A DISTRICT COOLING SYSTEM

Field of the Invention

The invention relates to a district cooling system, and in particular efficient means for integrated mixed use regions.

Background

For typical air-conditioning systems, there are two energy loops needed to achieve cooling. The two loops exchange energy but not heat transfer medium. One loop (technically the "evaporation" and cooling process) is to circulate the cold energy to end point of use and in the process take away the heat generated in the room. The heat transfer medium used for this loop is refrigerant or water. The other loop (technically the "condensation" and heat rejection process) is to reject the heat removed from the room plus the work done by compressor to the atmosphere. The heat transfer medium used for this loop is air or water.

For residential developments, direct expansion (DX) air-cooled systems which typically comprise of both an external compressor and a fan (outdoor condensing unit) and internal fan-coil units (FCU) at individual household level has been the prevalent system. Under this system, the heat continuously gathered within the room is rejected to the atmosphere via the outdoor condensing unit using the ambient air as heat transfer medium, hence the term air-cooled system. DX air-cooled systems use refrigerant as the heat transfer medium to circulate cold between the FCU and the outdoor condensing unit. One drawback of DX air-cooled system is that the outdoor condensing unit cannot be located too far from the FCU because of the small size of the compressor.

Larger air-conditioning systems use water as a heat transfer medium to reject heat gathered within the living space to outdoor, hence the term water cooled system. Unlike air, water is the more effective medium of heat transfer given its superior heat conductivity (sensible heat) and ability to absorb large quantity of heat by transforming

itself into vapour (latent heat). In addition, large air-conditioning systems use water as the medium to circulate the cold energy between the point of production (the chillers) to the end point of use (either the air handling unit or chilled water fan coil). Unlike the smaller DX air-cooled system, there is no longer a distance of coverage constraint. It is also more economical to circulate water over long distance as water is cheaper than refrigerant. Hence, for large-scale non-residential developments such as offices, hotels and retail malls where cooling demands are consistently high, water cooled chilled water system has been favoured.

In each large scale development, a typical chilled water system comprises of a central chilled water production and distribution (chillers, cooling towers and pumps) as well as end user units (air handling units, fan coil units and pre-cooled air units). The chilled water flows from the production unit (often located in the basement of buildings) to end use points located in various parts of the buildings. The chilled water which acts as heat transfer medium provides the cold and also to carry away the heat from the space. In the process it becomes warmer chilled water and flows back to the chiller plant to be re-cooled and the cycle repeats.

Instead of each development having its own chiller plant, cooling of a cluster of buildings using one or more centralised chiller plants, also known as district cooling system (DCS), has gained popularity.

Summary of Invention

In a first aspect, the invention provides a district cooling system for providing a supply of chilled water to a plurality of buildings, the system comprising; a plurality of chiller plants in fluid communication with the plurality of buildings; each of the buildings falling within at least one of a plurality of categories; wherein each of the categories defined by a respective peak demand within a different time period; wherein the plurality of chiller plants are in fluid communication with each other.

In a second aspect, the invention provides a district cooling system for providing a supply of chilled water to a plurality of buildings, the system comprising; a chiller plant in fluid communication with the plurality of buildings, wherein the plurality of buildings comprises one or more building falling within a first category and one or more building falling within a second category; wherein each of said categories defined by a respective peak demand in a different time period, and wherein the peak demand of the first category supplements the peak demand of the second category so as to optimize the system.

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According to one aspect of the present invention, a localized district cooling system according to the present invention may, at least in part, directed to:

1) Improving energy efficiency for households, by moving away from the less efficient air-cooled DX unit to the water cooled system
2) Aggregate the household cooling load, so as to implement a water cooled system and therefore allow households in one or two housing blocks to be supplied from one single water cooled chilled water plant. The households will be provided chilled water service similar to that of a centralized chilled water system.
3) Ensuring chilled water is considered a new urban utility for both commercial and residential. As such, there is a need to ensure reliability of supply for residential dwellers because a billed air-conditioning service will be provided.

In one embodiment, a localized district cooling system may comprise interconnected chiller plants that are built on the rooftops of, say, three, four or five residential blocks and may form a cluster to provide centralised cooling supply.

Benefits of this embodiment may include:

- It may be implemented in areas with pure or predominantly residential development;

- Centralized cooling with interconnected chiller plants may significantly improve reliability and efficiency of the cooling system.
- Higher energy efficiency and lower energy consumption/costs per household may be achieved compared to the conventional split unit system.
- Community amenities within or close to the cluster, such as hawker centres and outdoor community spaces, may also tap on the system to benefit from a cooler and more enjoyable environment.

