacity.

Extra generated cooling capacity can be used for other cooling demands, such as applications in the spreading machine cooling, thermostatic fermentation workshop ($18\sim 22^{\circ}\text{C}$), office buildings and other buildings, etc.



The distillation cooling cycle flow is shown in the diagram above. 22°C low-temperature water is fed into the condenser of each distillation unit, after condensing the alcohol vapor into raw liquor, the low-temperature water rises to 80°C . Since the running time and cooling water flow rate of each condenser are not consistent, the medium-temperature cooling water from each condenser is collected into the large buffer tank. The 80°C medium temperature cooling water is pumped to the hot water absorption chiller and then cooled down to 55°C . The absorption chiller produces 7°C chilled water sending to the heat exchanger to cool down the medium temperature cooling water to 22°C , and the extra cooling capacity is used to the cooling machine. The 37°C cooling water produced by the cooling process is circulated through the cooling tower to cool down.

The 55°C medium temperature cooling water is finally cooled down to 22°C by the primary heat exchanger and secondary heat exchanger and sent to the low temperature water buffer tank for recycling. The heat from the primary heat exchanger can be used to preheat the water for moistening grains or to cool it down by air cooling.

The base of Liuchixiang Distillery in Yibin, Sichuan has an annual production capacity of 25,000t/year of raw liquor. There are 18 sets of coolers in brewing workshop 1, with inlet and outlet temperature of $20/85^{\circ}\text{C}$ and hourly flow rate of 20t/h. The medium-temperature cooling water produced is directly discharged, which wastes energy and causes thermal pollution. In addition, the cooling process uses electric chillers, which consumes a lot of electricity. After the innovation of cooling process, a hot water absorption chiller (cooling capacity of 400kW) is used to achieve a cooling cycle of $85/20^{\circ}\text{C}$ also bears 60% of the cooling demand of the cooling process. Annual water savings of 130,000t, electricity savings of 732,600kWh.

Before the renovation of Guangdong Foshan Shiwan Distillery, cooling towers were used to cool down the condenser with an inlet and outlet temperature of $32/52^{\circ}\text{C}$. Under high temperature and high humidity weather in summer, the cooling water temperature was high, resulting in lower liquor output and longer output time. After the cooling process was innovated as a high-temperature condenser, the temperature of the medium-temperature cooling water was as high as 90°C with a flow rate of 126t/h. A hot water absorption chiller is used to produce 2,733kW of cooling capacity for nearly 30,000 m^2 of buildings with no extra cost, saving 1.23 million kWh of electricity annually.



Cooling and Heating with Steel Mill Waste Heat

In China, the iron and steel industry accounts for about 15% of the total industry energy consumption, of which waste heat resources account for about 37%. The utilization rate of waste heat in China's large domestic iron and steel plants is 30~50%, which is far lower than the utilization rate of 90% in advanced foreign enterprises, and there is huge space for energy saving. The waste heat of iron and steel plants is mainly sensible heat from waste exhaust gas, product, cooling water and slag.

- Coking, sintering, iron making, steel making, steel rolling and other processes produce high temperature exhaust gas waste heat, which is generally converted into steam by waste heat boiler
- Slag flushing process section generates hot water of 70~90°C
- The steel production process generates a large amount of cooling water of 30~40°C

The main cooling and heating demands of the steel plant are as follows:

- Cooling demand of office building, electric control room and workshop in the plant, especially the cooling demand of instrumentation area in electric control room is large and stable; heating demand of office building, workshop and surrounding residential houses in winter
- Coking water gas cooling and purification process section needs 16/23°C chilled water
- The chiller is used to cool down and dehumidify the blast furnace combustion air and reduce the coke ratio to improve the blast furnace output.

Blast Furnace Air Dehumidification — Jiangsu Yonggang Group



The moisture in the blast furnace air is removed by cooling, so that the humidity of the air is reduced to the optimum operating requirements, and is suitable for steel plants in high temperature and high humidity environments. The main functions include.

- Reducing coke ratio. If the air humidity is reduced by 1g/Nm³, the coke ratio will be reduced by 0.8~1.0kg/t; if the coke ratio is reduced by 1%, then the blast furnace output will increase by 1%.
- Lower air humidity by 1g/Nm³ can increase the theoretical combustion temperature with 6°C, spray 1.5~2kg/t more pulverized coal, and reduce coke consumption
- Saving the electricity consumption of the blower. After the air is dehumidified, the air density increases, reducing the blower shaft power and saving electricity consumption

Project Overview

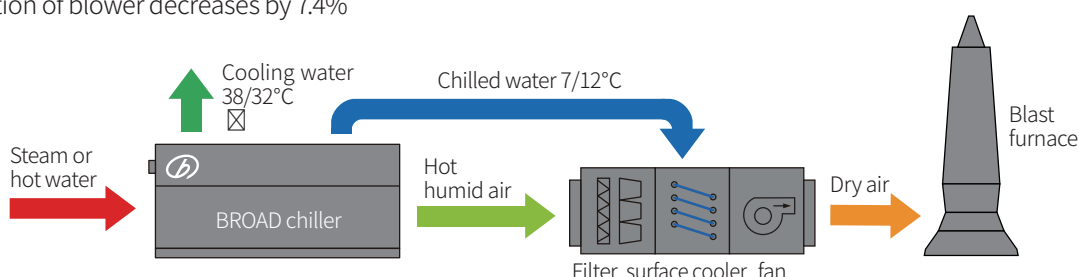
Jiangsu Yonggang Group Co., Ltd., founded in 1984, has become a private steel enterprise with exceptionally strong competitiveness in China's steel industry after more than 30 years of development. It develops and produces high-quality steel materials for the energy field, transportation field and construction field, and now has an annual steel production capacity of 9 million tons.

Application Form

Jiangsu Yonggang is located in coastal area. The average relative humidity in this area in summer is 75~90%, and the water content in the air at 20°C is about 18~25g/kg. Yonggang has built three same blast furnaces with area of 1,080m³. The project uses 0.6MPa residual steam from the steel plant to drive three BROAD BS600 (5.2MW/unit) steam absorption chillers to produce chilled water, which is used to reduce the water vapor in the blast air.

Application Value

From the analysis of actual operation data from dehumidification, the blower dehumidification amount is 7.4g/kg dry air, the coke ratio of blast furnace decreases by 8.2%, the coal injection amount increases by 1.3%, and the energy consumption of blower decreases by 7.4%





Cooling and Heating of Steel Mill Slag Water Waste Heat

—Linyi Iron and Steel Investment Group Special Steel Co., Ltd

Process: After the slag is separated from the molten iron, it enters the granulation area, and the high-speed water jet from the flushing box quenches, granulates and cools the slag. Then it is further granulated in the water-slag ditch, it flows into the cage pool equipped with water-slag separator, and the slag is separated out by the cage stirrer with spiral blades (also called spiral machine), and becomes dry slag after dewatering. Slag flushing water temperature can reach about 90 °C, the original process is cooled by nature or cooling tower

Project Overview

Linyi Iron and Steel Investment Group Special Steel Co., Ltd is located in Advanced Special Steel Park in Lingang District, covering a total area of 215 hectares, with the focus on the production of special steel smelting, new materials and new equipment. The main products are high-end oil special billets, bearing steel, gear steel, spring steel, etc. In order to build a "ecological safety, wisdom and low-carbon" circular economy demonstration base. It is planned according to "steel A-class enterprise standard" with high standard, high quality construction and high efficiency operation, in order to protect the environment and promotion of enterprise development.

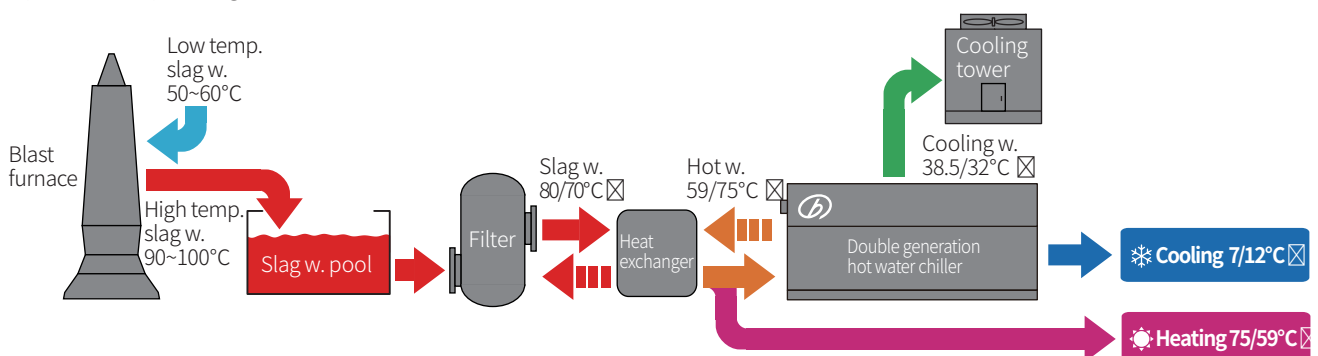
Application Form

In this project, a new blast furnace with area of 2,770m³ and two supporting slag water heat exchange stations are built. The filtered slag water is exchanged for 75°C hot water through the water-water plate exchanger, and the hot water is then pumped into two BROAD hot water absorption chillers, model: BDH400 (cooling capacity 2,605kW/unit) for cooling the office area, dormitory and electrical control room. In winter, the slag flushing water is used to provide hot water for heating in the plant through plate exchange.

Application Value

The slag water temperature is as high as 80~90°C with large water flowrate, which contains a lot of heat, but the utilization rate of waste heat is extremely low, most of it is discharged by direct cooling. In this project, in addition to using the waste heat for winter heating, it is also creatively used to drive the hot water absorption chiller for cooling.

The waste heat of slag water is used for heating and cooling, so that the waste heat can be fully utilized. In winter, the hourly waste heat recovery is 11MW, which is equivalent to 1.35t of standard coal; in summer, the hourly cooling capacity is 5,210kW, which is calculated by COP5 of electric chiller, saving 1,042kWh of electricity per hour, which is equivalent to 0.4t of standard coal. This project is expected to save 5,000t of standard coal and reduce 12,800t of CO₂ in a year, which is equivalent to planting 700,000 trees.



Cooling and Heating of Large Temperature Difference from Geothermal Water —ENN Kaixin Elder Care Demonstration Park

Application Analysis

Geothermal is a renewable and clean energy, it is one of the most important zero-carbon energy sources under carbon neutrality in the future. Geothermal energy is currently only simply used for heating in the form of heat exchange, and the utilization rate of heat energy is low and single. Absorption chiller/heat pump technology can use middle and deep layer of geothermal water as heat source to achieve large temperature difference cooling or heating, improving the utilization rate of geothermal energy.

