



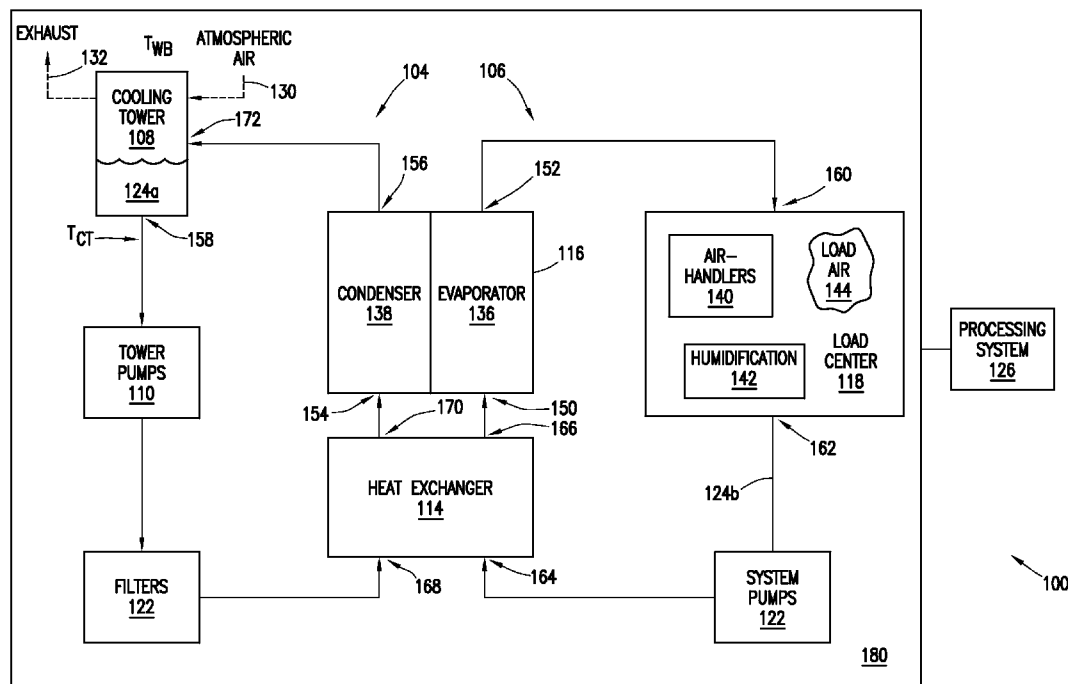
US 20160178262A1

(19) **United States**(12) **Patent Application Publication**
Rocha et al.(10) **Pub. No.: US 2016/0178262 A1**(43) **Pub. Date: Jun. 23, 2016**(54) **METHOD AND SYSTEM FOR PRE-COOLING**(71) Applicant: **CLEAResult Consulting, Inc.**, Austin,
TX (US)(72) Inventors: **David Rocha**, Austin, TX (US); **William
A. Gast, JR.**, Buda, TX (US)(21) Appl. No.: **14/576,049**(22) Filed: **Dec. 18, 2014****Publication Classification**(51) **Int. Cl.**
F25B 49/02 (2006.01)(52) **U.S. Cl.**CPC **F25B 49/027** (2013.01)

(57)

ABSTRACT

Methods and systems are provided for pre-cooling. The cooling system includes a condenser including a condenser inlet and a condenser outlet. The system also includes a cooling tower including a cooling tower inlet and a cooling tower outlet. The system further includes a heat exchanger including a first heat exchanger inlet and a first heat exchanger outlet. The first heat exchanger inlet is fluidically coupled to the cooling tower outlet, and the first heat exchanger outlet is fluidically coupled to the condenser inlet.



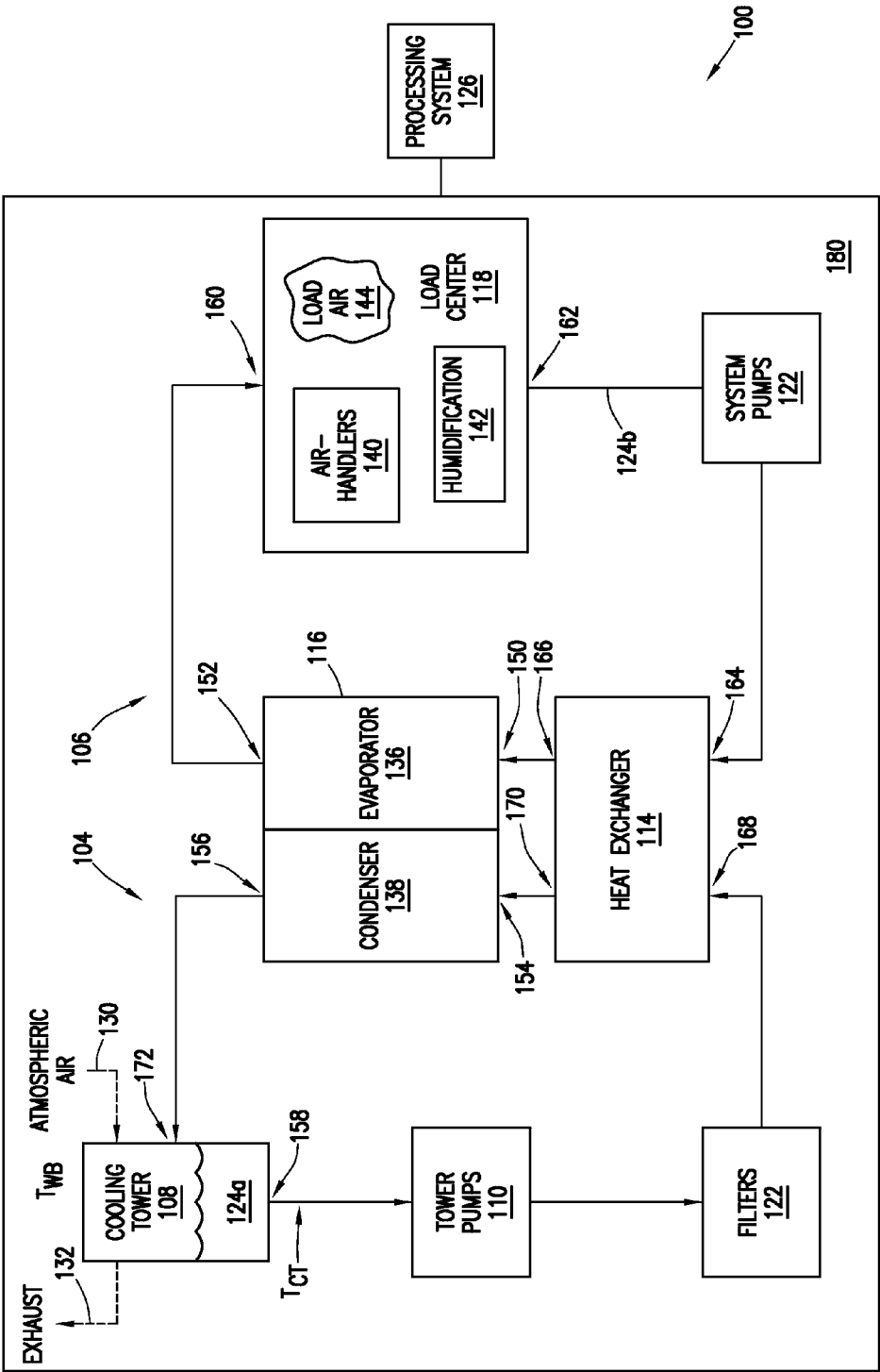
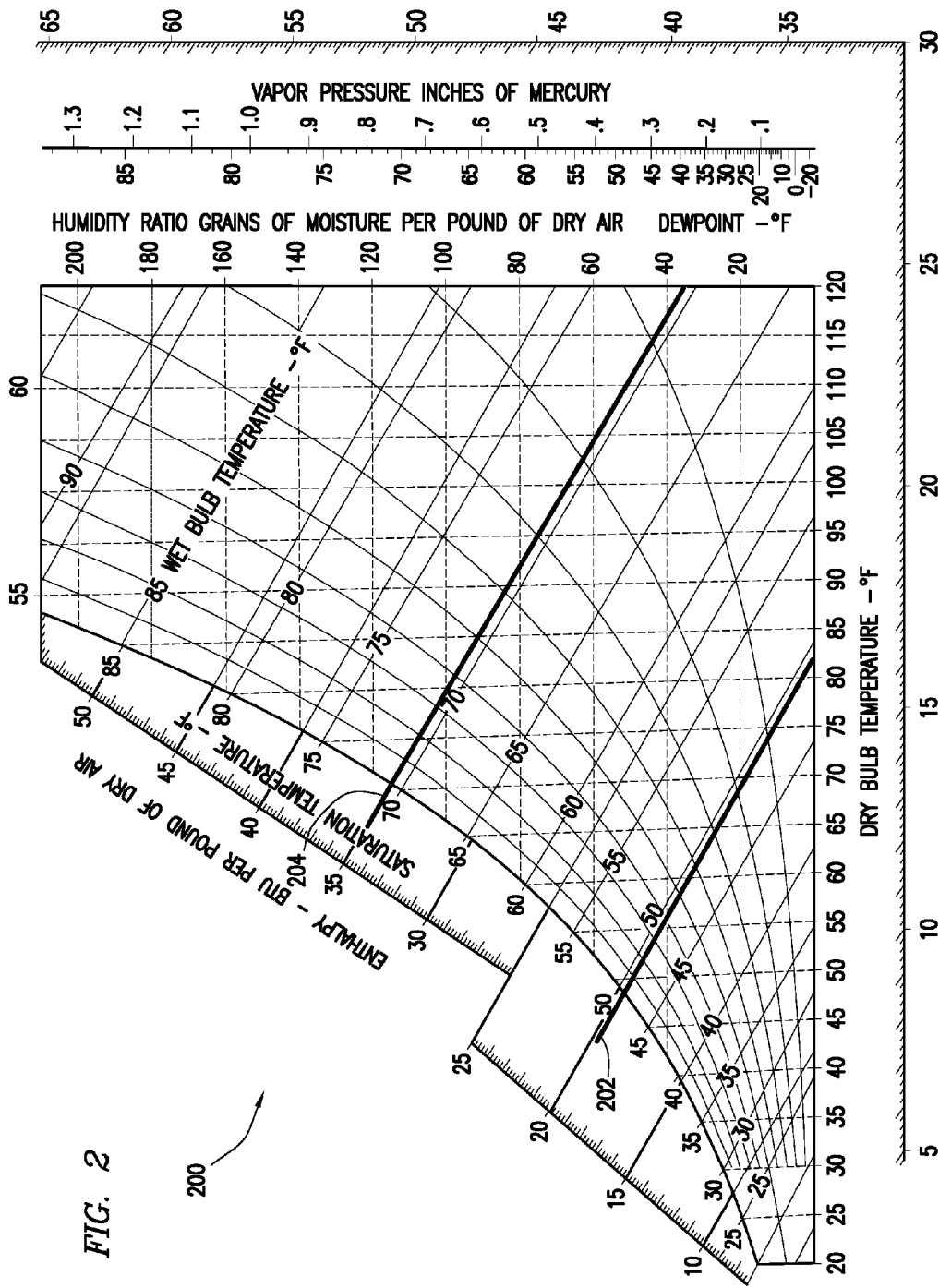