According to a further aspect of the present invention, a district cooling system (DCS) may be implemented within a non-residential/mixed-use development area. A DCS may supply cooling water to an area with reasonably high cooling demand that normally peaking at daytime and weekdays, which can be extended to the nearby residential precincts where cooling needs typically peak at night and over the weekends. Such countercyclical demand from residential and non-residential developments allow sharing of the cooling system investment and hence derive economic values to be shared by all stakeholders.

Brief Description of Drawings

It will be convenient to further describe the present invention with respect to the accompanying drawings that illustrate possible arrangements of the invention. Other arrangements of the invention are possible and consequently, the particularity of the accompanying drawings is not to be understood as superseding the generality of the preceding description of the invention.

Figure 1 is a schematic view of a district cooling system according to one embodiment of the present invention;

Figure 2 is a plan view of a localized district cooling system according to one embodiment of the present invention;

Figure 3 is an elevation view of a localized district cooling system according to one embodiment of the present invention, and;

Figure 4 is a schematic view of a district cooling system according to a further embodiment of the present invention.

Detailed Description

Thus, the invention may include a district cooling system arranged to service different categories of use, with the categories defined by the time period for chilled water demand.

In so doing, the DCS may have a capacity determined by the greater peak demand of the various categories.

Accordingly, Figure 1 shows a modified district cooling system (DCS) 5. Here, a decentralized district cooling plant 10 supplies chilled water through pipe network 15 to a series of buildings 30, 40. In particular, each building includes a heat exchanger 25, 35 for exchanging heat within the buildings 30, 40 for eventual return water 20.

The DCS 5 according to the present invention is arranged to service buildings of different categories, including commercial buildings 30 and residential buildings 40. On the basis that, during the daytime, specifically during weekdays, the demand for chilled water is substantially higher for the commercial sites 30 and reduced for the residential sites 40. This demand is reversed during the weekend and night cycles whereby the demand in the residential properties 40 increases. The timing of the peak demand for each of these categories is then determined by the respective time periods.

The DCS may be designed for the peak demand experienced either during the night/weekend cycle or the daytime and weekday cycle. The highest peak demand of either of these options therefore will accommodate the demand for the reverse cycle. This has the benefit of optimizing the DCS assets which otherwise may be underutilised

during either cycle. It may also provide an opportunity to reduce the capital expenditure of the DCS as compared to conventional district cooling systems which provide for both peak demands for each cycle respectively rather than as alternatives.

To this end, infrastructure within the DCS 5 according to one embodiment of the present invention will include monitoring of peak cooling demand and peak electrical demand. The mixed use application of the DCS 5 therefore provides benefits in excess of those experienced in prior art systems.

Figures 2 and 3 show another aspect of the present invention. Here a localized district cooling system 45 operates on a local level. As shown in Figure 2, four buildings 50A, B, C, D include respective chiller plants 55A, B, C, D for providing chilled water to the respective buildings. The localised district cooling system 45, however, includes fluid communication 60 between each of the chiller plants 55A, B, C, D and thus benefits from variations in demand between the buildings within the localised area to optimize the system based on specific needs. It will be appreciated that the localised district cooling system 45 may be entirely residential, entirely commercial or a mixed use system whereby demand within the localised system 45 may fluctuate based on recognized cycles.

It will be appreciated that in different embodiments, the chiller plants may be located at an intermediate height, ground level or below ground level.

The elevation view shown in Figure 3 of the localised area shows the chiller plants 55A, B for two buildings 50A, B showing the distribution of the chilled water to the respective occupational cells/apartments 85. Each apartment 85 includes distribution pipe 90 and an array of chilled water fan coil units 95 receiving chilled water, hence achieving energy efficiency and efficient capital expenditure. In determining the number of the chiller plants for a localized district cooling system, this will be a function of the number of the residential buildings in the respective localized precinct or cluster for which the localized district cooling system provides cooling. A further, related factor, may be the comparative capital expenditure of an equivalent split cooling systems, as compared to the capital expenditure of the chiller plants of the localized district cooling system providing similar

cooling capacity for the same residential buildings. Given, a localized district cooling system according to the present invention may be more capital efficient, the ratio of chiller plants to buildings may be less than 1:1.

In one embodiment, for a cluster of 5 residential buildings, 3 chiller plants may provide the same cooling effect as a comparable system using split systems. The 3 chiller plants may be set up on the 3 of the 5 residential buildings which are located around the center of the cluster such as for easy transmission of the chiller water.

Chilled water is shared between the buildings through networking pipes 60 and thus each of the chiller plants 55A, B, C, D act to service each of the buildings within the localised district cooling system as compared to the inefficiencies of chiller plants located within a single building.