- In summer, the geothermal water above 70°C drives the hot water absorption chiller to produce chilled water at 7°C which improves the utilization rate of geothermal wells and achievement of zero-carbon cooling.
- In winter, the geothermal water above 80°C drives the absorption heat exchanging unit to produce 40~50°C hot water, and the heat of residual geothermal water can also be further used by heat pump to improve the utilization rate of geothermal water.

Project Overview

ENN Kaixin Elder Care Demonstration Park is located in the capital economic circle, 50 KMs south of Beijing, with an area of more than 2 m², it is mainly engaged in health care and pension, physical examination, medical services, spa physiotherapy and other life and service packages. This project uses geothermal water as heat source of to provide cooling and heating for the building., the direct-fired absorption chiller as back up when the heat source is unstable or insufficient

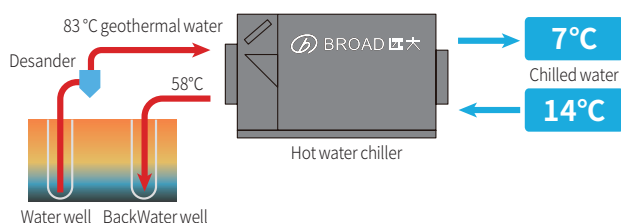


Geothermal Application

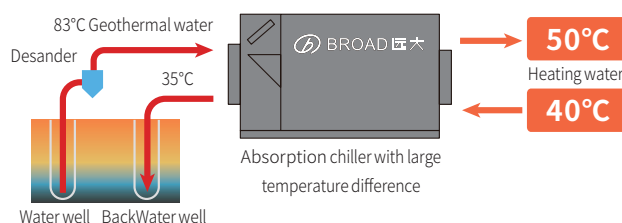
Summer: 58°C geothermal water that decreases from 83°C drives TG hot water absorption chiller, producing 7°C chilled water for building cooling. The effective cooling temperature difference of geothermal water reaches 25°C which is 10°C higher than conventional hot water absorption chiller (83/68°C), increasing the usage ratio of geothermal water by 67% with extra 880kW of cooling capacity which equals to the cooling area of more than 100,000m²

Winter: 35°C geothermal water that decreases from 83°C drives non-electric chiller with large temperature difference directly to produce 50 °C hot water for the heating of building and greenhouse. The most significant feature of the non-electric chiller with large temperature difference is that the effective heat exchange temperature difference of geothermal water is up to 48°C, 15°C higher than conventional heat exchanger (83/50°C), increasing the utilization rate of geothermal water by 45% with extra 2,617kW heating capacity which equals to the heating area of more than 40,000 m².

■ Summer



■ Winter



Application Value

ENN Kaixin Elder Care Demonstration Park uses geothermal energy to provide cooling and heating for the entire park, nearly zero energy consumption for chiller. New technology used in the project maximizes the utilization of geothermal energy, which can save 2,000t of oil and USD 968,500 of chiller operation cost for customer per year. The emission reduction of CO₂ is about 6,295t, which is equivalent to planting 344,000 trees.

Cooling and Heating by Waste Heat of Air Compressor

—Shanxi Cathay Biotech

Application Analysis

About 75% of the electric energy input during the air compression process is converted into heat energy in the hot oil, which is taken away by the cooler; about 10% of the electric energy is lost as radiation after converted to heat energy; about 5% of the electric energy is converted into motor heat; finally, about 10% of the electric energy goes to the compressed air after converted into heat energy, that is, 85% of the electricity (75% of the hot oil and 10% of the compressed air) will be converted into waste heat and discharged. About 80% of the heat, which is 0.8 of the electric energy times 0.86 equals to 68% of heat discharges in the form of cooling water.

If the temperature of cooling water from air compressor is higher than 70°C, it can be used to produce sanitary hot water or heating as well as cooling if needed. Electric/cooling conversion rate (ratio of power converted into cooling capacity) is about 15~32%, higher hot water temperature brings more conversion efficiency.

Project Overview

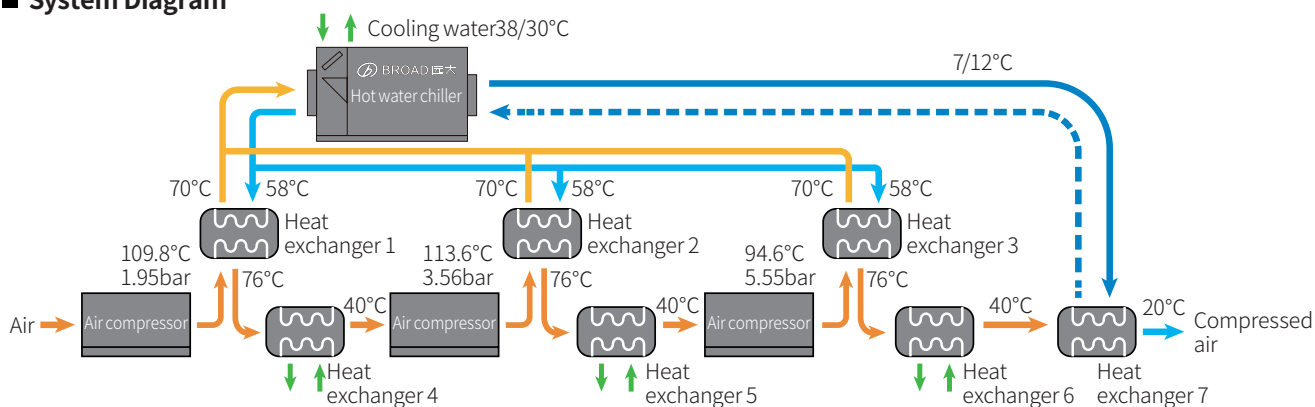
Shanxi Cathay Biotechnology Co., Ltd. is a high-tech enterprise in the synthetic biology industry, known as "The largest project in the history of synthetic biology", the company will achieve 2.4 million t/y corn deep processing capacity, 500,000 t/y biological ethylpentanediamine, 900,000 t/y bio-based polyamide project and 80,000t/y biological long-chain dibasic acid capacity.



System Information

In this project, 6 large air compressors are used to provide clean, oil-free compressed air for the corn fermentation process. The air compressor is a three-level compression, single power is 16,000kW with air processing capacity of 3,500Nm³/min per unit, the final air exhaust pressure is 0.55MPa (G). 70°C hot water produced by each air compressor is used to drive a DG hot water chiller BDH600 with cooling capacity of 3,500kW, and the chilled water produced is used to chill the compressed air down to 20°C. The heat exchanger is directly used to provide heat for the factory when there's no cooling needed in winter

■ System Diagram



Application Value

6 units of BDH600 hot water chillers are used to recover the waste heat of air compressors for cooling and heating. In summer, the electricity/cooling conversion rate is 22%, compared to electric chiller with COP5, it can save 24.69 million kWh of electricity per year. The electricity/heat conversion rate for heating in winter is 44%, which saves 172,800 tons of steam per year compared with heating by steam heat exchanger. The system is expected to save 39,100 tons of standard coal throughout the year and reduce carbon emissions by 101,700 tons, equivalent to planting 5.55 million trees.

Typical Cases of Medium Temperature Hot Water



Petrochemical: Sinopec Zhijiang Fertilizer (hot water from process)

Use the hot water generated from the production process to drive the 4 units of BROAD hot water chiller with cooling capacity of 6.4MW to produce chilled water for the cooling in ethylene glycol process

Model number:BDH800*4
Hot water temperature:
75/98°C
Chilled water temperature:
7/12.3°C

Annual CO₂ emission
reduction: 40,800t
Annual standard coal saving: 15,700t
Annual equivalent tree planted:
2,230,000



Manufacture: BMW US factory (Gas turbine)

Recover the heat of medium temperature exhaust gas from gas turbine to generate hot water,driving 1 unit of BROAD hot water chiller with cooling capacity of 5,687kW for comfort cooling of factory.

Model number:BDH400*1
Hot water temperature:
104.4/132.2°C
Chilled water temperature:
6.7/15.6°C

Annual CO₂ emission
reduction: 10,091t
Annual standard coal saving: 808t
Annual equivalent tree planted:
1,100,000



District heating: STEAG,Germany (Geothermal water)

Absorb the heat of steam from gas boiler to drive a BROAD heat pump with 7,400kW of heating capacity,producing hot water for district heating with geothermal water as low temperature heat source.

Model number:BDS500
Low temperature water:
25/61°C
Middle temperature water:
80/62°C

Annual CO₂ emission
reduction: 9,677t
Annual standard coal saving: 3,371t
Annual equivalent tree planted:
506,912



Shopping mall: IKEA, Singapore (Solar panel)

The hot water from the solar concentrator drives one unit of BROAD hot water qchiller with cooling capacity of 1,300kW to produce chilled water for building cooling

Model number:BDH150*1
Hot water temperature:
75/85°C
Chilled water temperature:
6/12°C

Annual CO₂ emission
reduction: 51t
Annual standard coal saving: 20t
Annual equivalent tree planted:
2,800

Typical Cases of Medium Temperature Exhaust Gas



Starch factory: CPP Starch, Thailand (Biomass and process hot water)

Recover biomass from starch fermentation and hot water of process to drive one unit of BROAD direct fired and hot water chiller with 302kW of cooling capacity to produce chilled water for process cooling in factory

Model number: BZDH30*1
Hot water temperature:
82/92°C
Chilled water temperature:
7/12°C

Annual CO₂ emission
reduction: 25t
Annual standard coal saving: 445t
Annual equivalent tree planted:
557,500



Glass factory: Sisecam Pasabahce, Turkey(Furnace)

Recover heat of low temperature exhaust gas(450°C) from glass melting furnace to drive one unit of BROAD exhaust chiller with 4,210kW of cooling capacity to produce chilled water for process cooling

Model number: BE400*1
Exhaust temperature:
450°C
Chilled water temperature:
6/12°C

Annual CO₂ emission
reduction: 4,724t
Annual standard coal saving: 1,830t
Annual equivalent tree planted:
262,444

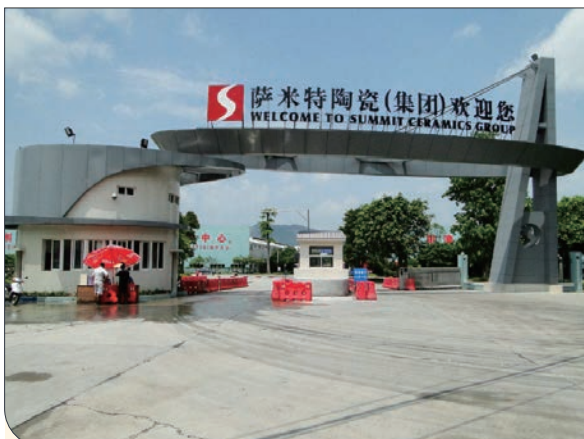


Circuit board manufacture: Jinan Guoji Co., Ltd. (Boiler)

Recover heat of medium temperature exhaust gas (250°C) from steam boilers and heat transfer oil boiler to generate hot water through heat exchange, driving 2 units of BROAD hot water chiller with cooling capacity 5,129kW for process cooling and workshop cooling

Model number: BDH300*1
Hot water temperature:
88/98°C
Chilled water temperature:
7/14°C

Annual CO₂ emission
reduction: 2,688t
Annual standard coal saving: 1,034t
Annual equivalent tree planted:
147,000



Ceramics factory: Summit Ceramics group (Furnace)

Recover heat of low-temperature exhaust gas from ceramic furnace to generate hot water through heat exchange, driving one BROAD hot water chiller with 582kW of cooling capacity to produce chilled water for building cooling.