FIG. 1



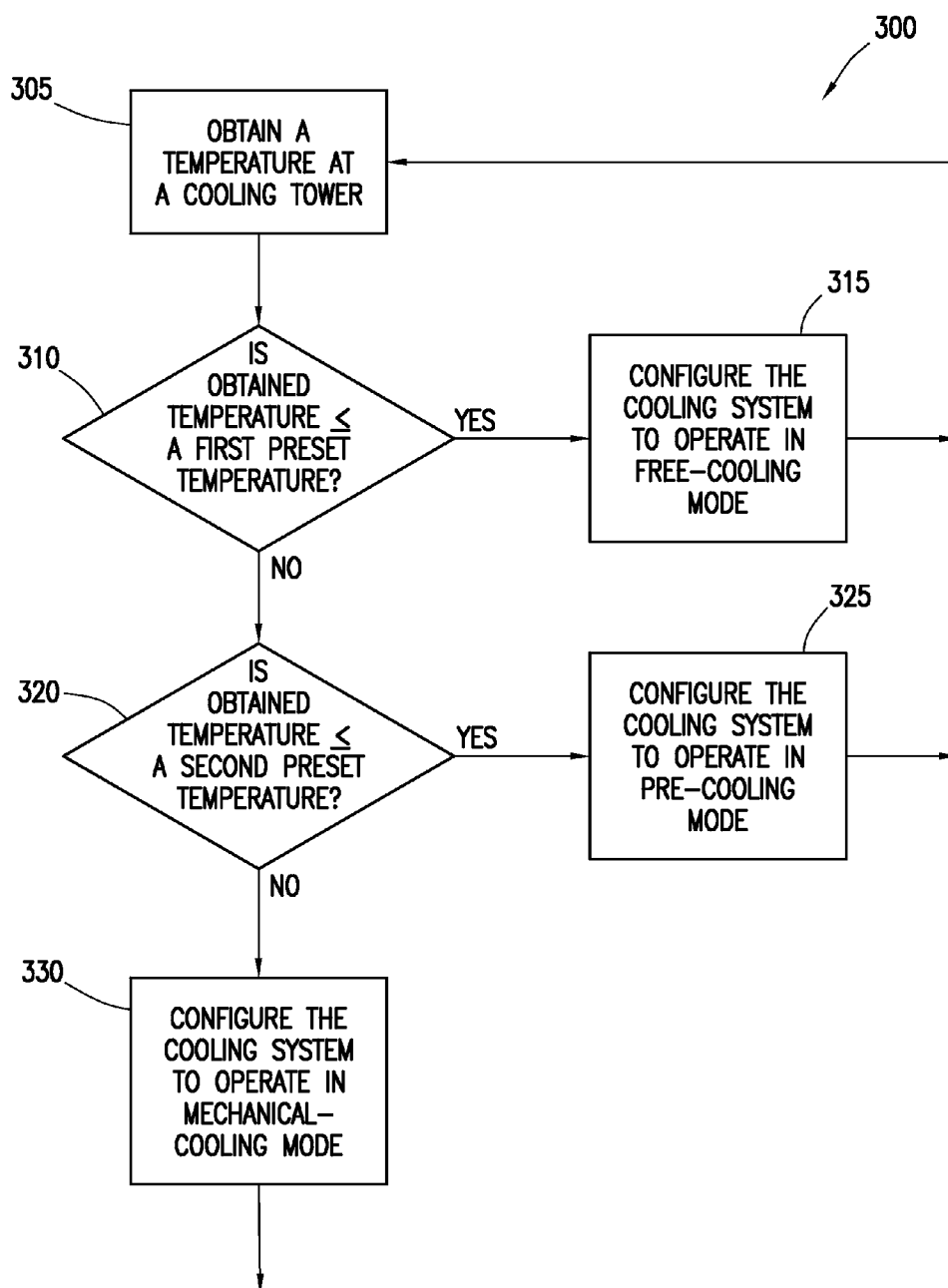


FIG. 3

METHOD AND SYSTEM FOR PRE-COOLING

TECHNICAL FIELD

[0001] The present disclosure relates in general to cooling systems for buildings and process load centers, and more particularly to pre-cooling systems and associated methods.

BACKGROUND

[0002] Generally, cooling systems for industrial, computing, commercial, residential, and other load centers are designed to maintain environmental standards. For example, modern computer data centers have servers, switches, and networking equipment that are maintained within particular environmental temperature and humidity ranges. As such, data centers use a significant amount of energy to operate, and in fact, data center energy use is one of the fastest growing segments of energy consumption in the United States. This is encouraging driving data centers, especially large data centers, to find and use more energy efficient methods and systems.

[0003] One way in which industrial, computing, and commercial centers may become more energy efficient may be through increasing the efficiency of associated cooling systems. Conventional cooling systems may include a chiller, direct expansion gas cooling, water-side economizer, air-side economizer, or some combination of these components. In addition, conventional cooling systems often utilize water or glycol as a cooling medium in closed loop systems. Alternatively, conventional cooling systems may utilize room air cooling units, for example, placed near the server racks in a data center. In these systems, cooling may be accomplished by the operation of a direct expansion system, a water-side economizer system, or the circulation of chilled water or, in some cases, glycol as a cooling medium in closed loop systems. Additionally, cooling systems may be designed to operate in a variety of cooling scenarios and conditions including some conditions that may exist for only a small fraction of the required cooling time in a given year.

