A typical district cooling plant room

A Primer on District Cooling Systems

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A District Cooling System (DCS) distributes thermal energy in the form of chilled water from a central source to multiple buildings through a network of underground pipes to spaces or processes for cooling purpose. The cooling or heat rejection is provided from a central cooling plant, thus eliminating the need for separate systems in individual buildings. *Figure 1* shows the graphic of a typical DCS.

Components of a District Cooling System

A DCS consists of three major components: the central plant, the distribution network and the consumer system. The central plant may include the cooling equipment, power generation and thermal storage. The cooling equipment consists of large tonnage absorption or electrically driven compression chillers such as centrifugal/ screw chillers or gas/ steam turbine or engine driven centrifugal/ screw chillers or a combination of absorption and compression chillers. Electrical compression chillers are water cooled and generally with 11 kV (HT) motors. The distribution or piping network is critical and often the most expensive portion of DCS and it needs to be designed carefully to optimize its use. The piping material used for distribution network can be

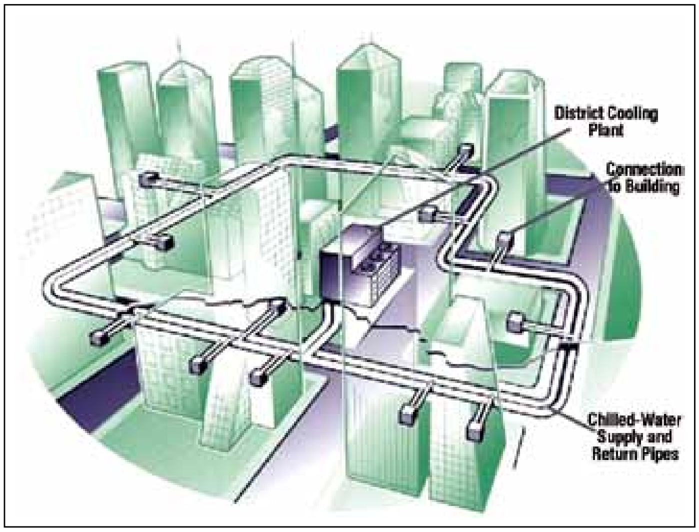

Figure 1 : Graphic of a typical DCS.

About the Author

Shrikant Kanduskar is a mechanical engineer and MBA, with 22 years industry experience. He has worked with several MEP consultants in the Middle East, who are into design and supervision of large projects.

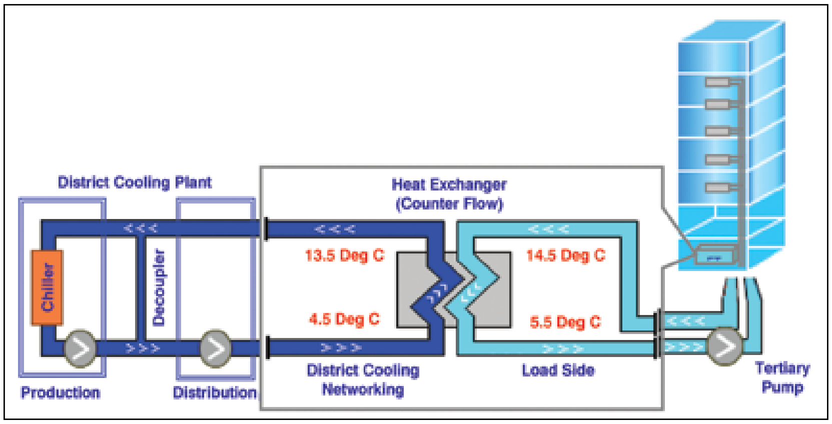

Figure 2 : Water side flow diagram in an Energy Transfer Station (ETS).

pre-insulated steel, ductile iron or high density polyethylene. The selection of piping material depends on the pressure requirements, velocity and type of installation.