Model number: BDH50
Hot water temperature:
88/98°C
Chilled water temperature:
7/14°C

Annual CO₂ emission
reduction: 305t
Annual standard coal saving: 117t
Annual equivalent tree planted:
1,067

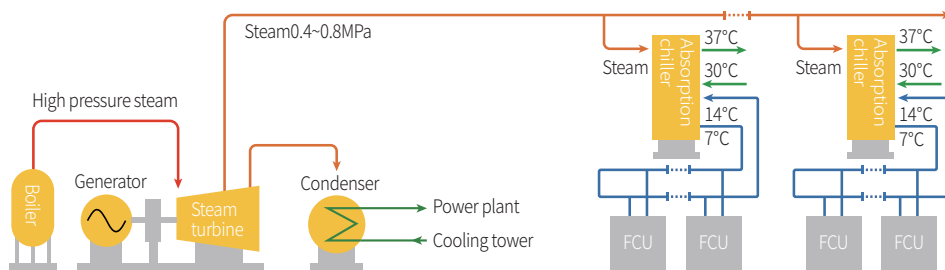
Combined Cooling Heating & Power(CCHP)

CCHP follows the principle of energy cascade utilization which utilizes energy gradually according to its grade: High-grade heat energy is preferentially used to produce high-quality electric energy, and then the low-grade heat from power generation is used for cooling or heating to achieve "temperature counterpart, cascade utilization" of energy, the utilization efficiency of primary energy can reach 60~90%

CCHP in Thermal Power Plant

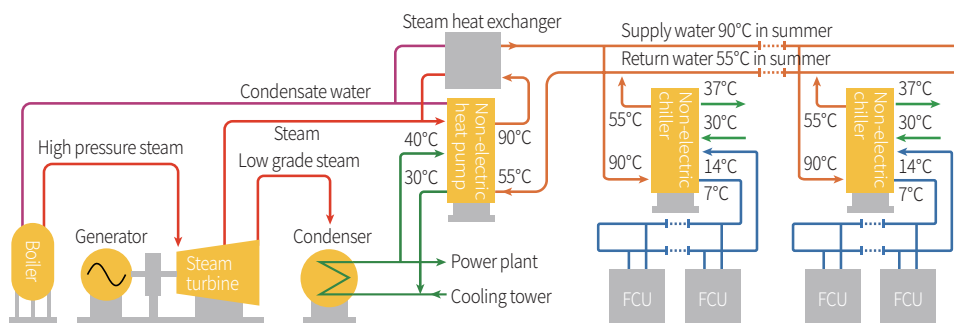
Mode 1: Steam chiller cooling

The steam turbine in the power plant generates electricity, the medium and low pressure steam from power generation is transported to the user end to drive the steam chiller for cooling. Around 1.1kg steam ($\geq 0.4\text{MPa}$) can produce 1kW of cooling capacity; Around 2kg steam ($< 0.3\text{MPa}$) can produce 1kW of cooling capacity



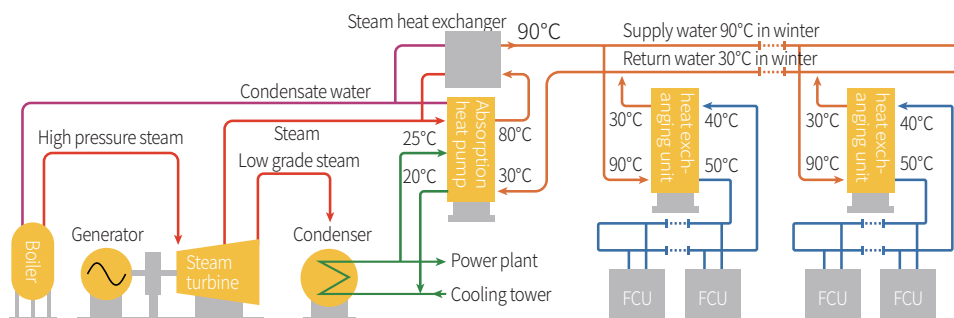
Mode 2: Waste heat recovery and large temperature difference cooling

In power plant, the non-electric heat pump is used to recover heat of the cooling water for heating, the insufficient part is supplemented by steam, and low grade heat energy side uses TG hot water non-electric chiller for cooling



Mode 3: Waste heat recovery and large temperature difference heat exchange

In the power plant, absorption heat pump is used to recover the heat from cooling water for heating, and the insufficient part is supplemented by steam. Secondary heat exchange station uses the heat exchange unit to increase the temperature difference between the supply and return water of the primary network to improve the heating capacity of the heating network



CCHP in Gas Generator

Natural gas drives gas-fired reciprocating engines or gas turbines to generate electricity, high temperature exhaust gas and jacket water from electricity (exhaust gas only for gas turbine) and drive absorption chiller for cooling and heating to complete CCHP mode.

CCHP with gas generator is applicable for the following projects:

- Certain volume and good distribution of business formats: e.g. as commercial complexes
- Stable consumption of cooling, heating and electricity, e.g. data centers, hospitals, etc.
- Long energy using time, more than 2,500 hours of operation time per year
- Low gas price, high electricity price or insufficient power supply from the grid and places with power limitation.



Conventional energy

Power generation efficiency: 35%
Transmission loss: 4%
Useless waste heat: 65%
Comprehensive utilization rate of energy: 31%

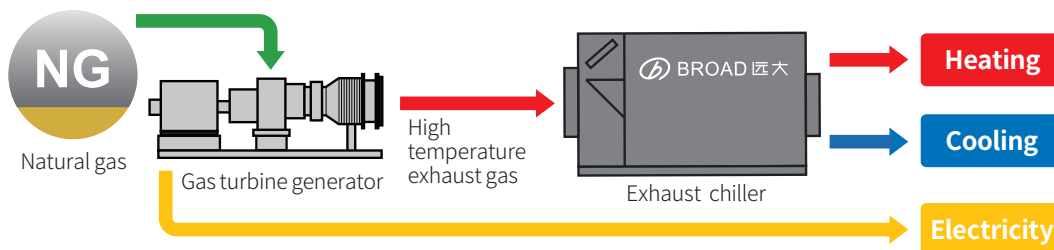


Distribution energy

Power generation efficiency: 35-45%
Waste heat for cooling and heating: 35-45%
Useless waste heat: 10-30%
Comprehensive utilization rate of energy: 70-90%

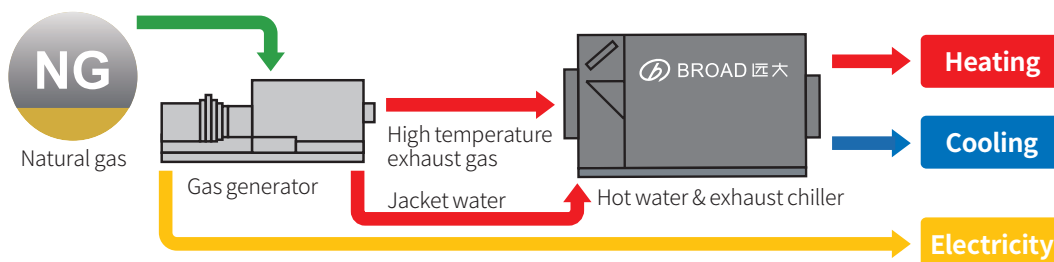
Mode 1: Exhaust gas type

Gas turbine generates electricity to buildings, chiller uses exhaust gas for cooling and heating without using fuel at all.



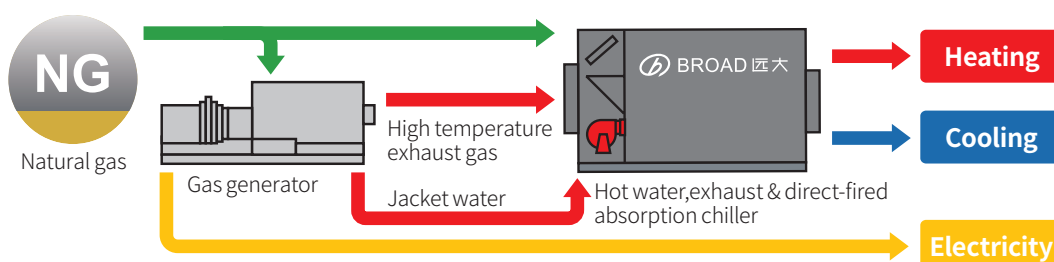
Mode 2: Hot water & exhaust type

Gas generator generates electricity to buildings, chiller uses exhaust gas and jacket water for cooling and heating without using fuel at all.



Mode 3: Make up type

Gas generator generates electricity to buildings, non-electric chiller uses exhaust gas or jacket water for cooling and heating, the natural gas can be make up source in case of no electricity generation or partially electricity generation.



Power Saving and PUE Reduction in Data Center-Combined Cooling & Power(CCP)

PUE(Power Usage Effectiveness) means the ratio of all energy consumed by the data center and the energy consumed by IT loads,it is a relatively common measure of data center power efficiency in the world. With the PUE value closer to 1 brings the higher greenness of the data center.

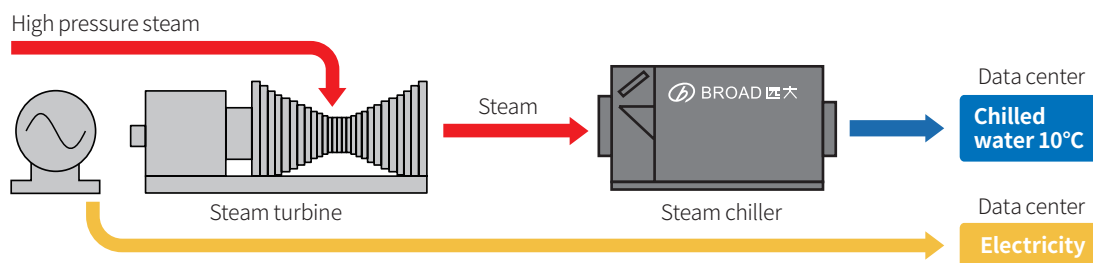
In the "Green Data Center Evaluation Index System", PUE is regarded as the most important indicator in the evaluation of green data centers with 60% of proportion.By the end of 2025,PUE value requirements of the new large-scale and super-large data center will drop below 1.3 in China.