SUMMARY

[0004] In accordance with one embodiment of the present disclosure, a cooling system is provided that includes a condenser including a condenser inlet and a condenser outlet. The system also includes a cooling tower including a cooling tower inlet and a cooling tower outlet. The system further includes a heat exchanger including a first heat exchanger inlet and a first heat exchanger outlet. The first heat exchanger inlet is fluidically coupled to the cooling tower outlet, and the first heat exchanger outlet is fluidically coupled to the condenser inlet.

[0005] In accordance with another embodiment of the present disclosure, a method for a cooling system is disclosed. The method includes obtaining a cooling tower exit temperature of a first fluid. Based on the obtained temperature being greater than a first preset temperature, the first fluid is directed from a cooling tower outlet to a first heat exchanger inlet, from a first heat exchanger outlet to a condenser inlet, and from a condenser outlet to a cooling tower inlet.

[0006] Other technical advantages will be apparent to those of ordinary skill in the art in view of the following specifications, claims, and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] A more complete understanding of the present embodiments and advantages thereof may be acquired by referring to the following description taken in conjunction with the accompanying drawings, in which like reference numbers indicate like features, and wherein:

[0008] FIG. 1 illustrates an example block diagram of an exemplary cooling configuration for multiple cooling modes in accordance with certain embodiments of the present disclosure;

[0009] FIG. 2 illustrates an example psychrometric chart showing an exemplary cooling process utilizing a multiple mode cooling system in accordance with certain embodiments of the present disclosure; and

[0010] FIG. 3 illustrates a flow chart for an example method for cooling system transitions using multiple cooling modes in accordance with certain embodiments of the present disclosure.

DETAILED DESCRIPTION

[0011] Design and specifications relating to a cooling system for a building that houses equipment or personnel may be based on a target environment, which may include a designed or target temperature and a designed or target humidity. Based on the target environment and the amount of heat generated in a building or portion of a building, the cooling system provides a particular incoming temperature of chilled water, coolant, or fluid. As an example, a large data center may create an approximately 625 ton load and require a target ambient air temperature between approximately sixty-one and seventy-five degrees Fahrenheit and a humidity range of approximately forty to fifty-five percent. For example, based on the target environment for the building, the specified incoming fluid temperature may be approximately fifty-five degrees Fahrenheit. The fluid exiting the building is at a higher temperature based on the load in the building. For example, the fluid exiting the building may be at approximately seventy degrees Fahrenheit.

[0012] A cooling system may include a chiller to cool the fluid exiting the building. The chiller, when in operation, consumes a large amount of energy. Thus, improvements to the efficiency of cooling systems may be based on minimizing the requirements placed on the chiller. In the present disclosure, systems and methods are presented to provide pre-cooling of the fluid before it enters the chiller. Such pre-cooling reduces the amount of cooling that needs to take place in the chiller. In some embodiments, the cooling system may be configured to transition between multiple cooling modes. The transition may be based on the wet bulb temperature, target air temperatures for a building or portion of a building, or the fluid temperature exiting a cooling tower. As such, the cooling mode selected is appropriate or more efficient under the particular atmospheric and systemic conditions. The cooling system provides seamless transitions between economizing (for example, maximum utilization of free cooling through a cooling tower) and mechanical cooling (for example, operating a chiller to provide cooling).

[0013] Preferred embodiments and their advantages are best understood by reference to FIGS. 1 through 3, wherein like numbers are used to indicate like and corresponding parts.

[0014] FIG. 1 illustrates an example block diagram of an exemplary cooling configuration 100 for multiple cooling

modes in accordance with certain embodiments of the present disclosure. Cooling configuration 100 may be utilized to cool load center 118. Design and specifications relating to cooling configuration 100 may be based on a target environment for load center 118, which may include a designed or target temperature and a designed or target humidity. Based on the target environment for load center 118 and the amount of heat generated in load center 118, the incoming coolant temperature may be specified. The specified incoming coolant temperature may be based in part on the output of any air-handlers providing air flow to load center 118. As an example, a data center may create an approximately 625 ton load and require a target ambient air temperature of approximately sixty-five degrees Fahrenheit and a humidity range of approximately forty to fifty-five percent. This may be achieved by providing local cooling systems, such as a “cooling system” with chilled coolant. For example, based on the target environment for load center 118, the specified incoming coolant temperature may be between approximately fifty-five and sixty degrees Fahrenheit. As another example, load center 118 may be a hospital with a specified incoming coolant temperature of approximately forty-five degrees Fahrenheit.

[0015] Cooling configuration 100 may include cooling system 180 and processing system 126. Cooling system 180 may be configured as a double loop cooling system. In a double loop cooling system, cooling fluid flowing in first loop 104 is maintained separately from cooling fluid flowing in second loop 106. Cooling system 180 may include one or more cooling towers 108, one or more tower pumps 110, one or more filters 112, heat exchanger 114, chiller 116, load center 118, and/or one or more system pumps 122. Components of cooling system 180 may be fluidically coupled. Cooling system 180 may include piping sections through which a fluid circulates and that may connect components making up first loop 104. Also, cooling system 180 may include piping sections through which a fluid circulates and that may connect components making up second loop 106. The inclusion of first loop 104 and second loop 106 may allow the use of two different coolants or fluids that may be circulated separately. Fluid flowing through cooling system 180 may be contained in the same pipe, multiple pipes, or piping structure and may confine the same fluid in a continuous flow.

[0016] Additionally, fluids 124a and 124b (collectively “fluids 124”), for example, coolant, cooling water, or other cooling fluid, circulate through cooling system 180 at various temperatures at different sections of cooling system 180. Temperature measurement may be accomplished by temperature sensors placed and configured to measure fluids 124 or exterior temperatures or wet bulb temperatures as suitable for a specific implementation. Cooling system 180 includes fluid 124a that circulates through first loop 104 of piping, machinery, and other connections, and fluid 124b that circulates through second loop 106 of separate piping, machinery, and other connections.

[0017] In some embodiments, cooling system 180 may operate in different modes of cooling. For example, cooling system 180 may operate in a free-cooling mode, a pre-cooling mode, and a mechanical-cooling mode. In the present disclosure, the example temperature differences, loads, and efficiencies discussed below with respect to load center 118, heat exchanger 114, chiller 116, and cooling towers 108 are for ease of example and a cooling system design may account for

larger or smaller temperature differences and different inlet and outlet temperatures as suitable for a particular implementation.

[0018] In some embodiments, cooling system 180 may operate in free-cooling mode when the atmospheric temperature is below a target wet bulb temperature T_1 . For example, at a target wet bulb temperature less than or equal to approximately forty-nine degrees Fahrenheit (T_1), free-cooling mode may be the most efficient cooling mode to operate. Additionally, operation in free-cooling mode may be based on the temperature of fluid 124a exiting cooling tower 108 at cooling tower outlet 158, T_{CT} . In some embodiments, if T_{CT} is less than the target temperature of fluid 124b at load center inlet 160, free-cooling mode may be the most efficient cooling mode to operate. For example, T_{CT} may be approximately fifty-three degrees Fahrenheit and the target temperature of fluid 124b at load center inlet 160 may be approximately fifty-five degrees Fahrenheit.

[0019] In free-cooling mode, chiller 116 is inactive and all cooling is accomplished by cooling towers 108. However, as the wet bulb temperature rises above T_1 , free-cooling mode may not be the proper cooling mode to operate because the required cooling may not be provided by operation of cooling towers 108 alone. Thus, cooling system 180 may be configured to transition from free-cooling mode to another cooling mode when the atmospheric conditions or other suitable parameters indicate that free-cooling mode is no longer able to provide sufficient cooling. For exemplary purposes, the following discussion of free-cooling mode assumes a wet bulb temperature, T_{WB} , of approximately forty-nine degrees Fahrenheit.

