Co-generation with District Cooling
A Sustainable Energy Solution

Photo 1: A battery of exhaust fired VAMs installed in a DLF building in Gurgaon

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The rapid industrial development and growing urbanization has put an immense burden on the power infrastructure in the country. The real estate sector's fast development in the recent past has contributed a lot to this problem as the major portion of power is now being utilized by urban areas, be it metro or sub-urban cities. In modern office buildings and malls, it is very important to have continuous power supply and air-conditioning. Most complexes today are very large in size primarily IT-SEZs, Cyber Parks etc. and there is need of finding alternative solutions to operate them economically.

Conventional Systems

In the building sector, air conditioning and electric power are the major requirements which conventionally are provided by using electrical chillers and grid supply with a 100% backup by DG sets which are housed in a large central power plant.

Conventionally, grid power is generated in large power plants located in remote areas using coal as fuel in thermal power plants or through water in hydro power plants. The power is generated at 11KV system voltage at these plants and is stepped up to Extra High Voltage level up to 400KV or above for its dispatch to the load centre stations using long distance transmission lines. This high voltage power is then stepped down to sub-transmission level and further to distribution level at various stages, before it is actually consumed at the load centers. During the process approximately 30-40% of power generated is wasted as transmission and distribution losses.

Moreover, the long distance lines of thousands of kilometers are more prone to faults and breakdowns which makes the system un-reliable in continuous supply of power to the consumers. This system of energy supply from mega to ultra-mega capacities central power plants is costlier

About the Author

Bhattacharya is an electro-mechanical engineer with 45 years of experience and a rich background in construction and business management. This experience was earned in large companies like GEC, Fort Gloser and L&T and refined at DLF Group of Companies, which he joined in 1993. He has played different roles in developing DLF City, Gurgaon starting from construction stage to maintenance of highrise multi-storied residential and commercial complexes.

The successful design, erection and commissioning of DLP Golf Course night golfing facility and creating of gas-based power plants in DLF Cyber City, Gurgaon are some of his growing achievements.

He is a member of the executive committee of IGBC, a Fellow of Institution of Engineers and of ISHRAE.

Bhupender Singh is an electro-mechanical engineer with 14 years of experience in energy, power distribution and generation field in companies like ECE, L&T and further refined at DLF Group, which he joined in 1999.

He has been involved in design, erection and commissioning of gas-based captive power plants for DLF's projects across India. He is a member of Institution of Engineers and ISHRAE.

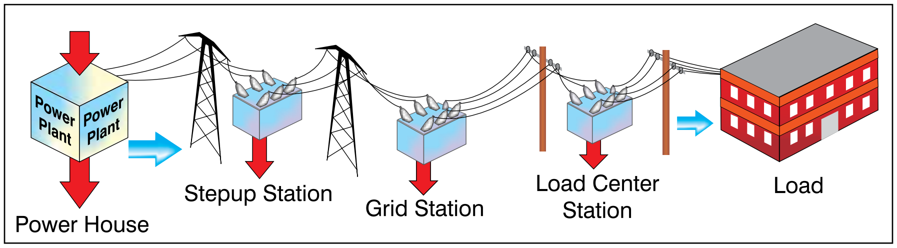

Figure 1: Typical power dispatch system from generation to the load centre

because of un-reliable grid supply resulting in use of liquid fuel for backup power. Also, this results in more space requirement and pollutes the environment by emission of a large amount of green house gases. A typical power dispatch system from generation to the load centre is shown as in *Figure 1*.

Alternate Solutions

An economical and sustainable solution to the above problem is the use of de-centralized captive power plants. These combined cycle plants can be centrally located near the load centers in urban areas as the space requirement is far less as compared to conventional central power plants and they also save a large amount of power lost during transmission and distribution. In these captive power plants, either liquid or natural gas is used as fuel in multiple units of small capacity turbines and generator sets for power generation.

Natural gas as fuel in place of liquid fuels makes these de-centralized captive plants cleaner and a more cost effective solution of power generation. These power plants run in a combined cycle mode, so that the waste heat of the power equipment i.e turbines or engines is utilized in boilers to generate steam and this steam is fed to run the steam turbines to produce electricity, and hence the overall system efficiency is increased. In this system of co-generation or combined cycle mode, energy losses occur in boilers and low efficiency turbines.