The energy consumption of the data center mainly includes IT equipment,the power distribution system, and chiller. However,the energy consumption of cooling by chiller accounts for about 40% of the total energy consumption of the data center. If it uses traditional electric chiller,PUE reaches 1.5. Therefore, chiller mode that consumes less or no power has become the most effective way to reduce PUE.

CCP - The waste heat generated by the generator is used to drive chiller for cooling, and the power consumption only accounts for 2‰ of the cooling capacity, reduces PUE to 1.3 or less. CCP not only ensures the efficient utilization of electricity nearby and the safety of electricity consumption in the data center, but also uses waste heat for cooling to reduce energy consumption in data center. Central air conditioning energy consumption is one of the important energy-saving means for green data center construction.

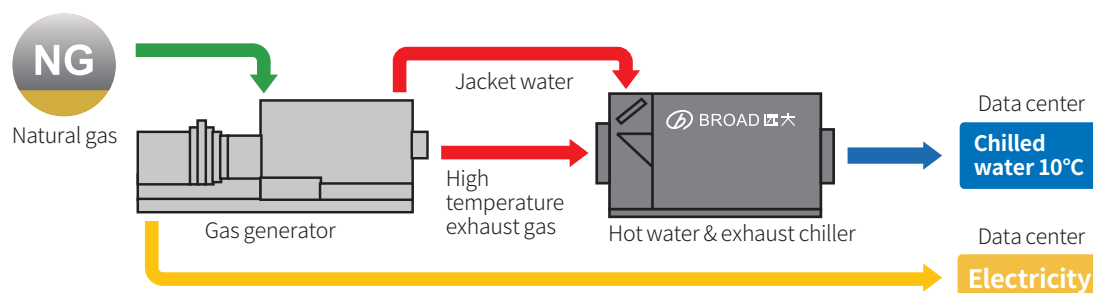
Mode 1: Steam type

Data centers are built near thermal power plants or steam pipelines. The electricity generated by the thermal power plant supplies power to the data center, and the residual pressure of the steam turbine is used to drive steam chiller to provide cooling for data centers. For thermal power plants, both electricity and waste heat steam are utilized, increasing the energy utilization ratio of thermal power plant as well as economy.



Mode 2: Natural gas type

The data center is built directly in gas-fired distribution energy station. The electricity generated by the gas generator supplies power to the data center; the waste heat from power generation (high temperature exhaust gas and jacket water) is used to drive chiller for cooling. The generator provides power nearby without transmission loss as well as a self-generating guarantee for the data center, making the operation safer and more stable; Use waste heat for cooling, the primary energy utilization efficiency reaches 90%, operating costs can be saved when the gas-to-electricity ratio is less than 5:1.



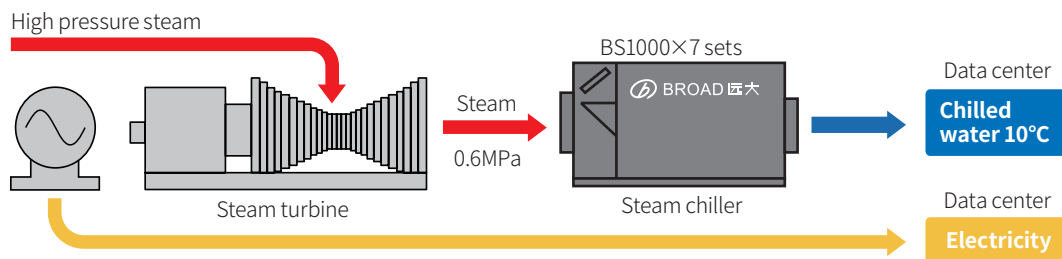


Steam Type CCP —Wusha(Kuanyuan) Big Data Center

Wusha (Kuanyuan) big data center is a super A-level data center in China. The total investment of this project is about USD 250 million, covering an area of 38,000m². 10,000 server cabinets can flexibly meet customer demands, with total cooling capacity of 19,800 URT, it's listed as an annual key project in Guangdong Province. The project is located in the core area of the Guangdong-Hong Kong-Macao Greater Bay Area, close to the four core urban engine centers of Hong Kong, Macau, Shenzhen and Guangzhou, connecting "intelligent manufacturing + offshore business". After completion, it will be the largest power plant waste heat energy station and the largest combined cooling and power data center in South China.

System Introduction

The data center is built in Shunde Wusha thermal power plant to reduce the PUE (Power Usage Effectiveness, it measures the comprehensive indicators of data center's energy efficiency of infrastructure) of the whole system. Residual pressure steam generated by the thermal power unit in the power plant is directly used as the driving heat source for the chiller. The energy station is constructed in 3 phases with 7 sets of steam chillers (6 work 1 standby), and another set of emergency standby centrifugal refrigeration system to form a 2(N+1) fault-tolerant configuration. The first-phase system uses 0.6MPa saturated steam from the thermal power plant to drive 3 sets of BROAD BS1000 steam chillers, sending 10/20°C chilled water for server cabinet cooling. The cooling water adopts the 32/39°C cooling circulating water from the power plant.



Application Value

This project actively responds to the national "13th five-year" plan in China for energy conservation and emission reduction, and is committed to building a green data center in South China. The construction of a data center in the power plant area not only achieves the cascade utilization of energy, but also increases the energy utilization rate of the power plant by 20~30% while consuming electricity and cooling nearby and reducing the transmission loss of the line, it also brings economic benefits to customers and reduces the pollution to the environment, providing a good demonstration role for the construction of the country's Internet smart energy. Using waste heat from power plants for cooling, the first phase of the project is expected to save 61.127 million kWh of electricity and reduce CO₂ emissions by about 52,800t, equivalent to planting 2.8 million trees.

Hot Water & Exhaust & Direct-fired Type CCHP

—Data Center of Hunan Radio and Television Headquarter

The construction site of the Hunan Radio and Television Program Production Base is located Changsha, Hunan, covering an area of about 110 hectares. The headquarters includes office buildings, live studios, art galleries, data centers and other building formats of about 150,000 m². Among them, the data center is designed with a total of 1,000 server cabinets, about 281 cabinets in the first phase and 719 cabinets in the second phase. Based on the diversity of buildings in the headquarter, the different characteristics of chiller loads in different functional rooms and guarantee of chiller service and power security in the data center, the energy station adopts the multi-energy complementary technology with gas CCHP as the core for the headquarter base, providing air conditioning and some electricity to the data center



System Introduction

This project uses three reciprocating generators (single unit power generation capacity 2MW, power generation efficiency 44.8%) and hot water & exhaust & direct-fired chillers (cooling capacity 1,900kW and heating capacity 1,300kW) to provide cooling and heating for the building

Summer: The high-temperature exhaust gas (376/110°C) and jacket water (95/80°C) generated by the reciprocating generator from power generation enter the hot water & exhaust & direct-fired chiller for cooling, providing 18°C chilled water for data center. When cooling capacity is insufficient, natural gas supplementary is used to provide 5,700kW cooling capacity stably.

Winter: The high-temperature exhaust gas (376/110°C) and jacket water (95/80°C) generated by the reciprocating generator from power generation enter hot water & exhaust & direct-fired chiller to obtain 55°C water for heating, supply heat to some auxiliary studios with a total heating capacity of 3,900kW, and natural gas supplementary is used when the heating is insufficient. When the wet bulb temperature is lower than 10°C, a cooling tower and a natural cooling plate are used to produce 18°C chilled water to provide cooling for the data center

Application Value

Stable and efficient:

With CCHP, making full use of the waste heat from the generator for free cooling and heating, the comprehensive energy utilization efficiency has increased from 44.8% to 88%. In winter, the existed equipment is used to obtain free cooling capacity by the natural cooling plate heat exchanger to reduce energy consumption. Efficient energy systems reach the basic electrical load of the project and partial cooling and heating requirements, achieving the project construction goals of energy-saving, environmental-friendly and high-efficiency, PUE drops to around 1.2, it reaches the national advanced green data center standard with significant energy saving effect.

Energy conservation and emission reduction:

The annual emission reduction of CO₂ is about 5,100 tons, which is equivalent to planting 280,000 trees. The project brings certain economic benefits to users while reduces the pollution caused by energy consumption to the environment, which is an effective way to achieve carbon peaking

Exhaust Gas Type CCHP

—Hangzhou Xiaoshan International Airport

The third-phase project of Hangzhou Xiaoshan International Airport is one of the ten iconic projects of Zhejiang Province's major corridor construction, and it is also a construction project for the 2022 Asian Games. Among them, the T4 terminal building has a construction area of 690,000 m² and is located on the west side of the T3 terminal building. After the completion of the T4 terminal building, the entire Xiaoshan Airport terminal building will be shaped like the initials "H" of "Hang". By 2030, the airport will be able to meet the throughput requirements of 90 million passengers.

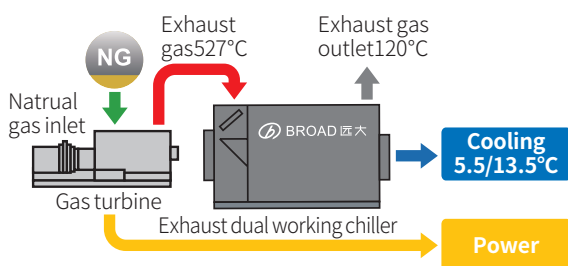
System Introduction

This project uses a gas turbine (power generation 7.83MW, power generation efficiency 32.9%) to drive a hot water & exhaust chiller and an exhaust type dual working conditions chiller respectively, supply cooling in summer and heating in winter

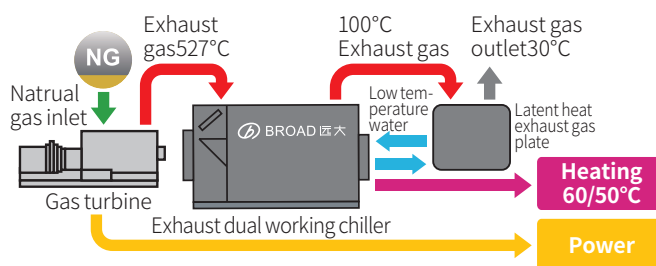
Cooling—When gas turbine burns natural gas to generate electricity, high-temperature exhaust gas (96,120kg/h) of 527°C is generated to drive hot water & exhaust type absorption chiller (BHE1000, cooling capacity 10.1MW) and exhaust type dual working conditions chiller (BE1000-R1, cooling capacity 9.1MW) respectively, producing 5.5°C chilled water for cooling in airport waiting halls, offices and other areas, and finally reducing the exhaust gas temperature to 120°C for discharge.