[0020] Free-cooling mode circulates fluid 124a in first loop 104 through tower pumps 110, filters 112, heat exchanger 114, and condenser 138. Free-cooling mode circulates fluid 124b in second loop 106 through evaporator 136, load center 118, system pumps 122, and heat exchanger 114. Fluids 124 may be passed thorough chiller 116 or chiller bypass valves may be utilized to divert fluids 124 around chiller 116. Thus, in free-cooling mode, chiller 116 may be inactive or switched off and cooling towers 108 may provide approximately one hundred percent of cooling for load center 118.

[0021] Fluid 124b circulating in free-cooling mode exits evaporator 136 through evaporator outlet 152 or bypasses evaporator 136 at a temperature of approximately fifty-five degrees Fahrenheit for example. Fluid 124b circulates through load center 118 and absorbs heat of a desired number of degrees. For example, fluid 124b may be heated approximately fifteen degrees Fahrenheit as a result of the desired removal of heat from load center 118. Thus, in the current example, fluid 124b exiting load center 118 at load center outlet 162 may be approximately seventy degrees Fahrenheit. Fluid 124b circulates through system pumps 122 and enters heat exchanger 114 at heat exchanger inlet 164. Heat exchanger 114 cools fluid 124b as a result of the transfer of heat to fluid 124a circulating from filters 112. For example, heat exchanger 114 may cool fluid 124b from system pumps 122 approximately fifteen degrees Fahrenheit. Thus, fluid 124b exiting heat exchanger 114 at outlet 166 may be approximately fifty-five degrees Fahrenheit in the current example, which is the target temperature at load center inlet 160.

[0022] Fluid 124a circulating in free-cooling mode exits cooling towers 108 at a particular temperature, T_{CT} , based on the wet bulb temperature and the cooling that occurs in cool-

ing towers 108. For example, fluid 124a exiting cooling towers 108 through cooling tower outlet 158 may be at a temperature of approximately fifty-three degrees Fahrenheit. Fluid 124a flows through tower pumps 110 and filters 112 and enters heat exchanger 114 at heat exchanger inlet 168. Heat exchanger 114 heats fluid 124a as a result of the transfer of heat from fluid 124b circulating from system pumps 122. For example, heat exchanger 114 may heat fluid 124a from filters 112 approximately fifteen degrees Fahrenheit. Thus, fluid 124a exiting heat exchanger 114 at outlet 170 may be approximately sixty-eight degrees Fahrenheit in the current example. Since condenser 138 is not operating in this mode, fluid 124a may pass through condenser 138 and exit condenser 138 through condenser outlet 156 or fluid 124a may bypass condenser 138 at approximately the same temperature, for example, approximately sixty-eight degrees Fahrenheit. Fluid 124a flows to cooling towers 108 and enters cooling towers 108 at cooling tower inlet 172. In cooling towers 108, the temperature of fluid 124a decreases. For example, cooling towers 108 may decrease the temperature of fluid 124a to approximately fifty-three degrees Fahrenheit in the current example.

[0023] In circumstances where the wet bulb temperature is above a selected T_1 , for example, approximately forty-nine degrees Fahrenheit in the current example, cooling system 180 may operate in pre-cooling mode. In pre-cooling mode, heat exchanger 114 is configured to pre-cool fluid 124b prior to entering evaporator 136. As such, the cooling provided by heat exchanger 114 and chiller 116 is combined to provide the necessary cooling of fluid 124b for load center 118. Thus, the cooling to be accomplished by chiller 116 may be minimized.

[0024] In some embodiments, cooling system 180 is configured to operate pre-cooling mode a range of target wet bulb temperatures, for example, from T_2 to T_1 . For example, at a wet bulb temperature greater than approximately forty-nine degrees Fahrenheit (T_2) and less than or equal to approximately seventy-one degrees Fahrenheit (T_1), pre-cooling mode may be the most efficient cooling mode to operate. However, as the wet bulb temperature rises above a specified T_2 , pre-cooling mode may not be the proper cooling mode to operate because the required cooling may not be provided. Additionally, operation in pre-cooling mode may be based on the temperature of fluid 124a exiting cooling tower 108 at cooling tower outlet 158, T_{CT} . In some embodiments, if T_{CT} is less than the temperature of fluid 124b at heat exchanger inlet 164, pre-cooling mode may be the most efficient cooling mode to operate. For example, T_{CT} may be approximately seventy-four degrees Fahrenheit and the temperature of fluid 124b at heat exchanger inlet 164 may be approximately seventy-five degrees Fahrenheit. Thus, cooling system 180 may be configured to transition from pre-cooling mode to another cooling mode when the atmospheric conditions or other suitable parameters indicate that pre-cooling mode is no longer able to provide sufficient cooling. For exemplary purposes, the following discussion of pre-cooling mode assumes a wet bulb temperature, T_{WB} , of approximately sixty-seven degrees Fahrenheit.

[0025] Pre-cooling mode circulates fluid 124a in first loop 104 through cooling towers 108, tower pumps 110, filters 112, heat exchanger 114, and condenser 138, and circulates fluid 124b in second loop 106 through evaporator 136, load center 118, system pumps 122, and heat exchanger 114. Fluid 124a circulating in pre-cooling mode exits cooling towers 108 at cooling tower outlet 158 at a particular temperature

based on the wet bulb temperature and the cooling that occurs in cooling towers 108. For example, fluid 124a exiting cooling towers 108 through cooling tower outlet 158 may be at a temperature of approximately seventy degrees Fahrenheit. Fluid 124a flows through tower pumps 110 and filters 112 and enters heat exchanger 114 at heat exchanger inlet 168. Heat exchanger 114 heats fluid 124a as a result of the transfer of heat from fluid 124b circulating from system pumps 122. For example, heat exchanger 114 may heat fluid 124a from filters 112 approximately three degrees Fahrenheit. Thus, fluid 124a exiting heat exchanger 114 at heat exchanger outlet 170 may be approximately seventy-three degrees Fahrenheit in the current example. Because chiller 116 is operating, fluid 124a may absorb heat as it travels through condenser 138 and exits condenser 138 through condenser outlet 156 at approximately ninety degrees Fahrenheit. Fluid 124a flows to cooling towers 108 and enters cooling towers 108 at cooling tower inlet 172. In cooling towers 108, the temperature of fluid 124a decreases. For example, cooling towers 108 may decrease the temperature of fluid 124a to approximately seventy degrees Fahrenheit in the current example.

[0026] Fluid 124b circulating in pre-cooling mode exits evaporator 136 through evaporator outlet 152 at a temperature of approximately fifty-five degrees Fahrenheit for example. Fluid 124b circulates through load center 118 and absorbs heat of a desired number of degrees. For example, fluid 124b may be heated approximately twenty degrees Fahrenheit as a result of the desired removal of heat from load center 118. Thus, in the current example, fluid 124b exiting load center 118 at load center outlet 162 may be approximately seventy-five degrees Fahrenheit. Fluid 124b circulates through system pumps 122 to enter heat exchanger 114 at heat exchanger inlet 164. Heat exchanger 114 cools fluid 124b as a result of the transfer of heat to fluid 124a circulating from filters 112. For example, heat exchanger 114 may cool fluid 124b from system pumps 122 approximately three degrees Fahrenheit. Thus, fluid 124b exiting heat exchanger 114 at heat exchanger outlet 166 may be approximately seventy-two degrees Fahrenheit in the current example. Fluid 124b enters evaporator 136 at evaporator inlet 150 and is cooled by heat removal to exit evaporator outlet 152 at approximately fifty-five degrees Fahrenheit.

[0027] Accordingly, in some embodiments, pre-cooling mode may utilize heat transfer from both heat exchanger 114 and chiller 116 in series to accomplish the desired removal of heat from fluid 124b. Additionally, adjusting the flow rate of fluid 124b by system pumps 122 may increase or decrease the amount of heat removal as fluid 124b flows through heat exchanger 114 and chiller 116. For example, by decreasing the flow rate of fluid 124b more heat may be removed as fluid 124b flows through heat exchanger 114 and chiller 116.