Combined Cooling, Heating and Power (CCHP) is the answer to overcome this problem and to achieve the best overall efficiency in combined cycle mode, wherein the flue gases from the power equipment is directly used in Vapour Absorption Machines (VAMs) to produce chilled or hot water for various applications.

CCHP systems, for commercial, institutional and industrial facilities, incorporate multiple technologies for providing energy services to a single facility or to multiple facilities. Electricity to such facilities is provided by on-site or near-site power generators, using one or more of the many options: Internal Combustion (IC) engines, combustion turbines, micro-turbines, and fuel cells.

In CHP systems, thermal energy in various exhaust streams from the power generation equipment is recovered, to operate equipment for cooling, heating, or controlling humidity in facilities, by using Absorption Chillers, Desiccant Dehumidifiers, or Heat Recovery equipment for producing steam or hot water. These integrated systems are known by a variety of acronyms: CHP (Cooling, Heating, Power), BCHP (Building Cooling, Heating & Power), IES (Integrated Energy Systems) etc.

CHP systems provide many benefits, including:

- Reduced energy costs.
- Improved power reliability.
- Increased energy overall efficiency.
- Improved environmental quality.

These de-centralized Energy Centers are located near the load centre and multiple facilities or building complexes can be hooked up with such an Energy Centre to cater to their power and chilled water requirements for air conditioning. Chilled water is generated at one central place and multiple users are connected, using the district cooling system for this plant, which results in optimizing the overall plant capacity and also better PLF and plant utilization factor.

District Cooling System

District cooling means the centralized production and distribution of cooling energy. Chilled water is delivered via an underground insulated pipeline to offices, industrial and residential buildings to cool the indoor air of the buildings within a district. Specially designed units in each building then use this water to lower the temperature of air passing through the building's air conditioning system.

The output of one cooling plant is enough to meet the cooling-energy demand of dozens of buildings. District cooling can be run on electricity or natural gas, and can use either regular water or seawater. Along with electricity and water, district cooling constitutes a new form of energy service.

District cooling systems can replace any type of air conditioning system but primarily competes with air-cooled reciprocating chiller systems serving large buildings which consume large amounts of electricity. This air conditioning system is subject to a difficult operating environment, including extreme heat, saline humidity and windborne sand. Over time, performance, efficiency and reliability suffer, leading to significant maintenance costs and ultimately to equipment replacement.