Heating—When gas turbine burns natural gas to generate electricity, the high-temperature exhaust gas at 527°C is fed into the two chillers respectively for heating. Among them, the hot water & exhaust chiller adopts separate heating to cool the exhaust gas to below 100 °C and generate hot water at 60 °C (heating capacity 8.56MW) for heating. Another exhaust type dual working chiller is switched to heat pump working condition, using 527 °C exhaust gas to drive the heat pump (heating capacity 10.68MW) and generate low-temperature water at 14.8°C, which is sent to the latent heat type exhaust gas plate heat exchanger of the two chillers to recover the heat of the low-temperature exhaust gas (100/30°C, waste heat 3.88MW), and finally all the heat of the exhaust gas with 60 °C hot water form is used for airport heating.

■ Cooling



■ Heating



Application Value

The project makes full use of the high-temperature waste heat exhaust gas generated by the gas turbine for free cooling (19.2MW) and heating (19.24MW), and the comprehensive energy utilization efficiency (the ratio of output electricity and cooling to the input natural gas heat) in summer can reach 100%, and the comprehensive energy efficiency in winter can reach 100%. (The ratio of output electricity and heat to input natural gas heat) can reach 101%, it is estimated that the annual electricity consumption will be saved by 9.216 million kWh, the natural gas will be saved by 4.16 million m³, and the CO₂ emission will be reduced by 17,500 tons, which is equivalent to planting 964,000 trees.



Fuel Cell Type CCHP

—University of California, San Diego Branch

Fuel cells are different from traditional forms of power generation, which can directly convert chemical energy in fuels (e.g. hydrogen, biogas, natural gas, etc.) into electricity. Since the conversion does not go through the combustion process, the energy conversion rate is high, and the electric energy conversion efficiency is 45~60%. After the fuel cell generates electricity, the residual heat is discharged into the form of high-temperature exhaust gas, the exhaust type absorption chiller is used to recover the high-temperature exhaust gas heat for cooling and heating, and the primary energy utilization efficiency can reach 70~90%.



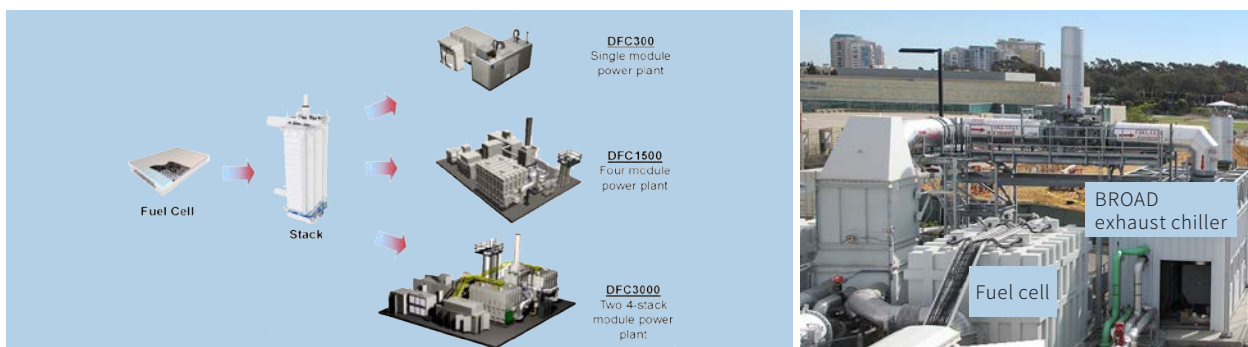
Project Introduction

The University of California, San Diego branch is a public research university located in San Diego-La Jolla, California, United States. An "Public Ivy League" and one of the top public research universities in the United States. The University opted for a new technology of fuel cells, rather than traditional reciprocating generators or turbine generators.

Application Form

The fuel cell power station directly utilizes renewable energy biogas to generate electricity of 2.8MW, the cornerstone of the micro-grid sustainable development of the University of California (UCSD), providing 92% of the required electricity load per year.

The BROAD exhaust type absorption chiller recovers the heat of the exhaust gas at 371°C of the fuel cell to provide cooling for the campus building with a cooling capacity of 1,315kW. Together with the existing chiller system, it can meet the needs of future construction planning. The waste heat is used as secondary energy, increasing the overall energy efficiency of the system to 78% compared to traditional power plants with only about 30%.



Application Value

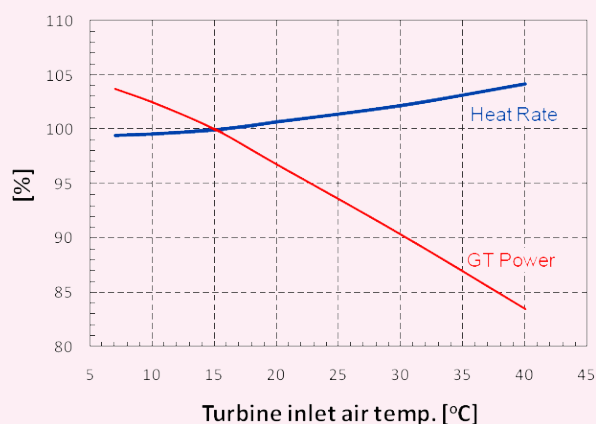
Contrary to the traditional chiller system that uses grid power, the fuel cell CCHP system can reduce carbon emissions by around 1,331 tons and save around USD 18 million in fixed asset acquisition costs per year. UC San Diego no longer has to buy electricity from the large grid, saving USD 800,000 per month by generating electricity from its own micro-grid while CCHP can reduce following:

- Energy losses due to transmission and distribution of electricity from large grids.
- Reliance on out-of-state coal-fired power generation.
- Regional congestion in San Diego Gas & Electric Grid System.
- USD 330,000 of cost per year, and the project will recover the investment of the chiller within 3.5 years

Turbine Inlet Air Cooling(TIAC)

—Lianyuan Iron and Steel Co., Ltd.

The rated operating conditions of the gas generator are according to the ISO standard that is the rated power generation when the ambient temperature is 15°C. However, in actual operation, the generator does not run at the standard temperature, especially in summer, when the temperature is high and the air density is low, the air quantity entering the compressor and gas turbine is reduced, which directly leads to the decrease of power generation and the increase of heat consumption of the gas generator. As shown in the figure on the right, when the temperature reaches 40 °C, the power generation of the generator decreases by 13%; the heat consumption increases by 4%. The waste heat from power generation or industrial by-product fuel is used to drive absorption chiller for cooling, not only makes full use of waste heat, but also improves power generation volume and power generation efficiency.



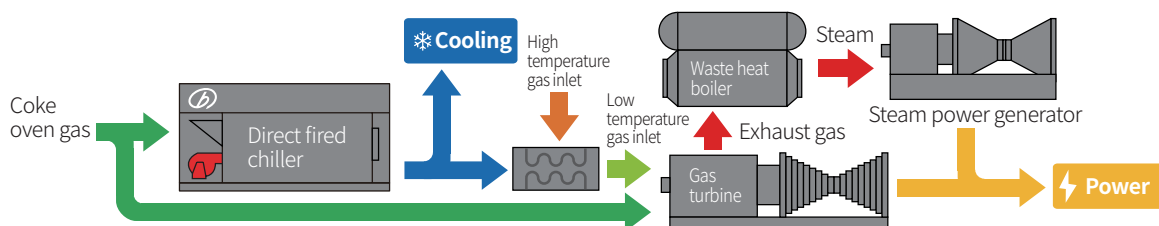
Project Overview

Lianyuan Iron and Steel Co., Ltd. is an important plate material production base in central southern China. The company was completed and put into production in 1958, and now it has a comprehensive scale with an annual output of 8 million tons of steel. It adopts Mitsubishi M251S gas turbine with gas compressor, and uses coke oven gas as raw material

Application Form

Loudi City is located in the central part of Hunan Province. The hot season lasts for 4 months (June to September), the average daily high temperature exceeds 28°C and the extreme temperature is as high as 40°C. Excessive air temperature leads to the decrease of power generation and the rise of heat consumption of the gas turbine as well as reduction of power generation efficiency.

In this project, the by-product coke oven gas is used as the heat source to drive three BZ250 (cooling capacity 2.9MW per unit) direct-fired absorption chiller to produce 7°C chilled water to cool down 35°C intake air to 17°C.



Application Value

The system has been put into operation since May 2018 and has been running stably so far. By adopting intake air cooling, the power generation of the gas turbine has been increased by 10%, and the annual power generation has increased by 8.2 million kWh. The power generation system and cooling system use coke oven gas produced by the coking process, which fulfills the efficient use of energy.

Typical Cases of Steam Type CCHP



Tire Manufacture: Pirelli Tire

The residual pressure steam of the thermal power plant is used to drive 10 sets of BROAD steam absorption chiller with a total cooling capacity of 48MW to produce chilled water for process and comfort cooling.

Chiller model:
BS500*3 BS400*6/BS250*1
Steam pressure: 0.8MPa
Chilled water temp.:
7/12°C 18/22°C

Annual emission reduction CO₂:
71,000 tons
Annual saved standard coal: 27,300 tons
Equivalent to annual trees planted:
3.8 million



Paper Factory: PT OKI Pulp & Paper Mills

OKI is the factory newly built among APP group in Indonesia, which is one of the biggest pulp & paper manufacturer in the world, adopting medium pressure steam from thermal power plan to drive 4 sets of BROAD steam absorption chillers with a total cooling capacity of 23.58MW for process cooling.

Chiller model: BS600 *4
Steam pressure: 0.8MPa
Chilled water temp.: 7/28°C

Annual emission reduction CO₂:
29,740 tons
Annual saved standard coal: 11,450 tons
Equivalent to annual trees planted:
1.6 million



Steel Factory: JSW Steel Limited

JSW is the biggest steel manufacturer in India, adopting coking by-product steam to drive 6 sets of BROAD steam absorption chillers with total cooling capacity of 24.38MW for process cooling.