[0028] In mechanical-cooling mode, chiller 116 provides all or nearly all of cooling for cooling system 180. Cooling system 180 is configured to operate mechanical-cooling mode above a target wet bulb temperature, T_2 . For example, at a target wet bulb temperature greater than approximately seventy-one degrees Fahrenheit (T_2), mechanical-cooling mode may be the most efficient cooling mode to operate. However, as the wet bulb temperature decreases below T_2 , mechanical-cooling mode may not be the most efficient cooling mode to operate because one hundred percent mechanical cooling provided by chiller 116 requires more energy than free cooling provided by cooling towers 108. Additionally, operation in mechanical-cooling mode may be based on the

temperature of fluid **124a** exiting cooling tower **108** at cooling tower outlet **158**, T_{CT} . In some embodiments, if T_{CT} is greater than or equal to the temperature of fluid **124b** at heat exchanger inlet **164**, mechanical-cooling mode may be the most efficient cooling mode to operate. For example, T_{CT} may be approximately seventy-five degrees Fahrenheit and the temperature of fluid **124b** at heat exchanger inlet **164** may be approximately seventy-five degrees Fahrenheit. Thus, cooling system **180** is configured to transition from mechanical-cooling mode to another cooling mode when the atmospheric conditions or other suitable parameters indicate that mechanical-cooling mode is no longer necessary. For exemplary purposes, the following discussion of mechanical-cooling mode assumes a T_{WB} of approximately seventy-three degrees Fahrenheit.

[0029] Mechanical-cooling mode circulates fluid **124a** in first loop **104** through tower pumps **110**, filters **112**, heat exchanger **114**, and condenser **138**, and circulates fluid **124b** in second loop **106** through evaporator **136**, load center **118**, system pumps **122**, and heat exchanger **114**. Fluid **124a** circulating in mechanical-cooling mode exits cooling towers **108** at a particular temperature based on the wet bulb temperature and the cooling that occurs in cooling towers **108**. For example, fluid **124a** may exit cooling towers **108** through cooling tower outlet **158** may be at a temperature of approximately seventy-five degrees Fahrenheit. Fluid **124a** flows through tower pumps **110** and filters **112** and enters heat exchanger **114** at heat exchanger inlet **168**. Because the temperature of fluid **124a** may be approximately equivalent to the temperature of fluid **124b**, heat exchanger **114** may not provide any heat transfer from fluid **124a** to fluid **124b**, or in circumstances in which the temperature of fluid **124a** is greater than the temperature of fluid **124b**, heat may be transferred from fluid **124a** to fluid **124b**. In such a case, heat exchanger **114** may be bypassed by utilizing one or more bypass valves. In the current example, fluid **124a** may exit heat exchanger **114** at heat exchanger outlet **170** at approximately the same temperature as fluid **124a** entered heat exchanger **114**, approximately seventy-five degrees Fahrenheit. Because chiller **116** is operating, fluid **124a** may absorb heat as it travels through condenser **138** and exit condenser **138** through condenser outlet **156** at approximately ninety-five degrees Fahrenheit. Fluid **124a** flows to cooling towers **108** and enters cooling towers **108** at cooling tower inlet **172**. In cooling towers **108**, the temperature of fluid **124a** decreases. For example, cooling towers **108** may decrease the temperature of fluid **124a** to approximately seventy-five degrees Fahrenheit in the current example.

[0030] Fluid **124b** circulating in mechanical-cooling mode exits evaporator **136** through evaporator outlet **152** at a temperature of approximately fifty-five degrees Fahrenheit for example. Fluid **124b** circulates through load center **118** and absorbs heat of a desired number of degrees. For example, fluid **124b** may be heated approximately twenty degrees Fahrenheit as a result of the desired removal of heat from load center **118**. Thus, in the current example, fluid **124b** exiting load center **118** at load center outlet **162** may be approximately seventy-five degrees Fahrenheit. Fluid **124b** circulates through system pumps **122** to enter heat exchanger **114** at heat exchanger inlet **164**. Because the temperature of fluid **124a** may be approximately equivalent to the temperature of fluid **124b**, heat exchanger **114** may not provide any heat transfer from fluid **124a** to fluid **124b**. Thus, fluid **124b** exiting heat exchanger **114** at outlet **166** may be approximately seventy-

five degrees Fahrenheit in the current example. Fluid **124b** enters evaporator **136** at evaporator inlet **150** and is cooled by heat removal to exit at evaporator outlet **152** at approximately fifty-five degrees Fahrenheit.

[0031] In some embodiments, some or all of free-cooling, pre-cooling, and mechanical-cooling modes may be included in a cooling system. The selection of the appropriate cooling mode may be based on a wet bulb temperature, target inlet fluid temperatures for any load centers, or the temperature of a fluid exiting a cooling tower in a cooling system.

[0032] Cooling towers **108** may be high efficiency designs with induced draft fans. In alternate embodiments, cooling towers **108** utilize other designs and configurations that perform the same or similar function. Cooling towers **108** use induced draft fans to draw or blow atmospheric air **130** through an atmospheric air inlet. The induced draft fan may be a fixed speed fan or a variable speed fan. Cooling towers **108** are open to the exterior environment and exposed to the external atmosphere. Atmospheric air **130** may interact with fluid **124a** that enters cooling towers **108** via return piping. As the fluid **124a** exiting the return piping mixes with the atmospheric air, the latent heat of vaporization is absorbed from fluid **124a** and the atmospheric air. As a result, fluid **124a** is cooled. Cooling towers **108** may additionally include temperature sensors, flow rate meters, pressure sensors, or any other suitable components to allow for monitoring and control of cooling towers **108**.

[0033] The rate and amount of cooling performed within cooling towers **108** depends on the wet bulb characteristics of the atmospheric air. Generally, the lower the wet bulb temperature of the atmospheric air, the more cooling capacity that can take place within cooling towers **108**. As example, cooling towers **108** may be four degree approach cooling towers, which indicate that the temperature of fluid **124a** is approximately four degrees higher than the wet bulb temperature after it passes through cooling towers **108**.

[0034] After the atmospheric air absorbs heat within cooling towers **108**, the atmospheric air exhausts to the atmosphere through atmospheric air exhaust **132** included in cooling towers **108**. In some embodiments, atmospheric air exhaust **132** is located in cooling towers **108** opposite from an atmospheric air inlet to form a defined flow path of atmospheric air through cooling towers **108**. In alternate embodiments, the location of atmospheric air exhaust **132** may vary. Just as the atmospheric air exhausts from cooling towers **108**, fluid **124a** that has been cooled, also exits cooling towers **108** at cooling tower outlet **158**.

[0035] One or more temperature sensors are coupled to portions of cooling system **180**. The temperature sensors are utilized to sense the temperature of fluids **124** or atmospheric air **130**. The temperature sensors are communicatively coupled to processing system **126** such that readings from the temperature sensors may be utilized to determine which cooling mode should be utilized.

[0036] Additionally, one or more valves may be fluidically connected or coupled via piping to portions of cooling system **180**. Valves may include one or more two-way or three-way valves to direct the flow of fluids **124**. Further, valves may be electronically controlled and coupled with other devices, such as flow rate meters, to direct fluids **124**. Valves may additionally include temperature sensors, pressure sensors, or any other suitable components to allow for monitoring and control of fluids **124**.

[0037] In some embodiments, cooling towers 108 are fluidically connected or coupled via piping to tower pumps 110. After fluid 124a is cooled in cooling towers 108, fluid 124a accumulates within cooling towers 108 and tower pumps 110 pump fluid 124a through tower pumps 110. Tower pumps 110 include one or more pumps in various configurations. For example, tower pumps 110 may be configured in parallel or may be configured such that one pump is designated as an operating tower pump while additional pumps are designated as standby pumps. Thus, the operating pump normally pumps fluid 124, while the standby pump remains in a standby mode in case the operating pump fails or another system condition requires the use of the standby pump. In alternate embodiments, tower pumps 110 are configured in series or a single pump is utilized.

[0038] Tower pumps 110 may be variable speed, thus allowing variable flow and pressure, or fixed speed pumps. Tower pumps 110 may be configured to maintain a consistent flow such as defined gallons per minute (GPM). Further, tower pumps 110 may be particular horsepower (hp) pumps. For example, tower pumps 110 may include one pump configured to operate at approximately forty-five hp and generate a flow of approximately 1,250 GPM. Tower pumps 110 may additionally include flow rate meters, pressure sensors, or any other suitable components to allow for monitoring and control of tower pumps 110.