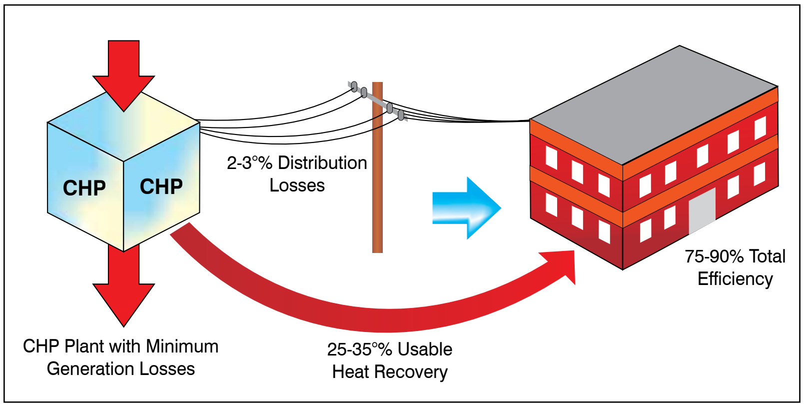

Figure 2: De-centralized power plant

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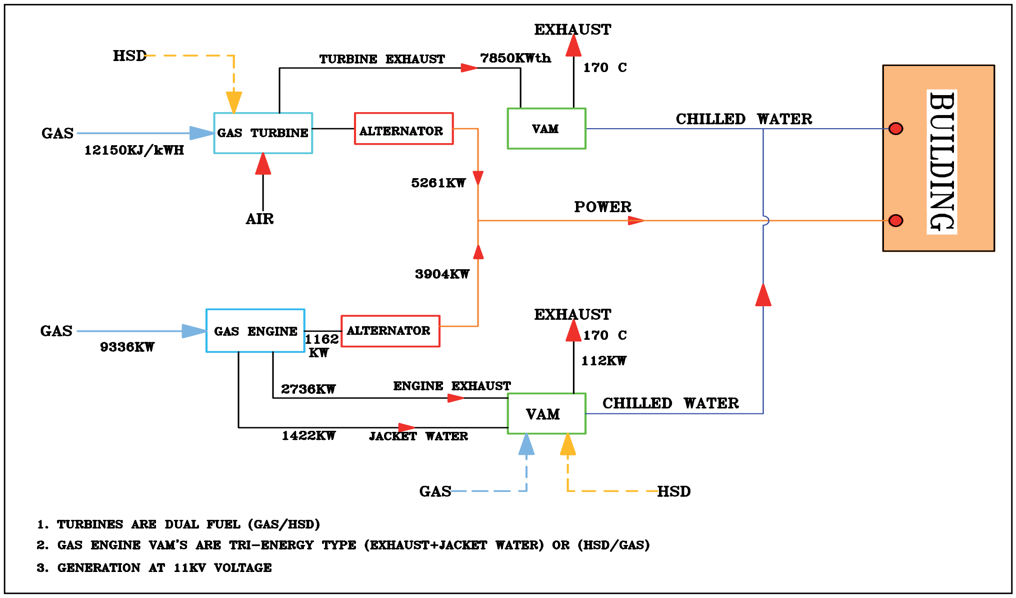

Figure 3: Flow diagram of a typical BCHP unit

Constituents of a District Cooling Plant are mainly chillers - centrifugal or absorption type, cooling towers, primary pumps, condenser pumps and secondary pumps and loads of piping along with electrical equipment like transformers, high voltage and low voltage switchgears.

Role Played by Control & Instrumentation

The plant has to supply chilled water at specific temperatures (for example: 5°C) and receives the warm return water at various temperatures up to 15°C. Water flow through the chiller evaporator circuit and chiller condenser circuit need to be regulated to the designed values. The remote Energy Transfer Station Buildings need to be supplied with sufficient water flow to meet the load demands. All of the above creates a requirement for monitoring the various process parameters such as temperature, flow and pressure in the plant and remote Energy Transfer Buildings. So, to monitor the process parameters, we need to have correct instruments installed in the plant.

To control the process to achieve the desired process conditions (such as 5°C / 3000 GPM etc), we need to have a control system which can act based on the process parameters and direct the control elements in such a way as to achieve the desired results.

Reduced Energy Consumption

As discussed above, integrated systems for CHP increase efficiency of energy utilization from 51% for conventional power generation systems to as much as 85%. Therefore, the use of these systems reduces the consumption of fossil fuels, for a unit of energy required for a facility, by about 40% of that used by conventional systems. In other words, conventional systems require 65% more energy than the integrated systems. This is important for prolonging the period of availability of our scarce fossil fuel resources (natural gas, oil and coal) and reducing our dependence on imported fuel and on nuclear energy.

Economy

Reduced life-cycle costs

Even though the initial cost of CHP systems is higher than purchasing all electric power needs and using conventional chillers and boilers for cooling, humidity control and heating needs, the life-cycle cost of the CHP systems is often lower because of the energy cost savings over its useful life of more than 20 years. For a typical system the Capx & Opexs are:

- Capital Cost : Rs. 4.5 crore/ MW
- Variable cost of power : Rs. 4.5/ kWh
- Variable cost in BCHP : Rs. 3.5/KWh @ gas cost of Rs. 16/scm

Analysis from the Indian Centre for Fuel Studies and Research has concluded that the unit cost DE sources such as BCHP over a 20 year lifespan can be about half as much as a centralized option

Attractive return on investment

As discussed above, on an overall basis, CHP systems can reduce energy costs for facilities. If the incremental installed cost of CHP systems over conventional systems is treated as an investment, and the annual savings in its energy costs are treated

Photo 2: A typical District Cooling centre

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Photo 3: 10MWe BCHP plant at DLF

Photo 4: DLF Infinity Tower - 10MWe BCHP plant

as the return on that investment, the return can be very attractive.