Chiller model: BS300 *6
Steam pressure: 0.4~0.55MPa
Chilled water temp.: 16/23°C

Annual emission reduction CO₂:
30,750 tons
Annual saved standard coal: 11,840 tons
Equivalent to annual planted trees:
1.6 million



Data Center: Chongqing Huaqing Energy

The residual pressure steam of the thermal power plant is used to drive 3 sets BROAD steam absorption chillers with a total cooling capacity of 25.6MW to produce chilled water for data center cooling

Chiller model:
BS800*2/BS600*1
Steam pressure: 0.6MPa
Chilled water temp.: 6/12°C

Annual emission reduction CO₂:
40,800 tons
Annual saved standard coal: 15,700 tons
Equivalent to annual planted trees:
2.23 million

Typical Cases of Exhaust Gas(Hot Water) Type CCHP



Hospital: Royal Children's Hospital, Melbourne, Australia

As a major specialist paediatric hospital in Victoria, adopting the exhaust gas and jacket water waste heat from 2 sets of gas reciprocating engines to drive 2 sets of BROAD exhaust & hot water absorption chillers with a total cooling capacity of 2.5MW to produce chilled water and hot water for hospital

Project mode:
exhaust gas & hot water type
Cooling capacity: 2,510kW
Chilled water temp.:
6.5/13°C

Annual emission reduction CO₂:
3,170 tons
Annual saved standard coal: 1,220 tons
Equivalent to annual planted trees:
171,410



Electronics Factory: Flextronics Guadalajara, Mexico

Flextronics is a Global Fortune 500 company, adopting the exhaust gas and jacket water waste heat from 3 sets of gas reciprocating engines to drive 3 sets of BROAD exhaust & hot water absorption chillers with a total cooling capacity of 7.47MW to produce chilled water for process cooling

Project mode: exhaust & hot
water type
Cooling capacity: 7,470kW
Chilled water temp.:
5/10.5°C, 7/10°C

Annual emission reduction CO₂:
9,410 tons
Annual saved standard coal: 3,630 tons
Equivalent to annual planted trees:
509,440



Data Center: Grameen Phone HQ, Bangladesh

The biggest telecom operator in Bangladesh, adopting the exhaust gas from 2 sets of gas turbine, together with natural gas supplementary combustion, to drive 2 sets of BROAD exhaust & direct-fired absorption chillers with a total cooling capacity of 5.8MW to produce chilled water for office and data center cooling

Project mode: Exhaust & NG
Cooling capacity: 5,805kW
Chilled water temp.: 7/13°C

Annual emission reduction CO₂:
7,320 tons
Annual saved standard coal: 2,820 tons
Equivalent to annual planted trees:
396,080



Studio City: Universal Studios, Beijing

The exhaust gas and jacket water from 3 sets of gas reciprocating engines are used to drive 3 sets of BROAD exhaust & hot water chillers to produce chilled/hot water for district cooling and heating

Project mode: exhaust gas & hot water type
Generating capacity: 6,000kW
Cooling capacity: 5,700kW
Heating capacity: 5,688kW

Annual emission reduction CO₂:
13,500 tons
Annual saved standard coal: 5,153 tons
Equivalent to annual planted trees:
729,000

Super Efficient Energy Station (SEES)

Under the premise of meeting the requirements of building or production energy (cooling, heating, electricity simultaneously or separately), adopting the method of factory production and on-site installation. In a complete operation cycle, each energy-consuming equipment meets or exceeds the higher energy efficiency standards energy station.

The SEES is a systematic project with refined design and intelligent operation and maintenance, its core includes four key parts: the selection of energy-saving products, the application of energy-saving technologies, system optimization design, and energy-saving operation and maintenance.

Advantage of SEES



Save energy

- a) Select high-efficiency energy-consuming equipment, such as high-efficiency imported gas generators ($\geq 40\%$), maglev oil free chiller (IPLV10), high-efficiency single-heat direct-fired chiller ($\geq 96\%$), etc., the energy efficiency reaches or far exceeds the national first-class energy efficiency.
- b) The packaged distribution system saves 70% of electricity compared with other distribution systems.
- c) Each energy-consuming equipment operates at the high-efficiency point through the centralized control system and the energy control system saving 15~25% of system energy.



Save money

- a) Integrated complete design and manufacture, investment saving in the design and installation of energy station
- b) All equipment is factory-made and assembled on site, and the construction period is less than one third of the conventional energy station with saving of management and time cost.
- c) A strong operation team provides rich operation and maintenance experience for the energy station with reduction of operating cost.



Save space

- a) The energy station is highly integrated, and the area of the machine room is reduced by 50% compared with the traditional energy station.
- b) The energy station can be installed outdoors or on the roof as required without occupying area for indoor machine room



Worry-free

- a) Provide refined execution plans from design, procurement, construction, operation and maintenance, etc., as well whole-process services guided by target energy efficiency
- b) Unmanned management of energy stations with Intelligent control system
- c) Global network monitoring, 24/365 fault warning, fault diagnosis, energy saving management

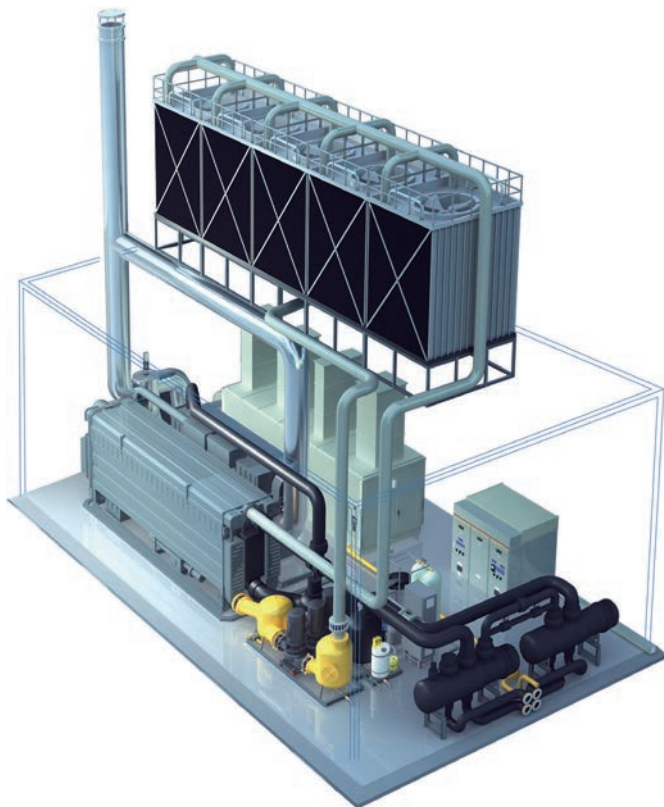
Super-efficient Cooling System

Using super-efficient oil free chiller and packaged water distribution system as the core, each equipment realizes efficient operation through centralized control system.



BROAD packaged power
efficient chiller model
selection and design manual

CCHP System



Integrate gas generator, exhaust (hot water) absorption chiller, water distribution system into a complete set of equipment upon a standardized, integrated and modular design. Each component realizes high-efficient operation through the energy control system

Operation Target:

The annual average energy utilization of natural gas CCHP system is between 80~90%

Note:

- The annual average energy utilization rate refers to the percentage of the total output of electricity, heating (cooling)/ the input heat of gas consumption during the annual operation cycle.

Super-efficient Heating System



Super-efficient gas-fired vacuum boiler and exhaust gas plate heat exchanger/heat pump are the core, and each equipment operates efficiently through centralized energy control system

Operation Target:

- The heating efficiency of super-efficient gas-fired vacuum boiler and exhaust gas plate heat exchanger exceeds 96%
- The heating efficiency of super-efficient gas-fired boiler and heat pump reaches up to 106%, and the exhaust temperature maintains below 40°C

Note:

- The thermal efficiency of boiler refers to the percentage of the heat output/the low heat of natural gas consumed by the boiler

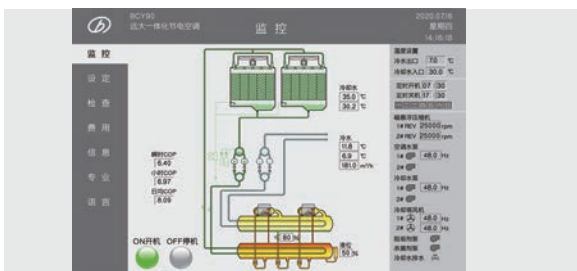


BROAD CCHP system - combustion type

Intelligent Control System (ICS)

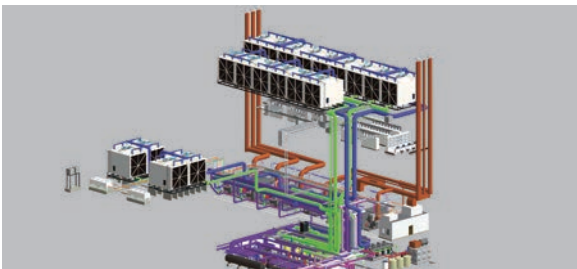


The ICS is the core of SEES system operation, and a good control system can achieve system energy saving up to 15~25%. BROAD ICS is mainly composed of the following five parts:



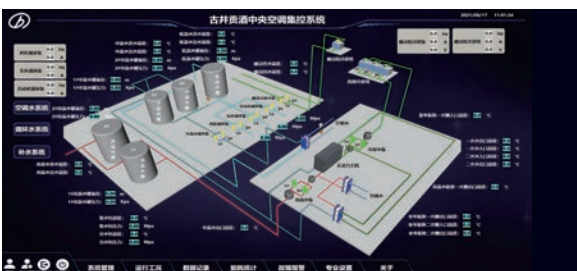
01

ICS control system (Host level): realize the "unmanned operation" and "uninterrupted operation" of the chiller



02

BIM plant room design (Design level): realize visualization, system optimization and reduce installation time



03

Plant room centralized control system (Plant room level): realize the collaborative automation and operating efficiently of multiple chillers and multiple equipments



04

Global network monitoring system (Service level): realize active service



05

Energy control system (operation level): realize energy measurement to ensure the energy station operation efficiency.

SEES Application

——Hunan Women's and Children's Hospital (HWCH)

The construction of SEES is based on energy-saving equipment, relying on refined design and system energy saving. The construction of SEES involves many links from equipment selection, system design and optimization, construction and operation, and no matter which party implements it, it cannot promise to achieve the operating efficiency. In this project, BROAD is not only an equipment manufacturer, a system designer, or an investment operator, and it has an unparalleled advantage in performing refined control and whole-process services for each process of the system.

Project Feature

The energy station of HWCH is invested, designed, constructed and operated by BROAD in accordance with the standard of SEES, which provides energy services such as cooling, heating (including sanitary hot water), electricity and steam for the first phase of the hospital. The energy station uses energy-saving technologies such as CCHP, oil free chiller, condensing heat recovery direct-fired chiller, and condensing direct-fired boiler (vacuum boilers). ". Among them, the first three items were selected into the "*National Key Energy-Saving Low-Carbon Technology Promotion Catalog*". The energy station formulates detailed operation strategies according to the operating characteristics of each equipment and energy prices to ensure the safe, stable and efficient operation.

Project Overview

HWCH is located in Changsha, China. It is a 3A women's and children's hospital in accordance with the scale of top-three medical institutions and the international JCI standard of "high starting point construction, high-quality operation, and high-level service". Provide Internet + smart medical treatment experience and full life cycle butler service.

The hospital covers an area of 86,600m², with a planned total construction area of 400,000 m² and 1,500 planned beds. The construction area of the first phase is 150,000 m², including the medical complex building and the logistics complex. The total construction area above ground: 105,100m², and the total underground construction area: 48,693m². 2 floors underground, 4-5 floors in the podium, 19 floors in the tower

Load Demand

The main building functions of the hospital are divided into outpatient clinic, medical technology area, ward, neonatal room, laboratory and other affiliated offices and meeting rooms. The interior design temperature is 23~25°C in summer and 22~24°C in winter. Humidity 40~60%. The total cooling load of the hospital is 17,807kW and the heating load is 13,476kW.