[0039] Tower pumps 110 circulate fluid 124a through various components and subsystems of cooling system 180. Tower pumps 110 are fluidically connected or coupled via piping to filters 112. In some embodiments, tower pumps 110 may additionally be connected via piping to a chemical treatment and monitoring subsystem. In such a configuration, piping connects the chemical treatment and monitoring subsystem to filters 112 such that at least a portion of fluid 124a circulates through the chemical treatment and monitoring subsystem prior to entering to filters 112. The portion of fluid that enters the chemical treatment and monitoring subsystem is controlled by one or more valves. The valves may be electronically controlled and coupled with other devices, such as flow rate meters, to direct suitable portions of the fluid 124a to the chemical treatment and monitoring subsystem in order to maintain consistent chemical properties in the fluid 124a. The chemical treatment and monitoring subsystem chemically treats fluid 124a to maintain optimum water quality. Additionally, a dedicated chemical subsystem pump or alternate pressure source circulates the portion of fluid 124a that enters the chemical treatment and monitoring subsystem.

[0040] Tower pumps 110 circulate fluid 124a to enter filters 112 either directly or once fluid 124a or a portion of fluid 124a is processed through the chemical treatment and monitoring subsystem. Filters 112 filter fluid 124a before it enters heat exchanger 114. Filters 112 may include, by way of example only, media filters, screen filters, disk filters, slow sand filter beds, rapid sand filters and cloth filters configured to filter various sizes of particles from fluid 124a. In some embodiments, filters 112 substantially prevent a particle of a predetermined size or larger from circulating with fluid 124a through the portion of cooling system 180 following filters 112. Filters 112 may additionally include flow rate meters, pressure sensors, or any other suitable components to allow for monitoring and control of filters 112.

[0041] Heat exchanger 114 is fluidically connected or coupled via piping to cooling towers 108, filters 112, chiller 116, load center 118, and/or system pumps 122. Heat

exchanger 114 may be a high efficiency counter-flow design. In alternate embodiments, heat exchanger 114 utilizes other designs and configurations that perform the same or similar function. Heat exchanger 114 has separate inlets and separate paths for fluid 124a from filters 112 and fluid 124b from system pumps 122. As different temperature fluids 124 from filters 112 and system pumps 122 travels through heat exchanger 112 in separate paths, heat from the higher temperature fluid, for example fluid 124b from system pumps 122, transfers to the lower temperature fluid, for example, fluid 124a from filters 114. Heat exchanger 112 may additionally include temperature sensors, flow rate meters, pressure sensors, and any other suitable components to allow for monitoring and control of heat exchanger 112. The rate and amount of cooling performed within heat exchanger 112 may depend on the design and specifications of heat exchanger 112, the temperatures of fluids 124, and the flow rates of fluids 124.

[0042] In some embodiments, chiller 116 may be utilized to chill fluid 124b. Chiller 116 may include evaporator 136 and condenser 138. Condenser 138 may be configured to absorb heat from fluid 124b flowing through evaporator 136. Fluid 124a may enter condenser 138 at condenser inlet 154 and may exit condenser 138 at condenser outlet 156. Condenser 138 may include motors, fans, compressors, and/or any other suitable machinery operable for absorbing heat and continuously providing cooling to fluid traversing evaporator 136. Condenser 138 may additionally include temperature sensors, flow rate meters, pressure sensors, or any other suitable components to allow for monitoring and control of condenser 138.

[0043] Evaporator 136 may be configured to work in connection with condenser 138. Evaporator 136 may condition fluid 124b to a predetermined temperature, such as approximately fifty-five degrees Fahrenheit. Fluid 124b may enter evaporator 136 at evaporator inlet 150 and may exit evaporator 136 at evaporator outlet 152. Fluid 124b enters evaporator 138 and may be at a temperature greater than a target fluid temperature for load center 118, for example, approximately seventy-two degrees Fahrenheit. Evaporator 136 may lower the temperature of fluid 124b to the target fluid temperature for load center 118. Evaporator 136 may additionally include temperature sensors, flow rate meters, pressure sensors, or any other suitable components to allow for monitoring and control of evaporator 136.

[0044] Load center 118 includes any equipment, machinery, and personnel that generate heat during operation. Load center 118 is designed to maintain a particular environment for the protection of equipment and machinery included in load center 118. For example, load center 118 may be a data center designed to maintain a supply air temperature of approximately sixty-five degrees Fahrenheit and a humidity level below a certain threshold, such as approximately sixty percent. Load center 118 may additionally include temperature sensors, flow rate meters, pressure sensors, or any other suitable components to allow for monitoring and control of load center 118.

[0045] In some embodiments, load center 118 may include multiple air-handler units 140, and humidification elements 142. Air-handler units 140 may provide an interface between fluid 124b cooled by heat exchanger 114 and/or chiller 116 and load air 144 that may have been heated in load center 118. For example, load air 144 may be heated by the operation of computing centers in a data center. Load air 144 may be

moved into air-handler units **140** through ducting. Fluid **124b** may enter load center **118** via piping, for example a cooling coil, that directs fluid **124b** proximate to air-handler units **140** or heated data center load air **144**. As fluid **124b** passes proximate to air-handler units **140** or heated data center load air **144**, to air-handler units **140** may cause the heat in the data center air to transfer to fluid **124b**. For example, air-handler units **140** in the form of fans may blow load air **144** across the piping that contains fluid **124b**. Thus, fluid **124b** that exits data center **118** may be at a higher temperature than fluid **124b** that enters data center **118**. The data center air that has been cooled may be directed by the air-handler units **140** back through data center **118**. Fluid **124b**, which has been heated, may be directed via piping to system pumps **122**.

[0046] The humidity of the data center air may be controlled by humidification element **142**. For example, if the humidity level needs to be increased to maintain the correct environment, humidification element **142** may inject water into ducting as load air **144** enters air-handler units **140**. In alternate embodiments, the humidity of the data center air could be controlled through use of an evaporative media section, or directly in load center **118**.

[0047] In some embodiments, cooling system **180** may utilize one or more system pumps **122**. System pumps **122** may include one or more pumps in various configurations. For example, system pumps **122** may be configured in parallel or may be configured such that one pump may be designated as an operating system pump while an additional pump may be designated as a standby pump. Thus, the operating pump normally pumps fluid **124b**, while the standby pump remains in standby in case the operating pump fails or another system condition requires the use of the standby pump. In alternate embodiments, system pumps **122** may be configured in series or a single pump may be utilized. System pumps **122** may also require a freeze protection subsystem to prevent damage if the pumps are exposed to temperatures below approximately thirty-two degrees Fahrenheit. System pumps **122** may additionally include temperature sensors, flow rate meters, pressure sensors, or any other suitable components to allow for monitoring and control of system pumps **122**. System pumps **122** may be variable speed, thus allowing variable flow and/or pressure, or fixed speed pumps.

[0048] In some embodiments, fluid **124a** that circulates in first loop **104** may be cooling water. Fluid **124b** that circulates in second loop **106** may be water, glycol, Freon, refrigerant, or any other suitable cooling fluid.

[0049] Components of cooling configuration **100** include processing system **126**. Processing system **126** includes any instrumentality or aggregate of instrumentalities operable to compute, classify, process, transmit, receive, retrieve, originate, switch, store, display, manifest, detect, record, reproduce, handle, or utilize any form of information, intelligence, or data for business, scientific, control, or other purposes. For example, processing system **126** may be a personal computer, other form of computer, a network storage resource, or any other suitable device and may vary in size, shape, performance, functionality, and price.

[0050] Processing system **126** includes one or more processing resources such as a central processing unit (CPU), microprocessor, microcontroller, digital signal processor (DSP), application specific integrated circuit (ASIC), or any other digital or analog circuitry configured to interpret data, execute program instructions, or process data. A processing resource may interpret or execute program instructions and

process data stored in memory, mass storage device, or another component of cooling configuration **100**.

[0051] Processing system **126** includes any system, device, or apparatus operable to retain program instructions or data for a period of time (for example, computer-readable media) such as hardware or software control logic, random access memory (RAM), electrically erasable programmable read-only memory (EEPROM), a PCMCIA card, flash memory, magnetic storage, opto-magnetic storage, or any suitable selection or array of volatile or non-volatile memory that retains data after power to processing system **126** is removed.