Also, depreciation benefits @ 80% in the very first year can be availed on heat recovery equipment like Vapour Absorption Machines (VAMs).

Environment Friendly

A combination of de-centralized power plant, running with fuel switching from liquid to natural gas with combined heat and power system mode and with district cooling helps the environment by achieving highest energy efficiency and drastically reducing environmental emissions including air pollution, greenhouse gas (GHG), carbon dioxide (CO_2) and ozone-destroying refrigerants.

The exhaust gases (flue gases) coming out of the BCHP plants have very low temperature of 100-150°C as compared to 460-550°C in a conventional power generation system. These low temperature gases can further be utilized in process plants for drying and processing in various manufacturing units. Moreover, these plants can be installed inside the basements of large commercial complexes, institution buildings as well as industrial units and hence they are almost sound proof unlike the conventional power plants.

In a typical BCHP plant, an estimated 1500 tons of CO_2 emission can be saved per year per MWe power generated. This reduction in CO_2 not only makes the system more eco-friendly, but also makes the plant liable for getting Carbon Credits as per Kyoto Protocol of UNFCCC, which is an added financial advantage for the project.

	Centralised Generation CCP* 2500 MW	Distributed Generation CCHP** 2100 MW	Distributed Generation with CCP* 2100 MW
Delivered Power	2000 MW	2000 MW	2000 MW
Capital Cost			
Generation	2.22 billion	2.34 billion	2.34 billion
Incremental T&D***	2.22 billion	0.23 billion	0.23 billion
Total Capital Cost	4.45 billion	2.57 billion	2.57 billion
Fuel Cost for 20 years	13.08 billion	5.49 billion	10.99 billion
Total Life Time Cost for 20 years Operation	17.53 billion	8.06 billion	13.59 billion
Unit Cost of Generation	96.53/MWh	49.31/MWh	66.49/MWh

** Combined Cycle Plant ** Combined Cooling, Heating & Power Plant*
**** Transmission & Distribution*

Table 1 : Capx & Payback with CCHP / BCHP

Since, BCHP plants can be housed indoor, most Middle East governments are parties to the United Nations Framework Convention on Climate Change. With most countries in the region having extremely high GHG emissions per capita, this issue will become increasingly important for government policy.

Typical Example

A typical example of such a combined cycle power plant with district cooling system is DLF Cyber City in Gurgaon, wherein, a 40 MWe capacity underground power plant of hybrid system of power generation, using dual fuel-fired Turbines and Gas Engine with Vapour Absorption machines is installed. The engines are more electrical efficient machines than the turbines but turbines give a large amount of heat rejection through exhaust gases, which when captured, gives more heat recovery for the generation of chilled water, making the turbines more thermal efficient. Hence a combination of gas turbine, typically of 5 MWe capacity and gas engine of 4 MWe capacity with compatible VAMs gives the highest overall combined system efficiency.

Multiple commercial and IT buildings scattered in a radius of 2 kms are connected through a ring main through underground pre-insulated chilled water lines and power cables of desired capacity with this power plant. The complete chilled water distribution system i.e pumping, valves and operation of chilling machines is monitored and controlled by a centralized energy management system installed at this plant.

Here, the turbines have dual-fuel advantage of running on gas as well as on HSD. Also the VAMs can be fired on HSD or gas using duel fuel burners, giving higher system reliability even in the event that supply of one fuel fails. Fuel switching being almost instant makes the system run very smoothly, unlike in conventional systems, where switching takes considerable time. The water requirement by the plant is met by a Sewage Treatment Plant for the area. This de-centralized power plant with a district cooling system has major advantages of combined overall efficiency and lower cost of generation, apart from savings in space requirement for the purpose and reduction in pollution.

However, for small buildings, lower capacity plants are also viable. DLF has already provided several plants of different capacities of 5, 10, 23, 40 MWe with corresponding chilling capacity for their commercial buildings and malls. ❖