Energy Transfer Stations

The consumer system would comprise of airside equipment and chilled water piping inside the buildings with energy transfer stations (ETS). The chilled water temperatures from chiller usually are 4.5°C leaving and 13.5°C return on the cold side i.e. district cooling plant side while on the hot side i.e. load side it could be 5.5°C supply and 14.5°C return water temperature. The airside equipment needs to be designed for the higher temperature difference and this is very critical to ensure the temperature difference on the plant side. *Figure 2* depicts the water side flow diagram in an ETS.

The ETS comprises of a plate type heat exchanger, DDC controllers, temperature sensors, DP transmitters and tertiary pumps with tertiary piping network. ETS serves as an interface between the district cooling chilled water network and the load side circuit. ETS is strategically important as it prevents contamination on load side, provides static head break and assures district cooling temperature difference.

Demand for District Cooling System in India

With the boom in the construction industry in India the air conditioning market has also grown. According to an article published in *BSRIA (Building Services Research & Information Association, UK)* in June 2008, the Indian market in 2007 was valued at US$ 5 billion. India was ranked as the sixth largest market by value but was estimated to be the second most attractive market in terms of growth by 2011. This market's value is expected to increase by US$ 360 million. With more than 200 SEZs approved and many other large size projects on the drawing board the total air conditioning requirement for large size projects is above 1 billion TR. The Indian air conditioning market is moving towards large size plants (district cooling plants.) where average size of plant is 15,000 TR.

Applications of District Cooling

Following are the applications where a district cooling plant solution is suitable

- Special Economic Zones
- IT parks
- Townships
- Large campuses
- Airports
- College campuses
- Shopping malls

Benefits of District Cooling Plants

In India the district cooling plant concept is applicable to single client with a large development, while in the USA and Middle East, there are district cooling service providers. These service providers build, own, operate and maintain the plant. They sell chilled water to building owners as a utility. The district cooling provides several benefits to the owners as follows:

Lower cost

The building owner need not invest in an air conditioning system, nor install chillers, cooling towers, pumps and related electrical works. This lowers building construction cost. In case of a single owner of a large development, the owner can reduce cost by having common plant room instead of installing an individual plant for each building where the equipment is installed with 25% or 50% redundancy. With a common plant room, plant capacity can be reduced, thus reducing cost. Also, the DCS or central plant room is more energy efficient than the individual plants, since each chiller is inherently of much larger capacity and tends to operate at or near peak efficiency. This reduces electricity bills. In case of DCS the individual building owner need not have skilled maintenance staff and a basic maintenance team to maintain the airside equipment and pumps on the tertiary circuit, are adequate. The maintenance of the large chilling plant is centralized.

Space saving

The building owner saves space as a plant room for chiller plant and substation is not required for individual buildings. This space, though not strictly convertible into office space, can serve as additional storage space.

Comfort cooling without operational disturbances, noise and vibration

As the plant room is located away from the building (occupied zone) there is no noise, vibration or pollution. It also eliminates the risk of Legionnaire's disease and bacteria formation due to cooling towers. The maintenance oriented plant room is away from buildings, giving building occupants privacy and security. The refrigerant handling is also restricted

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to a separate secluded space, providing additional security, especially in case ammonia is used as the refrigerant.

Reliability

The district cooling plants are of large capacity. The chillers and all other related components installed are of industrial design. This reduces the frequency of failure dramatically compared to commercial equipments. Also, the life span of industrial equipment is 30 years compared to 15 years of commercial equipment. According to *IDEA* (International District Energy Association) most district cooling plants operate at a reliability of "five nines" (99.999 percent).

District Cooling and Green Central Plant

Energy has a profound effect on the entire business landscape. Increasing demand, power disruptions and shortages, availability of water and fuel sources, regulatory uncertainty, fluctuations in fossil fuel prices, increase in energy costs and impact on environment, all these factors affect the decision of a developer.