[0052] Processing system **126** includes one or more storage resources (or aggregations thereof) communicatively coupled to the processing resource and may include any system, device, or apparatus operable to retain program instructions or data for a period of time (for example, computer-readable media). Storage resources include one or more hard disk drives, magnetic tape libraries, optical disk drives, magneto-optical disk drives, compact disk drives, compact disk arrays, disk array controllers, solid state drives (SSDs), and any computer-readable medium operable to store data. Computer-readable media include any instrumentality or aggregation of instrumentalities that may retain data and instructions for a period of time. Computer-readable media may include, without limitation, storage media such as a direct access storage device (for example, a hard disk drive or floppy disk), a sequential access storage device (for example, a tape disk drive), compact disk, CD-ROM, DVD, random access memory (RAM), read-only memory (ROM), electrically erasable programmable read-only memory (EEPROM), or flash memory; as well as communications media such as wires, optical fibers, microwaves, radio waves, and other electromagnetic or optical carriers; or any combination of the foregoing.

[0053] Additional components of processing system **126** may include one or more network ports for communicating with external devices as well as various input and output (I/O) devices, such as a keyboard, a mouse, and a video display. Processing system **126** may also include one or more buses or wireless devices operable to transmit communications between the various hardware components and any component of cooling system **180**.

[0054] Processing system **126** is operable to receive data from, and transmit data to, any component of cooling system **180** or other processing systems. Processing system **126** may be a host computer, a remote system, and any other computing system communicatively coupled to cooling system **180**. Processing system **126** may be included in load center **118** or may be remote from cooling system **180**.

[0055] FIG. 2 illustrates an example psychrometric chart **200** showing an exemplary cooling process utilizing a multiple mode cooling system in accordance with certain embodiments of the present disclosure. The psychrometric chart illustrates psychrometric properties of the atmospheric air **130** prior to entering cooling system **180**. For example, atmospheric air **130** entering cooling towers **108** shown with reference to FIG. 1. Psychrometric chart **200** may be based on a cooling system designed to deliver approximately fifty-five degree Fahrenheit fluid **124b** to load center **118**. Psychrometric chart **200** may further be based on a heat load at load center **118** of approximately fifteen to twenty degrees Fahrenheit.

[0056] Additionally, psychrometric chart **200** may be based on an approach temperature for cooling tower **108** and heat exchanger **114**. For example, cooling towers **108** may be three

degree Fahrenheit approach cooling towers and heat exchanger **114** may be a two degree Fahrenheit approach heat exchanger. However, modifications may be made to psychrometric chart **200**, for example, locations of T_1 line **202** and T_2 line **204** based on a different designed delivery temperature of fluids **124**, a different heat load at load center **118**, a different cooling towers **108** approach temperature, or a different heat exchanger **114** approach temperature.

[0057] In some embodiments, the psychrometric zone below T_1 line **202** corresponds to exterior air properties that enable free-cooling mode to be the most efficient operating mode for cooling system **180**. For example, T_1 line **202** corresponds to wet bulb temperature of approximately forty-nine degrees Fahrenheit. For free-cooling mode, cooling towers **108** provide approximately one hundred percent cooling as discussed above with reference to FIG. 1.

[0058] The psychrometric zone less than or equal to T_2 line **204** and greater than T_1 line **202** corresponds to exterior air properties that enable the pre-cooling mode to be the most efficient. As example, T_2 line **204** corresponds to a wet bulb temperature of approximately seventy-one degrees Fahrenheit. Thus, at wet bulb temperatures below approximately seventy-one and greater than approximately forty-nine degrees Fahrenheit, pre-cooling mode may be the most appropriate mode of operating cooling system **180**.

[0059] In some embodiments, the psychrometric zone above T_2 line **204** corresponds to exterior air properties that enable mechanical-cooling mode to be the most proper operating mode for cooling system **180**. For example, T_2 line **204** corresponds to wet bulb temperature of approximately seventy-one degrees Fahrenheit. For mechanical-cooling mode, cooling chiller **116** provides cooling as discussed above with reference to FIG. 1.

[0060] Accordingly, energy efficiencies may occur through utilization of pre-cooling mode at the appropriate wet bulb temperatures because heat exchanger **114** may offset a portion of the load. As an example, Table 1 illustrates the approximate load carried by an approximately 825 ton chiller **116** at particular wet bulb temperatures that may occur in operation of pre-cooling mode in cooling system **180** with an approximately 625 ton load at load center **118**.

TABLE 1

Wet Bulb Temperature (degrees Fahrenheit)	Load on Chiller 116 (tons)
Less than or equal to 49	0
51 degrees Fahrenheit	83
55 degrees Fahrenheit	250
59 degrees Fahrenheit	281
63 degrees Fahrenheit	437
67 degrees Fahrenheit	530
71 degrees Fahrenheit	593
75 degrees Fahrenheit	655

[0061] In determining design parameters for cooling system **180** of FIG. 1, atmospheric data may be gathered for a particular location where the cooling system may be placed. For example, a wet bulb temperature profile may be gathered or generated for a particular city. The wet bulb temperature profile may include the average number of hours in a year at each wet bulb temperature.

[0062] As an example, a wet bulb temperature profile for Boston, Mass., may indicate that on average Boston may experience wet bulb temperatures as high as approximately

seventy-seven degrees Fahrenheit. In such a location with relatively high wet bulb temperatures, a cooling system similar to cooling configuration **100** shown with reference to FIG. 1 may be utilized. For example, a cooling system may have a load of approximately 625 tons, e.g., heat to be dissipated at load center **118**. Cooling tower **108** may be designed as a three degree Fahrenheit approach cooling tower. For example, cooling tower **108** may be Marley cooling tower manufactured by SPX Cooling Technologies, Inc. (Overland Park, Kans.). Tower pump **110** and system pump **122** may be variable speed drive approximately forty-five horsepower pumps with a flow rate that may range from approximately 750 GPM to 1,000 GPM. Chiller **116** may be a 825 ton chiller manufactured by Trane, an Ingersoll Rand company (Davidson, N.C.). Chiller **116** flow rate may be approximately 2.0 GPM/ton. Fluid **124b** target temperature for load center **118** may be approximately fifty-five degrees Fahrenheit.

[0063] During operation of the current example, a psychrometric chart, such as psychrometric chart **200**, for the designed system may place T_1 line **202** at approximately forty-nine degrees. The designed system may place T_2 line **204** at approximately seventy-one degrees Fahrenheit. For approximately fifty-seven percent of the hours in each year, the wet bulb temperature may be lower than approximately forty-nine degrees Fahrenheit. Thus, cooling system **180** may be configured to operate in free-cooling mode. Chiller **116** may be turned off or bypassed in operation of free-cooling mode.

[0064] For an additional approximately forty-one percent of the hours in each year, the wet bulb temperature may be lower than approximately seventy-one degrees Fahrenheit. Pre-cooling mode may be useful to operate at these wet bulb temperatures. Operating pre-cooling mode may offset the cooling that chiller **116** needs to accomplish.

[0065] In the current example, the location may experience approximately two percent of the hours in each year with a wet bulb temperature over approximately seventy-three degrees Fahrenheit. Mechanical-cooling mode may be the proper mode to operate at these wet bulb temperatures. As such, chiller **116** may be operating at a high capacity in mechanical-cooling mode.

[0066] In the current example, the wet-bulb temperature profile includes hours in all three modes of cooling system **180** operation. For example, there may be approximately 191 hours of mechanical-cooling mode operation, 3,602 hours of pre-cooling mode operation, and 4,967 hours of free-cooling mode operation. A typical system may run approximately 625 tons of cooling year round (8,760 hours) using mechanical-cooling mode exclusively and consume approximately 3,611, 047 kilowatt-hours of energy. Using the pre-cooling mode and free-cooling mode, the resultant annual energy consumption may be approximately 972,763 kilowatt-hours of energy resulting in an approximately seventy-three percent (73%) decrease in cooling consumption and cost.

[0067] FIG. 3 illustrates a flow chart for an example method for cooling system transitions using multiple cooling modes in accordance with certain embodiments of the present disclosure. The steps of method **300** may be performed by various computer programs, models or any combination thereof. The programs and models may include instructions stored on a computer-readable medium that are operable to perform, when executed, one or more of the steps described below. The computer-readable medium may include any system, apparatus or device configured to store and/or retrieve programs or instructions such as a microprocessor, a memory, a disk con-

troller, a compact disc, flash memory or any other suitable device. The programs and models may be configured to direct a processor or other suitable unit to retrieve and/or execute the instructions from the computer-readable medium. For example, method 300 may be executed by processing system 126, an operator of the cooling system, and/or other suitable source. For illustrative purposes, method 300 may be described with respect to cooling system 180 of FIG. 1; however, method 300 may be used for cooling system transitions using hybrid cooling system of any suitable configuration.