One such advantage includes a chiller plant for a particular building must accommodate the potential demand for that building whether or not that demand is realised. By having a distribution system for the localised district cooling system, peak demand can be managed across all the chiller plants within the localised system and thus better manage demand in one building in a case where another building within the district cooling system is experiencing lower demand and therefore the infrastructure is better capable of meeting the required demand as an integrated network. In situation where one of the chiller plants is not in use due to maintenance or other reasons, the rest chiller plants may be configured to provide cold energy to the buildings within the district.

Figure 4 is a schematic of a housing development having individual localised areas 105 within the larger town 100. The town centre 110 may include a network of chiller plants 115 which are in fluid communication through network pipes 120 for servicing the commercial precinct within the town centre. This, therefore, will function as a conventional district cooling system. However, the district cooling system of the town centre may further have communication 125 with heat exchangers in adjoining residential 130 and thus have the benefit of mixed use application for the district cooling system according to one aspect of the present invention. Within that residential area there may exist a localised district cooling system similar to that described with

reference to Figures 2 and 3. This localised area 135 may or may not be in communication with the district cooling system of the town centre. Thus, the embodiment of Figure 4 has the potential of integrating both the mix use DCS system according to one embodiment of the present invention with localised DCS systems and according to another aspect of the present invention. Thus, the efficiency benefits gained by the mix use DCS can be enhanced through the benefits of the localised DCS according to another embodiment of the present invention further optimizing the capital expenditure of the chilled water distribution.

In considering a business model for the invention, a charge for access to the district cooling may be based on usage time and the size of the household unit. Meter for time usage may be installed for each unit of household. The rate may fluctuate according to time period where the peak demand is different.

Thus the cost for access to system may be a function of usage time and/or size of the household unit. In order to record this usage, a plurality of meters may be connected to each unit within each building, said meters arranged to record time usage.

Claims

1. A district cooling system for providing a supply of chilled water to a plurality of buildings, the system comprising;

a plurality of chiller plants in fluid communication with the plurality of buildings;

each of the buildings falling within at least one of a plurality of categories;

wherein each of the categories defined by a respective peak demand within a different time period;.

wherein the plurality of chiller plants are in fluid communication with each other.

2. The system according to claim 1, wherein the plurality of chiller plants are engaged in a network topology by means of fluid communication.

3. The district cooling system according to claim 1 or 2, wherein the capacity of the chiller plants is determined by the category having the highest peak demand.

4. The system according to claim 2, wherein a capacity of the network of chiller plants is determined by a demand of buildings supplied by the network.

5. The system according to any one of claims 1 to 4, wherein one category of buildings is limited to entirely residential use, having at least one chiller plant corresponding to a residential use category.

6. The district cooling system according to claim 5, wherein a capacity of the at least one chiller plant corresponding to residential use is determined by a demand of buildings within said residential category.

7. The system according to any one of claims 1 to 4, wherein one category of buildings is limited to entirely commercial use, having at least one chiller plant corresponding to a commercial use category.

8. The system according to any one of claims 1 to 7, wherein one category of buildings is for mixed use and therefore includes both residential and commercial use, having at least one chiller plant corresponding to a mixed use category.

9. The system according to claim 7, wherein a time period corresponding to the commercial use category includes weekdays daytime.

10. The system according to claim 5, wherein the time period corresponding to the residential use category includes weekdays and/or weekends night.

11. The system according to any one of claims 6 to 8, wherein each chiller plant is located proximate to one of the buildings to which the chiller plant supplies the chilled water.

12. The system according to any one of claims 1 to 6 and 8 to 10, wherein each chiller plant is located in the buildings to which the each chiller plant supplies the chilled water, and wherein the buildings fall within the residential use category .

13. The system according to claim 2, wherein the number of chiller plants within the network is less than the number of buildings within a precinct.

14. The system according to any one of claims 1 to 5, 9 to 13, wherein a cumulative capacity of each chiller plants is in a range of 100% and 150% of a cumulative peak demand of the plurality of buildings.

15. The system according to any one of claims 1 to 14, further including a fluid connection such that the district cooling system is in fluid communication with a second district cooling system.

16. The system according to any one of claims 1 to 15, wherein the chiller plants are located on a rooftop of one of the plurality of buildings to which the chiller plants supply the chilled water, and wherein the buildings fall within the residential use category.

17. A district cooling system for providing a supply of chilled water to a plurality of buildings, the system comprising;

a plurality of chiller plants in fluid communication with the plurality of buildings,

wherein the plurality of buildings comprises one or more building falling within a first category and one or more building falling within a second category;

wherein each of the categories defined by a respective peak demand in a different time period, and

wherein the peak demand of the first category supplements the peak demand of the second category so as to optimize the system;

wherein the chiller plants are in fluid communication with each other.

18. The system according to claim 17, wherein a cost for access to the system is a function of usage time and/or size of the household unit.

19. The system according to claim 17 or 18, further including a plurality of meters connected to each unit within each building, the meters arranged to record time usage.