Sanitary hot water consumption: the maximum daily hot water consumption in the first phase is 161.6m³/d, and the maximum hourly hot water consumption is 23.95m³/h. The daily heat consumption of the first phase is 12,378kW, the hourly heat consumption is 1,852kW, and the design hot water load is 2,000kW

Power load capacity of the hospital: 10,800kV • A



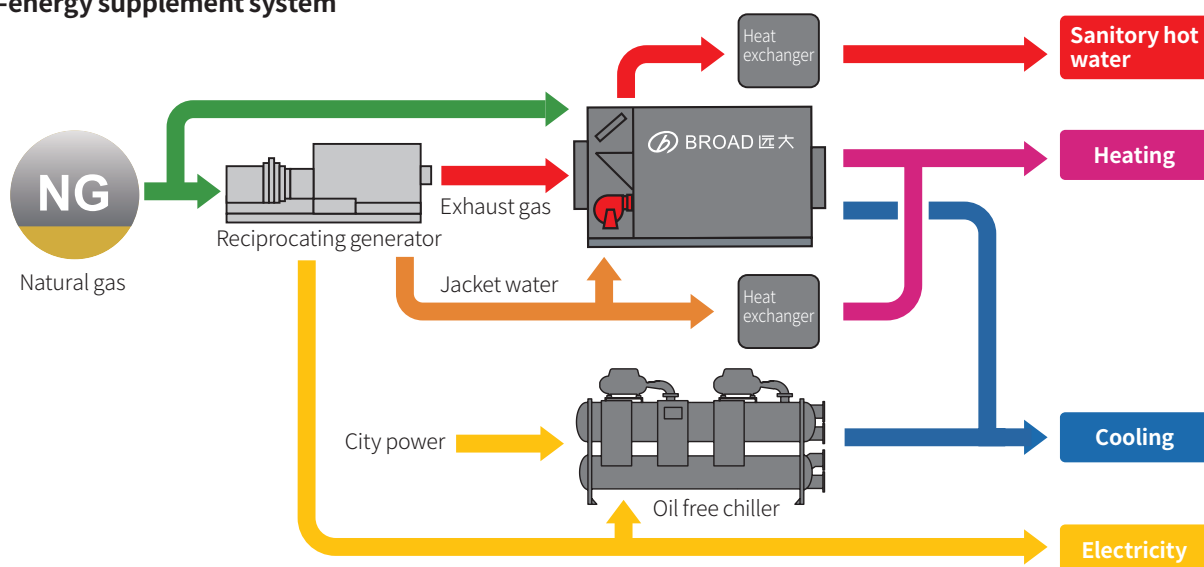
SEES Configuration

The system configuration of the energy station is mainly composed of a multi-energy complementary system consisting of CCHP, oil free chiller, direct-fired condensing heat recovery chiller, and condensing single heat boiler. Details as follows.

Equipment	Electricity kWh	Cooling capacity kW	Heating capacity kW	Sanitary hot water kW	Steam t
CCHP	1,000	1,450	1,147	/	/
Oil free chiller 1	/	4,200	/	/	/
Oil free chiller 2	/	4,885	/	/	/
Condensing heat recovery direct-fired chiller	/	4,652	5,739	1,600	/
Condensing single heat boiler	/	/	3,722	1,600	/
Condensing steam boiler	/	/	/	/	2
Total	1,000	15,187	12,476	3,200	2

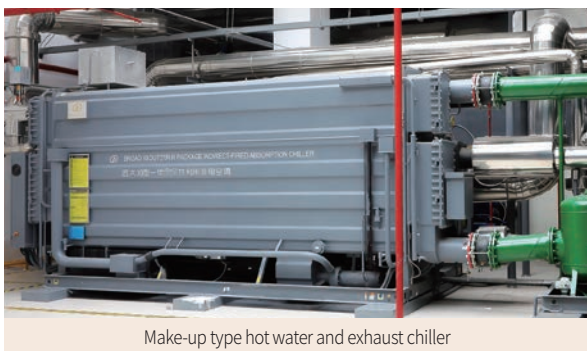
In addition, some areas of the outpatient building and the clean area of the medical technology building respectively use an air-cooled heat pump as a backup cold and heat source for the operating room; Some testing departments such as B-ultrasound, ECG room and other areas that have cooling demand, are installed VRV heat pumps.

Multi-energy supplement system





Generator



Make-up type hot water and exhaust chiller



Oil free chiller



Condensing single direct-fired heater



Condensing heat recovery direct-fired chiller

■ CCHP plant room

- Generator: The power generation is 1,000kW, the power generation efficiency is 41%, the exhaust gas temperature is 465°C, the mass flow rate is 5,656kg/h; the jacket water temperature is 80/91°C, and the volume flow rate is 45 m³/h. The electricity generated by the generator is given priority to meet the basic electricity load of the energy station, and the insufficient part of the mains electricity is supplemented
- Make-up type exhaust and hot water chiller: provide free cooling, heating and sanitary hot water through recovering the heat from high temperature exhaust gas and jacket water. The exhaust gas provides 853kW of cooling capacity and 514kW of heat; the jacket water provides 403kW of cooling capacity and 576kW of heat; 180kW of sanitary hot water is provided by exhaust gas heating exchanger at 120°C. By using gas burner, it can provide a maximum cooling capacity of 1,450kW and a heat capacity of 1,147kW

The natural gas CCHP system has a cooling energy efficiency of 99% in summer and 93% in winter

■ Oil free chiller

- The energy station is equipped with two oil free chillers with a cooling capacity of 4,200kW and 4,885kW respectively. The IPLV of the oil free chiller can reach more than 10, which is 40% more energy efficient than conventional chillers.
- Another major feature of the oil free chiller is that it operates without oil, which reduces failures, minimizes maintenance costs, and the lifespan of compressor is up to 30 years.

■ Exhaust heat exchanger

Direct-fired boiler and the steam boiler are equipped with exhaust heat exchangers for preheating constant pressure water of sanitary hot water and boiler hot water. The exhaust gas temperature is reduced to 40~50°C, and the utilization rate of natural gas is increased to 103%, which saves operating costs and also to remove part of the water vapor in the flue gas to achieve the purpose of white smoke elimination

■ Condensing heat recovery direct-fired chiller

The condensing heat recovery technology is an energy-saving technology for supplying sanitary hot water by extracting the condensation heat of the condenser during the cooling process. Compared with conventional direct-fired chillers or boilers, condensing heat recovery direct-fired chiller can reduce the energy consumption of sanitary hot water by more than 50%, and even provide free sanitary hot water

System Optimization Design and Energy Saving Design



■ BROAD packaged pumpset system

BROAD packaged pumpset system refers to the equipment installed on a common base for conveying chilled water, cooling water or sanitary hot water, mainly including pumpset, filters, valve sets, water treatment devices, metering devices and their control systems, etc. The BROAD packaged water distribution system has the following characteristics:

Save electricity	Zero-resistance filter and zero-resistance check valve are used, and there are no redundant valves at the inlet and outlet of the pump. The cross-sectional area of the resistance filter is 20 times larger than the traditional Y-type filter, and the measured resistance is almost zero that reduces the system resistance.
Save space	Installed on the same base, compact structure, easy maintenance, saving more than half of the floor space.
Worry free	Complete functions, eliminating the trouble of design, procurement, installation, service, etc., product quality responsibility is unified.
Thoroughly sterilized	Equipped with water treatment device, dosing device, etc., to automatically remove calcium and magnesium ions in the replenishment water and eliminate Legionella
Quick installation and use	Adopting a modular and integrated method, the entire system is manufactured and debugged in factories, and only needs to be connected to the external pipeline on site, and the installation period is less than one-tenth of the conventional one.

■ Water System Energy Saving

- The chilled water system adopts a large temperature difference and a small flow rate, and the temperature of the chilled water inlet and outlet is 7/13°C, which reduces the power distribution of the water pumps.
- The chilled water system adopts the combination of primary pump number regulation and secondary pump frequency conversion regulation. The primary pump is adjusted according to the number of refrigerators, and the secondary pump in the six zones is adjusted by frequency conversion to reduce the power consumption of the water pump.
- The water pump and cooling tower of the cooling water system are configured with three in operation and one backup, and the adjustment method combining the number of units and frequency conversion is adopted.

System Energy-Saving Operation and Maintenance

The SEES is a systematic project of refined design, intelligent operation and maintenance, and the energy-saving operation and maintenance will realize the efficient and coordinated operation for each component of the system and exert the potential of each device to achieve the highest energy efficiency of the system. In addition, system operation and maintenance should also achieve maximum energy saving under the premise of the most economical operation according to equipment operating characteristics and energy prices.

Energy-saving operation and maintenance mainly includes three aspects:

System operation strategy

The external energy purchased by the hospital mainly includes electricity and natural gas, and the output energy mainly includes electricity, cooling, heating, sanitary hot water and steam. The entire energy station is a multi-energy complementary multi-output system.

There are two kinds of power supplies for energy station: natural gas power generation and city power; there are oil free chiller and condensing heat recovery direct-fired chiller. The price of electricity and natural gas determines the economy of the system. More importantly, there is still a peak-to-valley electricity price difference in this project, and the operation is likely to result in an energy-saving system but high operating costs. According to the operating characteristics of each equipment and the energy price, formulate the strategy of "the most economical operation cost, the highest system energy efficiency, and the safest system operation"

Intelligent control system (ICS)

The ICS is the core of the SEES system operation. A good control system can achieve 15~25% energy saving of the system. BROAD intelligent control system mainly consists of BROAD ICS control system (host level), BIM plant room design (design level), plant room centralized control system (plant room level), global network monitoring system (service level), energy control system (operation level) five parts composition.

Operation management

Under the optimal conditions of both hardware and software, the ability and experience of operators determine the upper limit of the operation of the energy station.

BROAD is a pioneer and leader in EMC and district energy in China. It has built and operated hundreds of gas-fired distributed energy and multi-energy mutual complimentary district energy projects, with a total operating area of 70 million m². The operational advantages of BROAD are:

- With an experienced, high-quality, high-responsibility operation management team.
- With a large number of multi-climate conditions, multi-format building air-conditioning systems.
- Multi-condition operation database for core equipment
- Building energy operation management system supported by advanced information technology.