[0068] At step 305, the processing system obtains a temperature at a cooling tower. For example, with reference to FIG. 1, a temperature sensor senses the wet bulb temperature of atmospheric air 130 at cooling tower 108. In some embodiments, the processing system may obtain the temperature of fluid 124a that exits cooling tower 108, T_{CT} .

[0069] At step 310, the processing system determines if the obtained temperature is less than or equal to a first preset temperature. For example, processing system 126 determines if the wet bulb temperature atmospheric air 130 is less than or equal to T_1 discussed with reference to FIGS. 1 and 2. T_1 is based on design considerations, atmospheric conditions, sizes and loads on components in the cooling system, or any other suitable factor. T_1 may be the temperature at which it becomes more efficient to operate cooling system in free-cooling mode. For example, with reference to FIG. 1, T_1 may be set at approximately forty-nine degrees Fahrenheit. As another example, when the obtained temperature is the temperature of fluid 124a exiting cooling tower 108, it may be determined that the temperature is less than or equal to approximately fifty-five degrees Fahrenheit. If the obtained temperature is less than or equal to a preset temperature, then method 300 proceeds to step 315. If the obtained temperature is greater than the preset temperature, method 300 proceeds to step 320.

[0070] At step 315, the processing system configures the cooling system to operate in free-cooling mode. Free-cooling mode may include configuring a heat exchanger to provide approximately all of the heat transfer required to cool a load center. Free-cooling mode may also include configuring a chiller to be non-operational or bypassed. For example, with reference to FIG. 1, processing system 126 turns off chiller 116 or electronically configures valves to direct fluids 124 to bypass chiller 116. After step 315, method 300 returns to step 305.

[0071] At step 320, the processing system determines if the obtained temperature is less than or equal to a second preset temperature. For example, processing system 126 determines if the temperature atmospheric air 130 is less than or equal to T_2 . T_2 is based on design considerations, atmospheric conditions, sizes and loads on components in the cooling system, or any other suitable factor. T_2 may be the temperature at which it becomes necessary to operate the cooling system in mechanical-cooling mode. For example, with reference to FIG. 1, T_2 may be set at approximately seventy-one degrees Fahrenheit. As another example, when the obtained temperature is the temperature of fluid 124a exiting cooling tower 108, it may be determined that the temperature is less than or equal to approximately seventy-five degrees Fahrenheit. If the obtained temperature is less than or equal to a second preset temperature, then method 300 proceeds to step 325. If the obtained temperature is greater than the second preset temperature, method 300 proceeds to step 330.

[0072] At step 325, the processing system configures the cooling system to operate pre-cooling mode. Pre-cooling mode may include configuring a heat exchanger to provide a portion of the heat transfer required to cool a load center. Pre-cooling mode may also include configuring a chiller to operate at less than full capacity. For example, with reference to FIG. 1, processing system 126 turns on chiller 116 or electronically configures valves to direct fluids 124 to chiller 116. After step 325, method 300 returns to step 305.

[0073] At step 330, the processing system configures the cooling system to operate mechanical-cooling mode. Mechanical-cooling mode may include configuring a chiller to be operated at an elevated capacity or to be operated to provide approximately all of the cooling for a load center. Mechanical-cooling mode may also include configuring valves to bypass heat exchanger 114. For example, with reference to FIG. 1, processing system 126 turns on chiller 116 or electronically configures valves to direct fluids 124 to chiller 116. After step 330, method 300 returns to step 305.

[0074] Modifications, additions, or omissions may be made to method 300 without departing from the scope of the present disclosure and invention. For example, the order of the steps may be performed in a different manner than that described and some steps may be performed at the same time. For example, step 310 and step 320 may be performed simultaneously. Additionally, each individual step may include additional steps without departing from the scope of the present disclosure. For example, step 315 may be performed before or after step 310 without departing from the scope of the present disclosure.

[0075] Although the present invention and its advantages have been described in detail, it should be understood that various changes, substitutions and alternations can be made herein without departing from the spirit and scope of the invention which is solely defined by the following claims.

What is claimed is:

1. A cooling system comprising:

a condenser including a condenser inlet and a condenser outlet;

a cooling tower including a cooling tower inlet and a cooling tower outlet; and

a heat exchanger including a first heat exchanger inlet and a first heat exchanger outlet, the first heat exchanger inlet fluidically coupled to the cooling tower outlet, and the first heat exchanger outlet fluidically coupled to the condenser inlet.

2. A system according to claim 1, further comprising:

a load center including a load center inlet and a load center outlet;

an evaporator including an evaporator inlet and an evaporator outlet; and

wherein the heat exchanger includes a second heat exchanger inlet and a second heat exchanger outlet, the second heat exchanger inlet fluidically coupled to the load center outlet, and the second heat exchanger outlet fluidically coupled to the evaporator inlet.

3. A system according to claim 1, further comprising a temperature sensor to obtain a temperature of a first fluid that exits the cooling tower outlet.

4. A system according to claim 3, wherein the cooling tower includes a variable speed fan configured to adjust fan speed based on the obtained temperature.

5. A system according to claim 3, further comprising, based on the obtained temperature being greater than a first preset

temperature, a piping structure configured to direct the first fluid from the cooling tower outlet to the heat exchanger inlet, from the heat exchanger outlet to the condenser inlet, and from the condenser outlet to the cooling tower inlet.

6. A system according to claim 2, further comprising:
a temperature sensor to obtain a temperature of a first fluid that exits the cooling tower outlet; and
based on the obtained temperature being greater than a first preset temperature, a piping structure configured to direct a second fluid from the evaporator outlet to the load center inlet and from the load center outlet to the second heat exchanger inlet.

7. A system according to claim 6, further comprising based on the obtained temperature being less than or equal to a first preset temperature, a chiller configured to be non-operational, the chiller including the condenser and evaporator.

8. A system according to claim 2, further comprising:
a temperature sensor to obtain a temperature of a wet bulb temperature of an exterior atmosphere; and
based on the obtained temperature being greater than a first preset temperature, a piping structure configured to direct a second fluid from the evaporator outlet to the load center inlet and from the load center outlet to the second heat exchanger inlet.

9. A system according to claim 8, further comprising based on the obtained temperature being less than or equal to a first preset temperature, a chiller configured to be non-operational, the chiller including the condenser and evaporator.

10. A system according to claim 1, wherein the cooling tower includes a variable speed fan configured to adjust fan speed based on a wet bulb temperature of an exterior atmosphere.

11. A system according to claim 2, further comprising a first variable speed pump configured to circulate a first fluid and maintain a flow rate of the first fluid.

12. A system according to claim 11, wherein the first fluid is cooling water.

13. A system according to claim 11, further comprising a second variable speed pump configured to circulate a second fluid and maintain a flow rate of the second fluid.

14. A system according to claim 13, wherein the second fluid is coolant.

15. A method for a cooling system comprising:
obtaining a cooling tower exit temperature of a first fluid; based on the obtained temperature being greater than a first preset temperature, the first fluid directed from a cooling tower outlet to a first heat exchanger inlet, from a first heat exchanger outlet to a condenser inlet, and from a condenser outlet to a cooling tower inlet.

16. A method according to claim 15, further comprising based on the obtained temperature being greater than the first preset temperature, a second fluid directed from an evaporator outlet to a load center inlet and from a load center outlet to a second heat exchanger inlet.

17. A method according to claim 15, further comprising based on the obtained temperature being less than or equal to the first preset temperature, configure a chiller to be non-operational, the chiller including an evaporator and a condenser.

18. A method according to claim 16, further comprising configuring a variable speed pump to circulate the first fluid and maintain a flow rate of the first fluid.

19. A method according to claim 16, further comprising configuring a variable speed pump to circulate the second fluid and maintain a flow rate of the second fluid.

20. A method according to claim 16, further comprising configuring a variable speed fan in the cooling tower to adjust fan speed based on the temperature of the first fluid that exits the cooling tower outlet.

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