With district cooling the plant capacity is optimized reducing electrical requirement and distribution losses. Operating costs are very important for the district cooling service provider. The district cooling plants employ stringent maintenance schedule and emission control. Improved efficiency reduces CO_2 emission. Each kWh used from the electric utility network produces 1.05 kg of CO_2. District cooling plants can be coupled with thermal storage to utilize utility rate structures. The system can be further enhanced with a cogeneration system and renewable sources to form a green central plant.

Case Study

Following is a case study for a project which highlights the benefits of a district cooling plant. The case study is to understand capital cost difference between individual and central plant.

General Information: A township with a space of 27 lac ft^2 to be air conditioned, spread over 5 or 6 buildings

Availability of resources: Good water and electric supply available

Cooling load details: Full (max) load: 14,250 TR aprox, diversified load: 12,500 TR

Electrical power supply: Main supply 66/132 kV, step down supply 11 kV & 415V, multiple backup supply gensets available

Cost of power: Rs. 5/ kWh, Rs. 200/ kVA

Chilled water plant alternates considered:

Alt. I - Individual plant room for each building

Alt. II - Centralized plant room

From the number crunching in the adjoining tables, it is clear that at least from the chilling plant point of view, a centralized system will be more cost effective. Though additional costs would be incurred towards the distribution of chilled water, the advantages stated above, may amply justify the construction of large district cooling systems, especially where there is a broad based consensus between the different consumers or when, a single developer takes up the responsibility of generation and distribution of chilled water to individual tenants.❖

PLANT ROOM COST

S. No.	Description	Unit		
A	Chiller Type		Individual Plant Room	Combined Plant Room
B	Capacity	TR	14250	12500
C	No. of Chillers		15	5
D	Rate for Plant Room Cost	Rs./TR	35000	39000
E	Total Plant Room Cost	INR (in Lacs)	4988	4875

SPACE COST

S. No.	Description	Unit		
A	Chiller Type		Individual Plant Room	Combined Plant Room
B	Capacity	TR	14250	12500
C	No. of Chillers		15	5
D	Space required (chillers only)	sq. metres	800	450
E	Space required (transformers)	sq. metres	150	0
F	Total space	sq. metres	950	450
G	Savings of space	sq. metres	500	
Additional Investment @ Rs. 10,000/sq.m.		INR (in Lacs)	50.00	

STEP DOWN TRANSFORMER COST (11KV TO 415V)

S. No.	Description	Unit	
A	Chiller Type		Individual Plant Room
B	Capacity	TR	14250
C	No. of Chillers		15
D	kW of Chiller only @ 0.55kW/TR	kW	7838
E	Total kVA (based on VSD)	kVA	8250
H	Transformer Capacity @ 85% loading	kVA	9706
	Additional Investment @ Rs. 750/kVA	INR (in Lacs)	72.79

SAVINGS IN ELECTRICAL LOAD

S. No.	Description	Unit		
A	Chiller Type		Individual Plant Room	Combined Plant Room
B	Capacity	TR	14250	12500
C	No. of Chillers		15	5
D	IkW/TR of Plant Room (Chiller+PCHWP+COWP+Tower)		0.75	0.75
E	Total kW	kW	10688	9375
H	Difference in kW	kW	1313	
Additional Investment @ Rs. 12,000/kW		INR (in Lacs)	157.50	

NET DIFFERENCE IN CAPITAL COST

S. No.	Description	Unit		
A	Chiller Type		Individual Plant Room	Combined Plant Room
B	Capacity	TR	14250	12500
C	No. of Chillers		15	5
D	Plant Room Cost	INR (in Lacs)	4988	4875
E	Addl. Investment in Electrical Connection size	INR (in Lacs)	158	0
F	Addl. Investment in Transformer Cost	INR (in Lacs)	73	0
G	Addl. Investment in Space Cost	INR (in Lacs)	50	0
I	Grand Total		5268	4875
	Net Difference	INR (in Lacs)	392.79	