Typical Cases of SEES



Sino-Singapore Suzhou Industrial Park Moon Bay

Customer Information

Business model: PPP
Energy supply area:
350,000 m²
Energy equipment:
1 Energy Center
Service content:
cooling, heating

Service Value

Annual CO₂ emission
reduction: 5,400t
Annual standard coal
saving: 1,800t
Equivalent to annual
tree planting: 300,000



Nanjing Hexi New Town

Customer Information

Business model: PPP
Energy supply area:
15 km²
Energy equipment:
13 Energy Centers
Service content: cooling,
heating, sanitary hot water

Service Value

Annual CO₂ emission reduction:
120,000 t
Annual standard coal saving:
40,000 t
Equivalent to annual
tree planting: 6.6 million



Goteborg Energy

Customer Information

Energy supply area:
2.5 km²
BROAD equipment:
BDH400*3(River water as
cooling water)
Service content: District
cooling

Service Value

Annual CO₂ emission reduction:
27,500t
Annual standard coal saving:
10,580t
Equivalent to annual
tree planting: 1.5 million



CEPM District Cooling

Customer Information

Energy supply area:
190,000 m²
Total cooling Capacity
from heat recovery: 5,000Rt
BROAD equipment:
9units (BDH125*3/BDH250*
3/BDH300*3)
Service content: District cooling

Service Value

Annual CO₂ emission reduction:
28,872t
Annual standard coal saving:
9,624t
Equivalent to annual
tree planting: 1.57 million

Enquiry Form

Contact person:		Contact information:		
Project name:		Country:		
Demands	Cooling demand(Chiller) _____ $\times 10^4$ kcal/h (_____ kW) Cooling temperature ☐ _____ / _____ °C Type of application ☐ Process cooling ☐ Building cooling ☐ Others _____ Cooling time ☐ Full year ☐ Cooling season		Heating demand(Heat pump) _____ $\times 10^4$ kcal/h (_____ kW) Heating temperature ☐ _____ / _____ °C Type of application ☐ District heating ☐ Process heating ☐ Others _____ Heating time ☐ Full year ☐ Heating season	
External conditions	Cooling water Temperature _____ / _____ °C Flowrate _____ T Water quality report (For tube material selection) ☐ Yes ☐ No		Low temperature water Temperature _____ / _____ °C Flowrate _____ T Water quality report (For tube material selection) ☐ Yes ☐ No	Low temperature exhaust gas Temperature _____ °C Flowrate _____ ☐ Nm ³ /h ☐ kg/h Source from ☐ Natural gas _____ T ☐ Coal boiler _____ T ☐ Others _____
Waste heat	Hot water Temperature _____ / _____ °C Flowrate _____ T Source from _____ Corrosion ☐ No ☐ Yes	Steam Pressure _____ MPa Flowrate _____ T Source from _____ Corrosion ☐ No ☐ Yes	Exhaust gas Temperature _____ °C Flowrate _____ ☐ Nm ³ /h ☐ kg/h Source from _____ Exhaust pressure _____ kPa	Gas Heat value _____ kWh/ Nm ³ Pressure _____ kPa Source from _____ Corrosion ☐ No ☐ Yes
Energy	Electricity _____ USD/kWh Steam _____ USD/T Coal _____ USD/T Gas _____ USD/ Nm ³ Water _____ USD/T		For calculation of operation cost and investment payback period. Fill in when steam is income source or original heat supply type Fill in when coal is income source, i.e.thermal power plant steam, coal boiler steam and etc. Fill in when gas is income source or gas-made type For For calculation of operation cost and investment payback period.	
Note: This form is for consultant of any industrial waste heat projects to get more knowledge for BROAD customer manager and engineer. In case any data in this form is unknown, please feel free to contact us, BROAD can do field survey if necessary. E-mail Address: international@broad.net				

BROAD Low Carbon Practice

1988

To tackle the problem of boiler explosion hazards, we established BROAD. In the following year, we invented pressure-free heating boilers and transferred the technology to more than ten boiler manufacturers, actualizing the primitive original capital accumulation

1996

To tackle the problem of remote real-time service of air conditioning, BROAD invented a global networked monitoring system, which was a forerunner of "INTERNET +" and IoT

1992

To tackle the problem of ozone layer depletion caused by CFCs, BROAD invented non-electric air conditioning and has sold products to more than 80 countries



2004

To tackle the problem of high energy consumption in central air conditioning, BROAD invented the zero-resistance packaged distribution system, achieving an energy savings by 70%

2009

To tackle the earthquake resistance and energy-saving problems of buildings, BROAD invented factory-made steel structure buildings, achieving a 9-magnitude earthquake resistance and five times higher energy efficiency

2021

The 'Holon' building was officially launched, and the first 11-storey apartment "Homeland No. 1" was built in Changsha in 29 hours, saving 80% to 90% of energy compared to non-insulated buildings. The emission reduction per household is equivalent to planting 600 trees

1999

To tackle the problem of climate change, BROAD invented a new type of air conditioning that uses power plant exhaust to provide cooling and heating, achieving zero emissions

2008

- To tackle the problem of indoor air pollution, BROAD invented clean fresh air machine, making indoor air 100 times cleaner than outdoor
- Refining waste minerals, waste emulsified oil and other waste resources into lubricating oil with original technology, protecting and optimizing the environment with clean and renewable energy
- BROAD discovered that building insulation is more energy efficient, and immediately started to renovate 15 residential and office buildings in BROAD Town, adding 15cm-thick insulation, triple-glazed windows, window shading and fresh air heat recovery, saving 3~5 times of energy compared to the past.

2019

Invented the structural material – the B-CORE slab, a seemingly extremely simple structural material, will transform the world's construction, transportation and energy industry from the foundation due to its superior high mechanical properties, huge size, and ultra-low cost.



Company Profile

BROAD Group is a privately-owned enterprise founded in 1988 in China with RMB 30,000. The company has developed hundreds of hi-tech products and has never copied any technology of its peers since inception. The mission of BROAD Group is "For Humanity's Future: Protecting the earth with innovative, energy efficient & durable proprietary technologies, protecting humanity with innovative, clean and safe proprietary technologies."

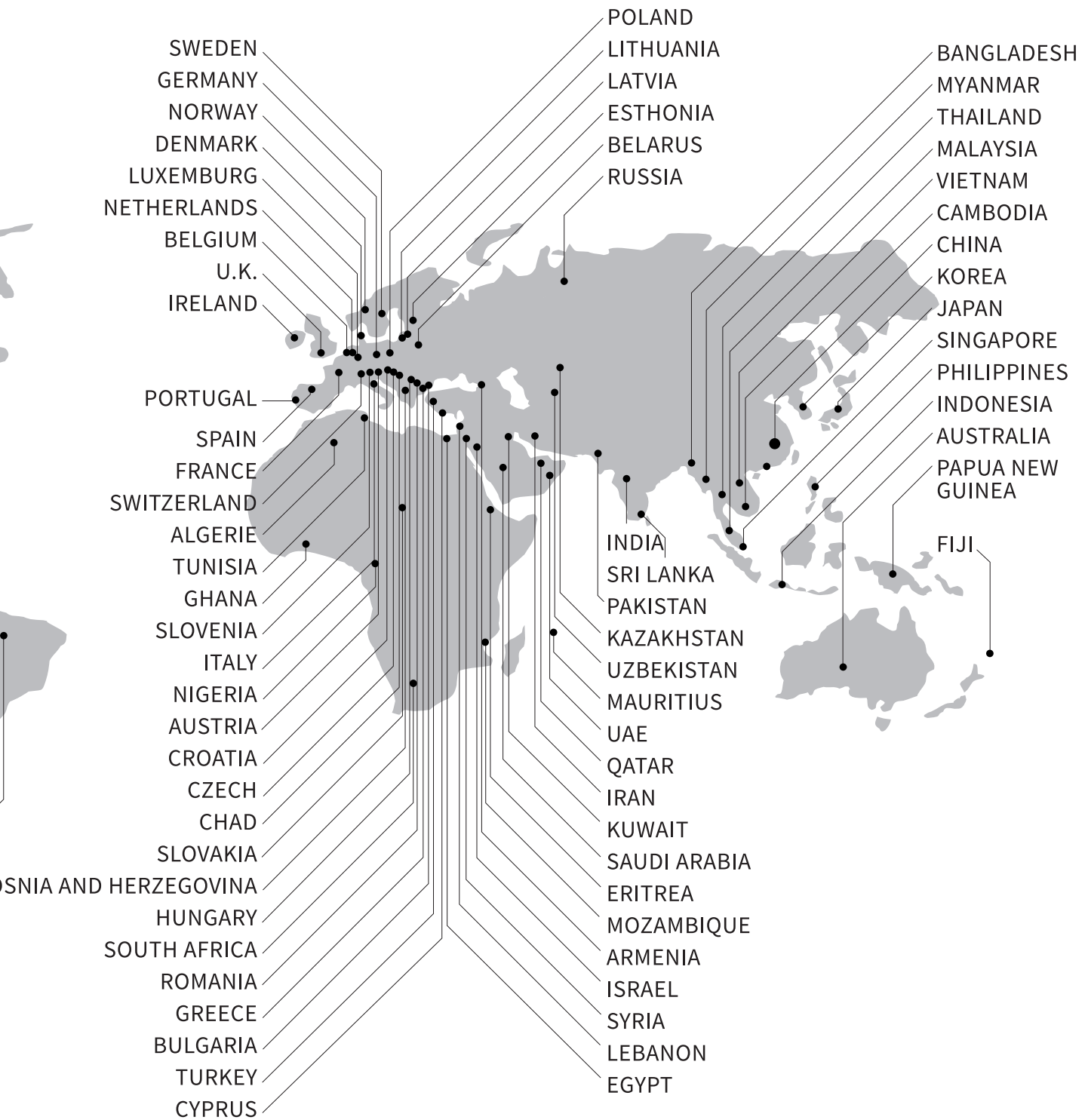
BROAD Air Conditioning was founded in 1988, manufactures non-electric chiller powered by industrial waste heat, exhaust gas and natural gas, district heating and cooling systems, and oil free chiller. The company's mission is to "continuously deepen research and development and services to lead the global direction of energy efficiency"

All products and technologies of BROAD Air Conditioning are independent and original, and all services are centered on energy saving and consumption reduction.

The company always pursues the world's first, and it is the only company in this industry that all products have obtained CE, UL, ETL, ASME and other world high-level certifications. It is the designer and manufactory of world's smallest and largest absorption chiller, the first exhaust chiller, the three functions chiller (cooling, heating and sanitary hot water). It is also the first manufacturer in the world to realize the network monitoring of all products, and as the first environmental protection case in China, announced at the annual meeting (Global Compact) in the United Nations.

BROAD Air Conditioning is world-renowned for its super energy-saving non-electric chillers, covering more than 80 countries, and has been installed by the distinguished projects, such as the tallest building in South America, the tallest building in Beijing, the largest airport in Europe, and the largest airport in Asia. Reduce carbon emissions by more than 70 million tons every year, equivalent to planting 3.8 billion trees on the earth.







BROAD non-electric chillers, power-efficient chillers and packaged water distribution system are ISO, CE, ETL, ASME, AHRI certified



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100g

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2022.07.28 The first edition
Quantity: 500
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